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Evaluating E-learning systems success: An empirical study

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ABSTRACT

E-learning, as a direct result of the integration of technology and education, has emerged as a powerful medium of learning particularly using Internet technologies. The undeniable significance of e-learning in education has led to a massive growth in the number of e-learning courses and systems offering different types of services. Thus, evaluation of e-learning -systems is vital to ensure successful delivery, effective use, and positive impacts on learners. Based on an intensive review of the literature, a comprehensive model has been developed which provides a holistic picture and identifies different levels of success related to a broad range of success determinants. The model has been empirically validated by fitting the model to data collected from 563 students engaged with an e-learning system in one of the UK universities through a quantitative method of Partial Least Squares - Structural Equation Modelling (PLS-SEM). The determinants of e-learning perceived satisfaction are technical system quality, information quality, service quality, support system quality, learner quality, instructor quality, and perceived usefulness, which together explain 71.4% of the variance of perceived satisfaction. The drivers of perceived usefulness are technical system quality, information quality, support system quality, learner quality, and instructor quality, and these explain 54.2% of the variance of perceived usefulness. Four constructs were found to be the determinants of e-learning use, namely educational system quality, support system quality, learner quality, and perceived usefulness, and together they account for 34.1%. Finally, 64.7% of the variance of e-learning benefits was explained by perceived usefulness, perceived satisfaction, and use.

1. Introduction

The development of Information Technology (IT) has motivated improvements in various fields such as finance, business, health, and education. As a result, education has grown rapidly and stimulated the adoption of e-learning, which is a direct result of the integration of education and technology and is deemed to be a powerful medium for learning (Al-Fraihat, Joy, & Sinclair, 2017). E-learning has become mainstream in the education sector and has been massively adopted in higher education. According to Dahlstrom, Brooks, and Bichsel (2014), p. 99% of institutions have Learning Management Systems (LMSs) in place, and 85% of them have been utilized, and in the UK, 95% of higher education institutes have adopted LMSs to support their educational services (McGill & Klobas, 2009).

Accordingly, the quality of e-learning systems has received a considerable amount of research attention and a large number of researchers have attempted to identify e-learning success factors to maximize the effectiveness of these systems (e.g., Ali & Ahmad, 2011; Fathema, Shannon, & Ross, 2015; Islam, 2013; B. C. Lee, Yoon, & Lee, 2009; J. K. Lee & Lee, 2008; M. C. Lee, 2010; Mohammadi, 2015; Mtebe & Raphael, 2018; Park, 2009; Wahab, 2008; Wang, 2003)). Broadly, the majority of these studies have examined individual parts of key determinants of e-learning systems success ignoring the synergistic effects of the success variables interacting together (Eom & Ashill, 2018). Another direction of research has dealt with the direct relationships between e-learning quality factors and usage or satisfaction (e.g., Selim, 2003; Ozkan & Koseler, 2009).

The significant amount of research in e-learning has advanced our understanding of the pivotal success factors of e-learning, such as system quality, information quality, service quality, satisfaction, and usefulness. However, the excessive number of measurements among dependent and independent variables is the main challenge that researchers face toward developing an e-learning success model.

Evidently, there is a need for a comprehensive success model for multiple levels of success (Eom & Ashill, 2018). Bearing in mind that an e-learning system is an information system that integrates human entities (i.e., learners and instructors) and non-human entities (e.g., learning management systems), it is crucial to investigate multiple dimensions of success in relation to both entities.

Cidral, Oliveira, Di Felice, and Aparicio (2018) classified studies in

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e-learning from 2001 till 2016. It was found that studies from 2001 started with a focus on intention to use, adoption, usability, course contents and customization and evolved later to include satisfaction from 2007. Recently, from 2013, studies have focused on "the overall success of e-learning and on how students' characteristics affect e-learning" (Cidral et al., 2018). In general, earlier studies have been concerned more about the technology itself. However, as the technology becomes increasingly reliable and accessible, recent research has focused more on students' and instructors' attitudes and interactions, which play a vital role in e-learning success (Cheng, 2011; Liaw, Huang, & Chen, 2007; Selim, 2007). Further research is needed to evaluate these systems for continuing improvement and meeting learners' needs.

On account of the fact that e-learning success factors vary in terms of their relative significance based on the context, different strategies have been adopted to deal with these factors. For example, in developing countries, obstacles are found in resources, accessibility and infrastructure, as well as existence of communication features, and the important role of social factors (e.g. learner and instructor) receive more attention. In contrast, in developed countries, enhancing lifelong education, quality of information, usefulness of the systems, and ethical and legal considerations are more pronounced (Bhuasiri, Xaymoungkhoun, Zo, Rho, & Ciganek, 2012; Mohammadi, 2015). Thus, this study aims to fill this void and address these problems by investigating the factors that influence the success of e-learning, and proposing a model that incorporates the determinants and aspects for e-learning success that are of recent concern and interest to e-learning users, and sharing practical experiences of e-learning success measurements in developed countries such as, the UK.

2. Theoretical foundation

E-learning has expanded rapidly with a variety of technologies and devices to access learning resources, such as laptops, computers, smartphones, and tablets. Technology has profoundly impacted education and learning and teaching methods. Traditionally, accessibility to learning materials has been restricted to few individuals. Collaboration and communication has also been limited to students in the same classroom. Today, a great number of learning resources in different formats (e.g., text, images, audio, videos) are available through the Internet fostering self-paced learning and transcending geographical boundaries. In addition, more opportunities for collaboration and interactive communication features have been expanded, such as wikis, forums, chat and peer-to-peer activities.

Due to the continuous evolution of technology, there is no single consensual definition for e-learning. For example, Lee, Hsieh, and Hsu (2011) defined e-learning as "an information system that can integrate a wide variety of instructional material (via audio, video, and text mediums) conveyed through e-mail, live chat sessions, online discussions, forums, quizzes, and assignments". Other researchers use the concept of e-learning to refer to the technology intervention in the learning process (e.g., Sun, Tsai, Finger, Chen, & Yeh, 2008). In this research, we adopt the definition that considers an e-learning system as an information systems. Thus, the success of an e-learning system is viewed as an IS success.

Reviewing the literature revealed four categories for measuring the success of e-learning based on the DeLone and McLean information systems success model; the Technology Acceptance Model (TAM); the User Satisfaction Models; and E-Learning Quality Models (Al-Fraihat et al., 2018). More details about each approach is given as follows.

2.1. *E-learning success based on DeLone and McLean information systems success model*

In the context of information systems, attempts to define the success of information systems were shallow and imprecise due to the complexity and interdisciplinary nature of the discipline (Petter et al., 2008). To address this, DeLone and McLean (1992) introduced a model to measure information systems success, after reviewing 180 research papers published during the period 1981–1987 for measuring the success of information systems. The model contains six variables: system quality, information quality, use, user satisfaction, individual impact, and organizational impact.

Indeed, the model is considered, more precisely, as a comprehensive framework or a taxonomy, as no empirical validation was proposed by the researchers. DeLone and McLean (1992) called for further development and validation for their model. Information systems researchers attempted to examine this model partially or completely (Igbaria & Tan, 1997; Jurison, 1996; Seddon & Kiew, 1994; Taylor & Todd, 1995). Seddon and Kiew (1994) were among the early researcher who partially tested the model and supported some paths in the model. Other researchers (e.g., Pitt, Watson, & Kavan, 1995) incorporated 'service quality' to the model. Jurison (1996), in a longitudinal study, researched the nature of information systems benefits and argued that individual impacts can be assessed first, but organizational impact needs a long period of time to be assessed. Seddon (1997) criticised their model and considered the reciprocal relationship between use and user satisfaction very confusing. He respecified the model and replaced 'system use' with 'perceived usefulness' and allowed only one direction of causality. Rai, Lang, and Welker (2002) subsequently conducted an empirical study and compared the DeLone and McLean (1992) and Seddon (1997) models. Rai et al. extended Seddon's model and proposed a new model to include a correlational path between perceived usefulness and use. Ten years later, DeLone and McLean updated their model. The new model introduced 'service quality' as a new construct to the model, the 'use' construct was split into 'intention to use' and 'use' to measure systems success in areas where the use of the system is voluntary and mandatory, and two constructs (individual and organizational impacts) were merged into benefits. Researchers adopted this model partially and totally to better understand the success of a variety of information systems including e-learning systems (Chen, 2010; Cidral et al., 2018; Hassanzadeh, Kanaani, & Elahi, 2012; Lin, 2007; Lwoga, 2014; Marjanovic, Delić, & Lalic, 2016; Wang & Chiu, 2011).

Surveying the literature reveals that there is a consensus about the validity of this model (or part of it) to evaluate the success of e-learning systems. However, there is a contradiction in the results among the studies. For example, while some studies found a significant effect of the overall quality aspects (system, information, and service quality) on actual system usage, other researchers reported the insignificance of this relation. A study on actual use of the online learning system OLS (Lin, 2007) found a significant effect of system quality, information quality, and service quality on the actual use through user satisfaction and behavioural intention to use OLS. Another study by Eom, Ashill, Arbaugh, and Stapleton (2012) investigated the direct relationship between system quality and information quality on system use and found it significant. In contrast, in the studies conducted in an Australian university by Klobas and McGill (2010) and Cidral et al. (2018) in Brazilian universities, researchers reported the absence of any significant relationship between quality aspects and use. The contradiction among studies in the literature could be due to the mandatory or voluntary nature of using the system, according to Eom et al. (2012), which may be explained by the fact that, in a mandatory context, students use the e-learning system regardless of its quality because it is the only place to access learning resources, while in a voluntary context, the quality aspects of the system influence the users' decision to use the system or not. Another reason might be due to other intervening variables not explained by the model. Also, results could be dependent on both the context of the study and sample differences. There are also differences between the variance explained (R^2) by quality factors among the dependent variables in these models. For that reason, Eom et al. (2012) stated that "the DeLone and McLean model has limited explanatory power for explaining the role of e-learning systems on the outcomes of e-learning”. Researchers have called for further research to investigate e-learning quality factors to increase the explanatory power of the DeLone and McLean model (Awang, Osman, & Aji, 2018; Eom, 2015; Eom et al., 2012).

2.2. E-learning success based on technology acceptance model

The technology acceptance model (TAM) by Davis et al. (1989) was the second direction for evaluating the success of information systems. It has been the most widely used theory to measure the success of new technology in terms of the acceptance and use of technology (Surendran, 2012). This model was established based on the Theory of Reasoned Action (TRA) and classified under the theories of Social Psychology. The model suggests that when users are presented with new technology, a number of factors influence their decision about how and when they will use it (Davis, 1989). Based on this model, external factors, social factors (e.g., skills and language), cultural factors, and political factors (i.e., the impact of using the technology in politics), are the determinants of perceived usefulness and perceived ease of use (Surendran, 2012). In turn, perceived usefulness and perceived ease of use are the major determinants of attitude toward using the technology and intention to use. Successively, behavioural intention to use is the main determinant of actual system usage.

A large number of studies have been conducted based on empirically testing the robustness and validity of this model, and its instrument and measurement scales. The model has been widely extended using different variables, and has also been successfully used to explain usefulness and usage in different contexts, including the context of e-learning. An important extension, TAM2, to the original TAM was introduced by Venkatesh and Davis (2000), which expanded the original model by adding subjective norm, voluntariness, experience, and image (social influence processes). Also job relevance, output quality, and result demonstrability were added (cognitive instrumental processes). Empirical research showed that TAM2 better explained user acceptance. Three years later, Venkatesh et al. (2012) constructed the Unified Theory of Acceptance and Use of Technology (UTAUT). The introduction of UTAUT has significantly enhanced the explanation power of the variance in usage intention and has been extensively used by researchers. Extensions to TAM have been evolving over time, and in 2008 a new model was released named TAM3 by Venkatesh and Bala (2008), followed by UTAUT2 in 2012 (Venkatesh, Thong, & Xu, 2012).

TAM in its different versions: TAM, TAM2, TAM3, UTATUT, and UTAUT2 have received considerable attention from researchers in different fields and have been empirically examined. Studies carried out with TAM in the context of e-learning systems, similarly, have used the model to predict usefulness, intention to use and usage of e-learning systems. Researchers have extended the model by adding external variables to understand the determinants of e-learning systems' acceptance and usage. The external variables have assisted researchers in understanding why a particular system may not be adopted, thus appropriate ‘corrective steps’ can be taken (Davis, Bagozzi, & Warshaw, 1989). Based on the literature study conducted by Abdullah and Ward (2016), the five most used external factors by researchers and confirmed to have a relationship with TAM in the context of e-learning are self-efficacy, subjective norm, enjoyment, computer anxiety, and prior experience.

According to the review study conducted by Šumak, HeričKo, and PušNik (2011), TAM is the most popular theory adopted in e-learning acceptance research with 86% of studies utilizing this model as a ground theory. Though acceptance and use are necessary to measure success, they are not the same as success (Petter et al., 2008). The model has been widely criticised despite its frequent use. Chuttur (2009) noted that “Researchers share mixed opinions regarding its theoretical assumptions and practical effectiveness” and Legris, Ingham, and Collerette (2003) concluded “TAM is a useful model but has to be integrated into a broader one which would include variables related to both human and social change processes. Also, researchers criticised the poor fit of this model, limited explanatory and predictive power, and lack of practical value (Legris et al., 2003). To illustrate, both TAM and TAM2 explained about 40% of system use (Legris et al., 2003) while researchers extended TAM and provided better explanatory power models with total variance explained ranging from 52% to 70% (Abdullah & Ward, 2016). Furthermore, researchers claimed that the several attempts to expand this model led to “theoretical chaos and confusion” (Benbasat & Barki, 2007).

2.3. E-learning success based on user satisfaction models

Another significant direction of information systems research is the user satisfaction approach. Satisfaction has been found a fundamental measure in the success, effectiveness, usage, and acceptance of information systems (Bailey and Pearsons, 1983; DeLone & McLean, 1992; Doll & Torkzadeh, 1988; Harter & Hert, 1997; Ives, Olson, & Baroudi, 1983; Seddon, 1997; Thong & Yap, 1996). There is a wide agreement that satisfaction is an attitude held by individual users (Thong & Yap, 1996). Remenyi and Money (1991) defined user satisfaction as a measure of the discrepancy between a user's expectations about a specific information systems compared to the perceived performance of the system. Cyert and March (1963) are believed to be the first researchers to introduce the concept of user satisfaction to assess information systems success, and suggested that if an information systems meets users' needs, their satisfaction will increase. Similarly, Evans (1976 cited in Thong & Yap, 1996) stated that a lower satisfaction level about the information systems will hinder system usage. Seddon and Kiew (1994) concluded in her study that user satisfaction is the most general and important measure of information systems success. The same results were achieved by Igbaria and Tan (1997).

The first empirical attempt to identify user satisfaction as a measure in information systems success was by Bailey and Pearson (1983), where they developed an instrument with 39 factors for measuring computer user satisfaction. A shorter condensed instrument, with 13 factors, was produced by Ives et al. (1983). Goodhue (1986) criticised Ives et al.‘s (1983) instrument and considered it lacking strong theoretical support. Later, Baroudi and Orlikowski (1988) empirically validated their short instrument. The contribution of user satisfaction studies continued, and a highly rated reliable questionnaire to measure user satisfaction was proposed by Chin, Diehl, and Norman (1988). In 1992, DeLone and McLean (1992) employed satisfaction as a single construct in their model due to its high degree of reliability and validity compared with other measures. Further, Doll, Deng, Raghunathan, Torkzadeh, and Xia (2004) provided a 12-item valid scale for end-user computing satisfaction (EUCS).

Different approaches have been used to measure user satisfaction. One direction is based on assessing the level of satisfaction of a specific instance of information systems, i.e., at micro level (Ilias, AbdRazak, Rahman, & Yasoa, 2009, p. P18; Ong & Lai, 2007) or with all computer technologies available in the organization, i.e. at macro level (Landrum, Prybutok, & Zhang, 2010; Wixom & Todd, 2005). The other direction is based on assessing the success of information systems based on satisfaction as a single comprehensive construct (Doll et al., 2004; Leclercq, 2007; Somers, Nelson, & Karimi, 2003; Wang & Liao, 2007), or to incorporate it in the model as a construct together with other constructs (DeLone & McLean, 1992; Kang & Lee, 2010).

User satisfaction in assessing e-learning systems success has also been utilized as a single comprehensive factor or alongside other factors. For example, the model of Sun et al. (2008) considered the six dimensions – learners, instructors, course, technology, design, and environment – as being the critical dimensions affecting learner satisfaction. Thirteen factors under these six dimensions were hypothesised and among these, computer anxiety, instructor attitude toward e-learning, course quality, flexibility, perceived usefulness, perceived ease of use, and diversity in assessment, gained empirical support. The results of the study showed that improving users' satisfaction, through these factors, drives a successful e-learning system. Another important contribution to e-learning success evaluation was the model proposed by Ozkan and Koseler (2009). The researchers constructed a hexagonal model based on quality factors (system quality, information quality, and service quality) and social issues (supportive factors, learner perspective, and instructor attitudes). The relationships between the six dimensions and e-learning satisfaction were found significant and accounted for 76.9% of the variance of e-learning satisfaction. Researchers concluded that this model should be perceived as basics for assessing the effectiveness of e-learning and recommended extending the model with other dimensions. Another study of blended e-learning system environments undertaken by Wu, Tennyson, and Hsia (2010) introduced an e-learning satisfaction model BELS which was tested with 212 participants. The findings of the study indicated that computer self-efficacy, performance expectations, system functionality, content feature, interaction, and learning climate, are the primary determinants of student learning satisfaction. All relationships were found significant. The model explained 67.8% of the variance of learning satisfaction with BELS.

2.4. E-learning success based on e-learning quality models

The fourth direction of research in evaluating e-learning systems is to assess the overall quality of e-learning. Though quality is a general term, different approaches and models have emerged, and different aspects of and approaches to quality have been considered in e-learning quality models (e.g., excellence models, e-learning quality surveys, ISO 9000, benchmarking).

An important model proposed by MacDonald, Stodel, Farres, Breithaupt, and Gabriel (2001) was the Demand-Driven Learning Model (DDLM) to evaluate web-based learning (WBL) systems. The model was developed in response to the need to design new learning models to meet users' needs. The model incorporated five dimensions: consumer demands (i.e., quality content, delivery, and service); superior structural as the quality standard, i.e. "the required foundation that makes it possible to provide this level of content, delivery and service" (MacDonald et al., 2001), which requires understanding the learner's needs considering the learner's motivation; learning facilitators to establish a healthy collaborative learning environment; pedagogical strategies; conducting regular assessment strategies and evaluation of learners; and ensuring the e-learning environment is convenient for learners. The third dimension is the learner outcomes, e.g., lower cost for the learner, personal advantages, and achieving learning outcomes. The fourth layer is the ongoing program evaluation and the fifth dimension is continual adaptation and improvement. The researchers stated that these constructs are the recipe where WBL programs can succeed, and the model was empirically validated and tested by the researchers (MacDonald et al., 2005). Another multi-dimensional model, constructed by Ehlers (2004), was introduced to evaluate the quality of e-learning. Ehlers (2004) developed their model based on learners' perspectives, where he stressed the necessity to understand learners' needs before starting any e-learning project. According to this model, the quality of e-learning is a process of co-production between the learner and the learning environment to enable and empower the learner.

There are diverse approaches, models and frameworks in the literature. For example, Boud and Prosser (2002) assumed that higher e-learning quality can be measured by four aspects: learners' engagement; context acknowledgement; the challenge for learners; and the involvement of practice. Oliver (2005) studied quality assurance in e-learning and emphasized that there are two main approaches: benchmarking and specification of standards. Benchmarking "compares the performance and outcomes in one setting against that achieved" whereas the standards are the criteria used to judge performance. Pawlowski, Barker, and Okamoto (2007) proposed a quality adaption model by comparing the approaches of e-learning quality with ISO/IEC. The same approach was adopted by Abdellatief, Sultan, Jabar, and Abdullah (2011) where they proposed a quality model from the developer's perspective based on four variables: service content, system functionality, information technology, and system reliability.

A framework to evaluate the quality of e-learning by Ireland, Correia, and Griffin (2009) focused on improving the skills of academics and considered this the main stimulant of e-learning quality. Another direction of assessing the quality of e-learning was by establishing agencies and programs for the assurance of quality standards of e-learning, such as the Institute for Higher Education Policy in the USA, the European Union e-learning program, and the Quality Assurance Agency QAA in the UK (Oliver, 2005). Further, in Europe, a survey of the quality of e-learning was conducted to rate e-learning quality (Massy, 2002). A considerable amount of research and effort has focused on the quality of e-learning. However, due to the complexity of e-learning systems, diversity of e-learning stakeholders, and the generality of the 'quality' concept, there is uncertainty and ambiguity among what actually constitutes a quality e-learning approach (Oliver, 2005). Additionally, it becomes challenging to identify precise measurements suitable to evaluate e-learning systems based on quality approaches as the criteria vary from one organization to another.

3. Development of conceptual model

In order to provide a general comprehensive definition of e-learning success measurement, the four approaches found for evaluating e-learning and information systems from the literature review were considered in developing our model. Thus, different perspectives have been considered based on their potential of evaluating the success of e-learning, in relation to: quality; social factors (support system quality, learner quality and instructor quality); user beliefs (perceptions of satisfaction and usefulness); acceptance (actual usage); and benefits of using the e-learning system. These dimensions encompass the main components of the existing four approaches. The high order themes resulting from analysing the literature are depicted in Fig. 1.

3.1. Approach 1: DeLone and McLean information systems success model

The current study model mainly adopts the constructs of the DeLone and McLean information systems success model and extends it to included constructs and indicators from other models and theories to fit the context of e-learning. The constructs adopted from this model are:

1. System Quality
2. Service Quality
3. Information Quality
4. Satisfaction
5. Use
6. Benefits

It is worth mentioning that the satisfaction construct is common to the DeLone and McLean and the satisfaction models, and use is common

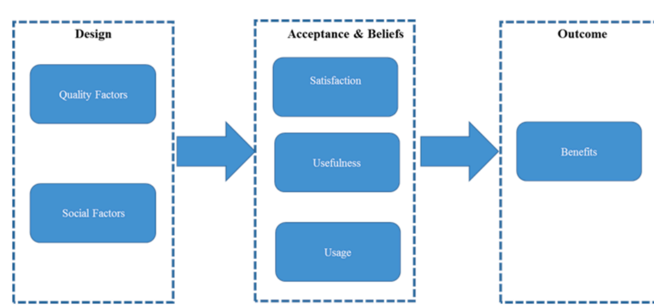

Fig. 1. The simplified conceptual model for evaluating the success of E-learning system.

to the DeLone and McLean model and TAM.

The DeLone and McLean model was built to measure the success of information systems. Hence, a more customized version to conform to the needs of e-learning systems is taken into consideration to develop our model. System quality is an important determinant of the quality of e-learning, thus it was integrated into our model but is broken down into three constructs:

1. Technical System Quality
2. Educational System Quality
3. Support System Quality

Technical system quality is related to issues like system reliability, availability, ease of use of system features, etc. Conversely, educational system quality revolves around the existence of features like interactivity and communication components, assessment material, and diversity of learning styles. Support system quality corresponds to supportive issues in the e-learning system related to ethics and legal issues, and promotion of the e-learning system. More details about the definition of each construct and the indicators used to measure each one will follow.

On the other hand, measuring benefits, at both individual and organizational levels, is a key construct for assessing e-learning systems. However, measuring benefits at the organizational level requires "asking senior managers to assess the improved profitability" (Petter, DeLone, & McLean, 2008). Therefore, the current study does not focus on such benefits, and considers only the individual benefits for learners. The organizational benefits are beyond the scope of this study.

3.2. Approach 2: technology acceptance model TAM

With respect to this approach, despite the plethora of TAM extensions, the two main constructs in this model are usefulness and ease of use (Abdullah & Ward, 2016). Usefulness has been included in our model from TAM, which was successfully integrated with the DeLone and McLean model in the study of Seddon (1997). In his extended model, usefulness was considered to be a general perceptual measure of benefits and was operationalized as a determinant of user satisfaction. We integrated usefulness in our model, as introduced by Seddon (1997).

In contrast to TAM, ease of use has not been operationalized as a separate construct in our model. Rather, it is an aspect related to technical system quality. The effect of technical system quality, as a whole, on perceived satisfaction, perceived usefulness, and use, is expected to be greater than the effect of ease of use on the same three constructs. Therefore, ease of use was incorporated in our model as one of the indicators under the technical system quality construct.

Acceptance, in terms of intention to use or actual system use, was also incorporated in our model. However, DeLone and McLean, in their updated model (2003), introduced intention to use as an alternative measure of use for some contexts, depending on the stage of using the system. Researchers have suggested that intention to use is a valid measure at an early stage of implementing a system. Since the e-learning system is in place in the context of the current study, it might be pointless to assess intention to use. Thus, assessing the actual system use is appropriate in our case, and was added to our model. In addition, the e-learning system in the context of the study is available for voluntary use, therefore system use can act as a determinant for benefits from using the system. In other words, the benefits of the e-learning system cannot be achieved if learners do not use the system (Abdullah & Ward, 2016; Alenezi & Karim, 2010; Lai, Wang, & Lei, 2012; Pituch & Lee, 2006; Seddon, 1997).

The part of TAM referred to as 'attitude towards using' was included in our model as an indicator related to the quality of learner and instructor. Therefore, the learner and instructor attitudes toward using the system were incorporated as indicators under the two constructs: learner quality and instructor quality.

In a survey study conducted by Abdullah and Ward (2016), the researchers studied 107 papers that extended TAM in the context of e-learning. The results of the study showed that "Self-Efficacy, Subjective Norm, Enjoyment, Computer Anxiety, and Experience are the most commonly used external factors of TAM". Accordingly, the three indicators (self-efficacy, computer anxiety, and experience) were included in our model as indicators for capturing learner quality. Subjective norm was added under instructor quality. Enjoyment and pleasant experience were also incorporated under the perceived satisfaction construct.

3.3. Approach 3: user satisfaction models

As mentioned earlier in chapter 2, there are different strategies for assessing user satisfaction at the micro level (assessing satisfaction with a specific instance of the e-learning system) and at the macro level (assessing satisfaction with all technologies introduced by the organization in relation to e-learning). In our case, this study adopted satisfaction at a micro level to assess perceptions of users about a specific instance of e-learning. Enjoyable experience, satisfaction with system performance, satisfaction with providing education needs, and overall satisfaction, are the indicators used in our model to represent this construct.

Among the e-learning satisfaction models, the model of Sun et al. (2008) and the model developed by Ozkan and Koseler (2009) provide potential contributions and good explanatory power for e-learning perceived satisfaction. From the two models, learner quality and instructor quality were added as two separate constructs in our model.

The learner quality construct is used to capture different aspects of quality related to learners, such as the learner's attitude, anxiety, previous experience, and self-efficacy. Similarly, the instructor quality construct assesses the instructor's quality indicators, such as the instructor's attitude, enthusiasm, prompt responsiveness to learners in the e-learning system, and communication with learners.

In Sun et al.'s model, the authors assumed an environmental dimension (with two indicators, diversity in assessment and interaction with others) as a determinant of satisfaction. This construct was renamed in our model as educational system quality, as discussed earlier in the DeLone and McLean approach. Further, in Ozkan and Koseler's model, 'supportive factors' was introduced as a determinant of satisfaction, which was also included in our model as a separate construct, as mentioned earlier in the DeLone and McLean approach.

3.4. Approach 4: E-learning quality models

No specific construct was added from e-learning quality models. However, some indicators were incorporated in our model from MacDonald et al.'s (2001), Attwell's (2006), and Ehlers' (2003) models: personalization, pedagogical strategies, learner needs, security, interactivity, cost expectation benefit, and learning outcomes.

Based on the results of previous studies and according to the four approaches, we propose a more comprehensive multidimensional model for evaluating e-learning systems success (EESS model), a synthesis of the four previous approaches listed above (i.e., the DeLone and McLean model, the TAM, the User Satisfaction Models, and the E-learning Quality Models) depicted in Fig. 2. The multidimensional model is comprehensive not based on the number of constructs but on the intention to provide a holistic picture and different levels of success related to a broad range of success determinants, rather than focusing on a specific construct.

3.5. Why a comprehensive model is needed?

This study contributes to the growing body of e-learning systems success literature by providing a comprehensive multidimensional model which considers the main dimensions and sub-dimensions of the

Fig. 2. Multidimensional Conceptual Model for Evaluating E-learning System Success (EESS model).

four approaches. A comprehensive model for evaluating e-learning system success is needed, for the following reasons.

- There is uncertainty and suspicion about what are actually the determinants of e-learning systems success. Hence, this study, as a discrete activity, enumerates the literature related to e-learning system success to distil these factors.
- The DeLone and McLean literature provides us with an explicit model for measuring information systems success, but it has to be broadened to include variables that fit the context of e-learning, enhance the explanatory power of the model, and focus on the very important role of human and social factors in the success of such systems. Further, DeLone and McLean did not empirically validate their model. Rather, the model was introduced as a framework for conceptualising information systems success dimensions. They recommended that other researchers further develop and validate the model in different contexts.
- In the same manner, the TAM allows the acceptance and adoption of new technologies to be assessed, including e-learning systems; however, acceptance does not guarantee success, but limits our understanding to aspects related to behaviour, while there is a need to fully understand the whole picture of success. Over and above this, there is a need to consider all phases prior to using the system (e.g., system design, information quality). Also of importance are phases during the utilization of the system (e.g., usefulness and satisfaction), and after using the system (benefits of using the system).
- User satisfaction is an important predictor of success, but it should be integrated with other approaches to build a conceptual bridge between the different phases of the system, the better to examine the important role of satisfaction in influencing the learning benefits and assessing system success, and to maximize the predictive power of this construct.
- In relation to e-learning quality approaches, and given the diversity and complexity of e-learning systems, the spontaneity, ambiguity, and generality of some of these approaches, coupled with a lack of theoretical underpinning, make adopting this approach impractical and challenging to identify precise and suitable measurements of success.

3.6. Constructs of the model

The proposed model is one which includes seven independent constructs: technical system quality, information quality, service quality, educational system quality, support system quality, learner quality, and instructor quality. In addition there are four dependent constructs: perceived satisfaction, perceived usefulness, system use, and benefits. More details about each construct and the indicators used to reflect each construct supported by related studies, are found in Appendix 1.

3.7. Research hypotheses

The hypotheses about the connections in the research model with the corresponding discussions are presented in this section. Each relationship between the constructs of the model is justified based on the assumptions empirically proved in the literature of e-learning and information systems success.

3.7.1. Technical system quality (TSQ)

Technical system quality is assumed in our model to be a determinant of three constructs: perceived usefulness, perceived satisfaction, and use. In the original model of Delone and McLean (2003) the researchers assumed that system quality directly affects use and user satisfaction. Several researchers applied the DeLone and McLean model in the information systems context and found a positive association between system quality and use (Halawi, McCarthy, & Aronson, 2008; Hsieh & Wang, 2007; Iivari, 2005). In the e-learning systems context, system quality was also proved to be strongly related to use (Balaban, Mu, & Divjak, 2013; Garcia-Smith & Effken, 2013; Lin, 2007; Marjanovic et al., 2016).

Other researchers have studied the relationship between system quality and user satisfaction and shown the existence of positive relationships between the two (Chiu, Chiu, & Chang, 2007; Halawi, McCarthy, & Aronson, 2008; Hsieh & Wang, 2007; Leclercq, 2007; Wu & Wang, 2006). Hassanzadeh et al. (2012), assumed that "whatever the technical quality of e-learning systems is more, user satisfaction is higher" and supported this claim by empirical research.

For the relationship with usefulness, Seddon and Kiew (1994) and Seddon (1997) in their studies showed that "increases in system quality will cause increase in usefulness" and found that system quality is an essential determinant of usefulness. Similar findings were obtained by Sabherwal, Jeyaraj, and Chowa (2006) and Liaw (2008).

Based on these findings, we therefore, assume that the higher the technical quality of the e-learning system, the more satisfied the users are. Also, if users find the e-learning system compatible with their requirements, this would positively make users utilize it and consider it useful. Thus, the following hypotheses are proposed:

H1a. Technical System Quality positively influences the perceived satisfaction with the e-learning system;

H1b. Technical System Quality positively influences the perceived usefulness of the e-learning system;

H1c. Technical System Quality positively influences the use of the e-learning system.

3.7.2. Information quality (INQ)

Information quality is a key and indispensable dimension in evaluating the success of information and e-learning systems due to the essential role of information in achieving learning goals and the serious problems resulted from poor quality of information (Al-Sabawy, 2013). The relationship between INQ and both use and user satisfaction came from the Delone and McLean (2003) model.

Based on the information systems literature, Rai et al. (2002) showed that there is a significant relationship between information quality and use. The same result was also obtained by studies conducted by Halawi et al. (2008) for knowledge management systems and Kositanurit, Ngwenyama, and Osei-Bryson (2006) in health information systems. In the same context, Seddon and Kiew (1994) and Seddon (1997) showed a significant relationship between information quality and perceived usefulness and user satisfaction.

The relationships between information quality and each of the three constructs – use, satisfaction, and usefulness – have been studied empirically by e-learning researchers. For example, Klobas and McGill (2010) and Eom et al. (2012) found a significant relationship between information quality and both use and satisfaction with the LMS. The relationship between information quality and perceived usefulness was found significant in the study of Chen (2010) with e-learning systems in an organizational context, and a similar result found by Lwoga (2014) with web-based LMSs. Therefore, we may assume that improved quality of information in the e-learning system will positively lead to an increase in perceived usefulness, perceived satisfaction, and system usage. Thus, we hypothesise that:

H2a. Information Quality positively influences the perceived satisfaction with the e-learning system;

H2b. Information Quality positively influences the perceived usefulness of the e-learning system;

H2c. Information Quality positively influences the use of the e-learning system.

3.7.3. Service quality (SRQ)

This construct was introduced as a new construct to the DeLone and McLean model (1992). The importance of this construct as a measure of information systems success is related to the DeLone and McLean model (2003) who assumed in their model direct relationships between service quality and both use and user satisfaction. Delivering services by IT personnel in the organization whether related to an information system or to an e-learning system is also expected to be of great usefulness for learners and positively influences their perceptions of satisfaction with the system.

The construct has been utilized in the information systems field. For example, the relationship between SRQ and satisfaction was confirmed by Chen and Cheng (2009) in an online shopping system. The direct relationship between SRQ and use was found significant by Wang and Liao (2008) in an e-government system.

Similarly, in the context of e-learning, the relationship between SRQ and satisfaction was found significant in the Roca et al. (2006) and Ozkan and Koseler (2009) models. The relationship between SRQ and perceived usefulness proposed in the conceptual model developed by Hagos, Garfield, and Anteneh (2016) and Lwoga (2014) was shown empirically to be significant in the study conducted by Al-Sabawy (2013) and Ngai, Poon, and Chan (2007). Accordingly, the following hypotheses are proposed:

H3a. Service Quality positively influences the perceived satisfaction with the e-learning system;

H3b. Service Quality positively influences the perceived usefulness of the e-learning system;

H3c. Service Quality positively influences the use of the e-learning system.

3.7.4. Educational system quality (ESQ)

In developing a model for measuring the success of e-learning in Iranian universities, Hassanzadeh et al. (2012) found that educational system quality positively and directly influences user satisfaction and indirectly the use of the system, which indicates that educational features in the e-learning system, and facilities like discussion forums, chat-rooms, collaborative learning tools, can result in user satisfaction and maximizing their usage of the e-learning systems. Social interaction was employed as a key factor of success in computer supported collaborative learning (CSCL) and found to have a significant effect on student learning (Xing, Kim, & Goggins, 2015). The relationship between educational system quality and perceived usefulness was found significant for web-based e-learning systems in the study undertaken by Liu, Liao, and Peng (2005) and by Almaiah and Jalil (2016) for mobile learning systems. Kim, Trimi, Park, and Rhee (2012) and Mohammadi (2015) found a positive relationship between educational system quality and satisfaction. In addition, the relationships between diversity in assessment materials, and learner interaction in the e-learning system with perceived satisfaction, were found significant by Cidral et al. (2018). Further, the relationship between educational system features and usefulness was found significant by Liu et al. (2005) for a web-based e-learning system. The same results were obtained by Liaw and Huang (2013) where a significant relationship between the interactive learning environment construct with both perceived usefulness and perceived satisfaction was found. Therefore, the following hypotheses about educational system quality are proposed:

H4a. Educational System Quality positively influences the perceived satisfaction with the e-learning system;

H4b. Educational System Quality positively influences the perceived usefulness of the e-learning system;

H4c. Educational System Quality positively influences the use of the e-learning system.

3.7.5. Support system quality (SUP)

In the literature on e-learning system success, supportive issues in the e-learning system such as ethics and policies that outline rules, regulations, guidelines and prohibitions to communicate within the e-learning system, assignments' plagiarism rules, data protection, and other legal and copyright issues of the uploaded materials in the e-learning system, in addition to the popularity and policy followed by the organization, all these issues influence the learners significantly (Khan, 2005). For example, in the empirical study conducted by Ozkan and Koseler (2009), the use of the LMS at Brunel University has increased significantly due to the encouragement students and academics received from the university to use the LMS in their modules. The researchers stated "the use of U-Link has increased significantly during the last three years … this is mainly because of the increasing popularity of e-learning portals." The researchers studied the relationship between supportive system issues and satisfaction and found it significant. On the other hand, the organizational promotion of the e-learning system significantly and positively affected employees' satisfaction in the study conducted by Navimipour and Zareie (2015).

For the relationships between support system quality and both perceived usefulness and use, these were not empirically tested in prior literature. However, we argue that the existence of supportive issues in an e-learning system is also expected to positively influence utilizing the system and perceptions of usefulness. This is because more attention has been given recently to ethical and legal issues, and new requirements have been introduced by data protection legislation. Further, considering the existence of communication facilities (e.g., forums, chat, and email), data generated from chat and forums may express personal opinions, personal data and personal biases that students are unlikely to want the outside world (through search engines) to know. Thus, providing information prior to using the e-learning system can increase their awareness and significantly influence their perceptions toward the overall usefulness of the system. Moreover, the popularity of the e-learning system, and the policy followed by the organization to promote their e-learning system, play an important role in increasing the usage of the system by academics and learners. Therefore, we propose the following hypotheses:

H5a. Support System Quality positively influences the perceived satisfaction with the e-learning system;

H5b. Support System Quality positively influences the perceived usefulness of the e-learning system;

H5c. Support System Quality positively influences the use of the e-learning system.

3.7.6. Learner quality (LER)

This construct was successfully operated in several models developed by prior e-learning researchers. Several researchers examined a subset of the learner quality construct, for example, the learner's self-efficacy was studied by Ong, Lai, and Wang (2004) and a significant relationship with perceived usefulness was found. The same result was achieved by Park (2009). McGill and Klobas (2009) studied the relationship between learner attitude toward LMS use and LMS utilization and found it significant. Additionally, the relationships between student involvement and both use and satisfaction were found significant in the study of Klobas and McGill (2010). Also, the relationships between self-efficacy and a learner's computer anxiety with perceived usefulness were studied by Chen and Tseng (2012).

The relationship between learner and perceived satisfaction was found significant in the models of Sun et al. (2008) and Ozkan and Koseler (2009). Given the positive relations of the indicators associated with the variety of learner's characteristics, it is more likely that the quality of the learner will influence perceived usefulness and use of the system. Thus, we propose the following hypotheses:

H6a. Learner's Quality positively influences the perceived satisfaction with the e-learning system;

H6b. Learner's Quality positively influences the perceived usefulness of the e-learning system;

H6c. Learner's Quality positively influences the use of the e-learning system.

3.7.7. Instructor quality (INS)

The instructor's role in the success of e-learning has received attention from researchers in the e-learning arena. To clarify, the model developed by Sun et al. (2008) researched the relationship between the instructor dimension, using two indicators (instructor response timeliness, instructor attitude toward e-learning), and satisfaction, and found it positively significant. Similar results were obtained by Cidral et al. (2018) where a positive relationship found between instructor attitude toward e-learning and user's satisfaction. Lwoga (2014) employed instructor quality as a separate construct and confirmed a positive significant relationship between instructor quality and both perceived usefulness and user satisfaction. Also, instructor quality has been found to have a significant effect on learners' satisfaction with an e-learning system in the study conducted by Mtebe and Raphael (2018).

Subjective norm as an indicator related to instructor quality was studied in the models developed by Park (2009) and Roca et al. (2006), and significant relationships with usefulness and satisfaction were found respectively. Little research has been found to investigate the relationship between instructor quality as a stand-alone construct and e-learning system use. Nevertheless, McGill and Klobas (2009) studied the correlation between instructor norms and LMS utilization and found it positively significant. In our research, we assume that aspects related to instructors, such as positive attitude, enthusiasm, recommendation to students, involvement with different levels of activities (e.g. interactive and communication and responsiveness to students) are also likely to influence utilizing the e-learning system. Based on that, we propose the following hypotheses:

H7a. Instructor's quality positively influences the perceived satisfaction with the e-learning system;

H7b. Instructor's quality positively influences the perceived usefulness of the e-learning system;

H7c. Instructor's quality positively influences the use of the e-learning system.

3.7.8. Perceived satisfaction (SAT)

It is clear that satisfaction has strongly proved its validity and reliability as an essential measurement of the success of both information systems and e-learning systems. In our study model, we have assumed that user satisfaction is a determinant of the benefits construct. The influence of user satisfaction on the benefits achieved from the system was empirically found significant in the DeLone and McLean information systems success model (2003). Hassanzadeh et al. (2012) explained that when users of the e-learning system are more satisfied, they are using the system and the benefits of using the system will be achieved. Cidral et al. (2018) found that perceived satisfaction explained 43.3% of the variance of individual impacts denoting a significant relationship between the two. The same results were obtained by Eom et al. (2012) and Hassanzadeh et al. (2012). Therefore, we assume the following hypothesis:

H8. Perceived Satisfaction toward the e-learning system positively influences students' benefits.

3.7.9. Perceived usefulness (USF)

Usefulness was used by Davis (1989) as a key determinant construct in the technology acceptance model. Acceptance is a necessary element for measuring the success of information and e-learning systems (Davis, 1989; Roca et al., 2006). The model of the study expects that perceived usefulness of e-learning could positively influence three constructs: perceived satisfaction, use, and students' benefits. The findings from the literature empirically support these relations. In the study conducted by Arbaugh (2000) it was hypothesised that "Perceived usefulness of the course software will be positively associated with student satisfaction with an Internet-based course", and this hypothesis was supported. Equivalently, the study of Seddon (1997) in information system success, Al-Sabawy (2013) in e-learning systems success, and Limayem and Cheung (2008), all found that perceived usefulness significantly and directly affect user satisfaction.

Correspondingly, if students perceived that the e-learning system is useful to them, they are more likely to use it. This relationship has been assessed in several e-learning studies, for example, Islam (2013), Pituch and Lee (2006), Van Raaij and Schepers (2008), Sandjojo and Wahyuningrum (2015), and Šumak et al. (2011).

Previous studies highlighted the direct significant relationship between usefulness and net benefits (Hwang, Chang, Chen, & Wu, 2008); usefulness and organizational benefit (Park, Zo, Ciganek, & Lim, 2011); usefulness and individual impact (Lee et al., 2011); usefulness and both individual and organization impact (Hasan et al., 2017). We, therefore, propose the following hypotheses:

H9a. Perceived Usefulness positively influences the perceived satisfaction with the e-learning system;

H9b. Perceived Usefulness positively influences the use of the e-learning system;

H9c. Perceived Usefulness positively influences students' benefits.

3.7.10. System use (USE)

Actual system usage is a measure common to the information systems success model of Delone and McLean (2003) and the TAM of Davis (1989). In the systematic literature review study conducted by Petter et al. (2008), it was reported that 'use' has a moderate association with benefits of using the system. Through prior studies, the relationship between use and benefits of the system was found significant (Chen and Tseng, 2012; Garcia-Smith & Effken, 2013; Hou, 2012). At an organizational level, the use of e-learning systems to deliver training courses for employees proved to directly and positively affect the net benefits of the company (Chen and Tseng, 2012). Other studies found similar results (Halawi et al., 2008; Kositanurit et al., 2006; Zhu & Kraemer, 2005). Accordingly, we expect that using the system can positively enhance students' benefits of increased knowledge, saving time, and managing the learning process systematically. Given support from prior research, the current study proposes the following hypothesis:

H10. The use of the e-learning system positively influences students' benefits.

Based on the literature and the above relationships, the components of the EPSS model were linked to reflect the hypotheses and show the directions of the assumed relationships, as depicted in Fig. 3.

4. Research methodology

Quantitative methods are used to test theoretical models and hypotheses, and a quantitative analytical survey was adopted in this study. The measurement items were obtained from the literature review and were deemed to represent all aspects of the construct. As a complementary step, experts' opinions regarding the items adopted to reflect each construct were solicited (Walker & Fraser, 2005). E-learning experts, through a questionnaire, were asked to assess the importance of each factor in the model based on a 3-point scale (Lawshe, 1975): essential, important (but not essential), and not relevant. In addition, an open-ended question was added "What are the factors that are important for the evaluation of e-learning system success?" to give experts the opportunity to submit their opinions about factors that might not be included in the close-ended question. Cronbach's alpha coefficient was employed to determine reliability of the questionnaire. According to the results of this test, the Cronbach's alpha coefficient value for the experts' questionnaire was 0.933. Based on the responses received, the items (overall usefulness and overall satisfaction) were added to the two constructs (perceived usefulness and perceived satisfaction) respectively. A statement was added to the support system quality construct 'Providing information about accessibility of content and any other personal data in the e-learning system'. Additionally, the interactivity statement was broken down into two: one for the existence of interactivity and communication features and one for the effective communication to provide good coverage for the educational system quality construct. Based on experts' feedback, measurements were confirmed, and no item was deleted. The final items numbered 58.

An online survey was collected from students enrolled in the Moodle LMS provided by the University of Warwick, the UK for the purposes of e-learning due to accessibility of data. Moodle was selected to test the model of the study because the University of Warwick has adopted Moodle as the main e-learning system designed to support teaching and learning materials and activities, and to provide a number of interactive activities including forums, wikis, quizzes, surveys, chat and peer-to-peer activities, serving most of the departments and students. In addition, Moodle is widely used in the education sector generally and in higher education specifically.

A total of 588 responses were received. After collecting the data, a preliminary data analysis was performed as a first step to check for any missing data, unengaged responses, outliers, and normality. As a result, 563 responses were considered valid for further analysis. The demographic information for the study sample is distributed as follows (Table 1).

5. Analysis and results

Researchers use different statistical methods to develop and confirm their research findings. Hair, Black, Babin, and Anderson (2010) distinguished between two generations of the application of statistical methods. Factor analysis and regression analysis were predominant and extensively used in the first generation. There was a shift since the 1990s toward more sophisticated multivariate methods such as structural equation modelling (SEM), which has dominated the research landscape in the second generation (Goggins & Xing, 2016).

There are two types of SEM, covariance-based SEM (CB-SEM) and composite-based SEM, also known as partial least squares SEM (PLS-SEM). In this research, PLS-SEM was used as a key technique to test the study model due to the complexity of the model – 11 constructs, 58 indicators, and 26 relationships – since PLS-SEM fits such kind of models (Hair et al., 2010). SmartPLS version 3.0 was utilized to test the measurement and structure model.

5.1. Measurement model

The measurement model was assessed using the following criteria.

Step 1: Indicator Reliability: outer loading for the indicator should be ≥ 0.70 (Hair et al., 2010).
Step 2: Internal Consistency Reliability: using two tests: Cronbach's alpha (α) and Composite reliability (CR). The cut off value is ≥ 0.70 for both tests (Urbach & Ahlemann, 2010).
Step 3: Validity:

1. Convergent Validity: the average variance extracted AVE should be ≥ 0.50 (Fornell & Larcker, 1981).

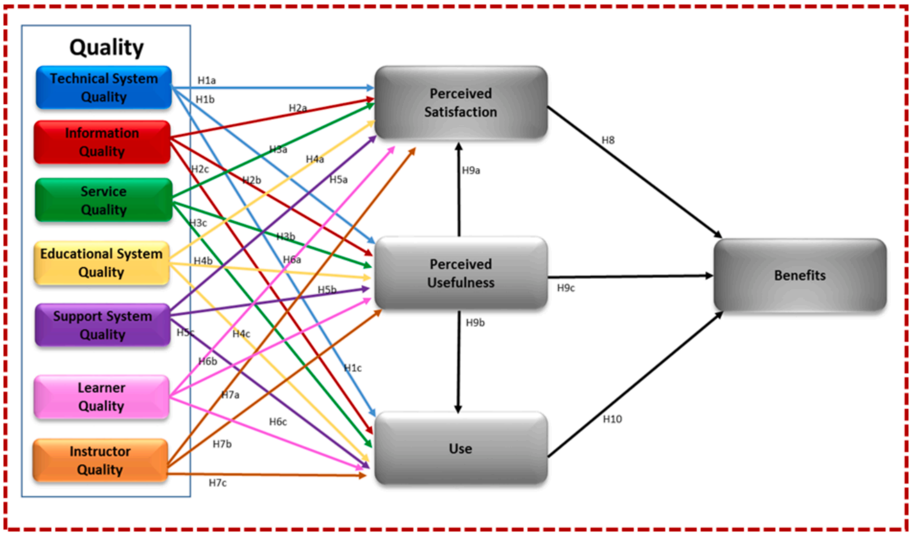

Fig. 3. Evaluating E-learning system success (EESS model).

Table 1
Sample characterization.

Sample Characterization		Frequency	Percent
Gender	Male	259	46%
	Female	304	54%
	Total	**563**	**100%**
Age	< 21	331	58.8%
	21–30	218	38.7%
	> 30	14	2.5%
	Total	**563**	**100%**
Enrolled Course	Undergraduate	495	87.9%
	Postgraduate	68	12.1%
	Total	**563**	**100%**
Experience with the e-learning system	Less than a year	291	51.7%
	1–2 years	133	23.6%
	More than 2 years	139	24.7%
	Total	**563**	**100%**
Number of online modules taken	One module	32	5.7%
	More than one	531	94.3%
	Total	**563**	**100%**
Field of study	Faculty of Medicine	88	15.63%
	Faculty of Science and Engineering	253	44.94%
	Faculty of Social Sciences	222	39.43%
	Total	**563**	**100%**
Nature of using the e-learning system	- Access learning resources only.	89	15.81%
	- Access learning resources, and accomplish and submit assignments or quizzes only.	285	50.62%
	- Access learning resources, and interact with my instructors and colleagues only.	36	6.93%
	- Access learning resources, accomplish and submit assignments or quizzes, and to interact with my instructors and colleagues.	153	27.18%
	Total	**563**	**100%**

2. Discriminant Validity: using three tests:
   2.1 Fornell-Larcker criterion (Fornell & Larcker, 1981);
   2.2 Cross-loadings (Urbach & Ahlemann, 2010);
   2.3 The Heterotrait-Monotrait ratio (HTMT) (Henseler, Ringle, & Sarstedt, 2015).

First, indicators with loadings less than 0.70 were analysed. The technique used to deal with them was based on the suggestion of Hair et al. (2010) which indicates that:

- If the outer loading is < 0.40 delete the indicator;
- If the outer loading is ≥ 0.70 retain the indicator;
- If outer loading is ≥ 0.40 but < 0.70 then analyse the impact of indicator deletion on AVE and composite reliability: if measures already meet the thresholds then retain the indicators, otherwise consider deleting the indicator.

As a result, seven items fail to meet the minimum criteria and have a significant impact on AVE and were deleted. These are ease to learn, system availability, system reliability, system fulfilment, security, personalization from Technical System Quality construct, and easier interaction and communication from Benefits construct.

Second, Cronbach's alpha α, CR, and AVE were retrieved to test the internal consistency reliability and validity. Table 2 shows that all values met the minimum requirement for internal consistency reliability. Also, the average variance extracted AVE employed to assess the convergent validity was ≥0.50 for all constructs.

Third, the correlation matrix for the Fornell-Larcker method is presented in Table 3. The AVE should explain the same construct more than the other constructs. In other words, the values on the diagonal should be higher in the same construct compared with other constructs. It is clearly shown that the diagonal values are larger than the other values inside the one column.

The cross loadings formed the second method utilized to assess the discriminant validity. The cross loadings were retrieved to assess the loading of each indicator (Appendix 2). It can be clearly seen that each indicator loads highest on the construct it is associated with. The HTMT is a criterion proposed by Henseler et al. (2015) to assess the discriminant validity, because the Fornell-Larcker criterion and cross

Table 2
Internal consistency reliability and convergent validity results.

Constructs	Cronbach's alpha α ≥ 0.70	Composite Reliability CR ≥ 0.70	AVE ≥0.50
TSQ	0.830	0.880	0.590
INQ	0.860	0.900	0.550
SRQ	0.850	0.890	0.630
ESQ	0.710	0.800	0.520
SUP	0.800	0.850	0.580
LER	0.840	0.890	0.620
INS	0.750	0.830	0.510
SAT	0.900	0.930	0.770
USF	0.900	0.930	0.770
USE	0.910	0.940	0.790
BNT	0.850	0.900	0.690

Table 3
The fornell-larcker discriminant validity correlation matrix.

	BNT	ESQ	INQ	INS	LER	SAT	SRQ	SUP	TSQ	USE	USF
BNT	**0.83**										
ESQ	0.35	**0.72**									
INQ	0.56	0.37	**0.74**								
INS	0.56	0.37	0.44	**0.71**							
LER	0.69	0.33	0.67	0.54	**0.79**						
SAT	0.73	0.33	0.68	0.52	0.58	**0.88**					
SRQ	0.32	0.14	0.43	0.29	0.35	0.41	**0.79**				
SUP	0.50	0.37	0.42	0.37	0.52	0.49	0.32	**0.76**			
TSQ	0.54	0.32	0.52	0.45	0.62	0.63	0.41	0.36	**0.77**		
USE	0.48	0.31	0.34	0.29	0.47	0.46	0.15	0.36	0.33	**0.89**	
USF	0.75	0.31	0.59	0.49	0.69	0.73	0.32	0.51	0.54	0.55	**0.87**

Table 4
The HTMT correlation matrix.

	BNT	ESQ	INQ	INS	LER	SAT	SRQ	SUP	TSQ	USE	USF
BNT											
ESQ	0.38										
INQ	0.65	0.41									
INS	0.68	0.48	0.52								
LER	0.79	0.37	0.75	0.66							
SAT	0.83	0.36	0.77	0.61	0.81						
SRQ	0.37	0.18	0.51	0.35	0.41	0.47					
SUP	0.52	0.35	0.42	0.41	0.52	0.47	0.37				
TSQ	0.64	0.38	0.84	0.55	0.71	0.72	0.50	0.37			
USE	0.55	0.32	0.38	0.33	0.52	0.50	0.17	0.34	0.36		
USF	0.83	0.33	0.66	0.57	0.76	0.80	0.36	0.50	0.62	0.61	

loadings are insufficiently sensitive to detect many discriminant validity problems. HTMT is equal to average Heterotrait-Heteromethod correlation relative to the average Monotrait-Heteromethod correlations. The Heterotrait-Heteromethod correlations are correlations of indicators across constructs measuring different phenomena, while the Monotrait-Heteromethod correlations are correlations of indicators measuring the same construct. The HTMT values were retrieved using SmartPLS software as shown in Table 4. All HTMT values are within the accepted threshold values ≤ 0.90.

A summary of the results of the measurement model assessment is presented in Appendix 3.

5.2. Structural model

The structural model has been assessed, as suggested by Hair et al. (2010), using the following steps:

1. Assess the structural model for collinearity issues (VIF < 5);
2. Assess the significance and relevance of the structural model relationships ($p < 0.05$);
3. Assess the level of R^2 (The cut off levels are: 0.190 weak; 0.333 moderate; and 0.670 substantial);
4. Assess the level of Q^2 (cut-off point larger than zero);
5. Assess the model's fit (SRMR ≤0.08; RMS_{theta} ≤ 0.12).

First, collinearity symptoms were assessed by generating the variance inflation factor VIF. A VIF value ≥ 5 indicates a potential collinearity problem. The retrieved VIF values are all within the accepted threshold values (VIF < 5). Thus, collinearity was not a problem in our data.

Second, the path coefficients (β values) of the relationships between the constructs in the model are shown in Fig. 4.

The significance of the path coefficient is assessed using the algorithm of bootstrapping in PLS. 5000 bootstrap samples were generated. The t and p values are used to test whether the path coefficients β values are statistically significant at 5% error probability. The statistical significance level at 5% indicates that p-value has to be < 0.05 to accept the hypothesis and t value > 1.65. Results of the bootstrapping algorithm are shown in Table 5.

Third, the coefficient of determination R^2 has been used to measure the explained variance of the latent dependent variables relative to the total variance. As can be seen in Fig. 4, perceived satisfaction, perceived usefulness and benefits of the e-learning system moderately to substantially explained 64.7% of the variance in benefits of the e-learning system. A substantial percent (71.4%) of e-learning satisfaction was explained by seven constructs: technical system quality, information quality, service quality, educational system quality, learner quality, instructor quality, support system quality, and perceived usefulness. Five constructs were the main determinants of perceived usefulness, namely technical system quality, information quality, learner quality,

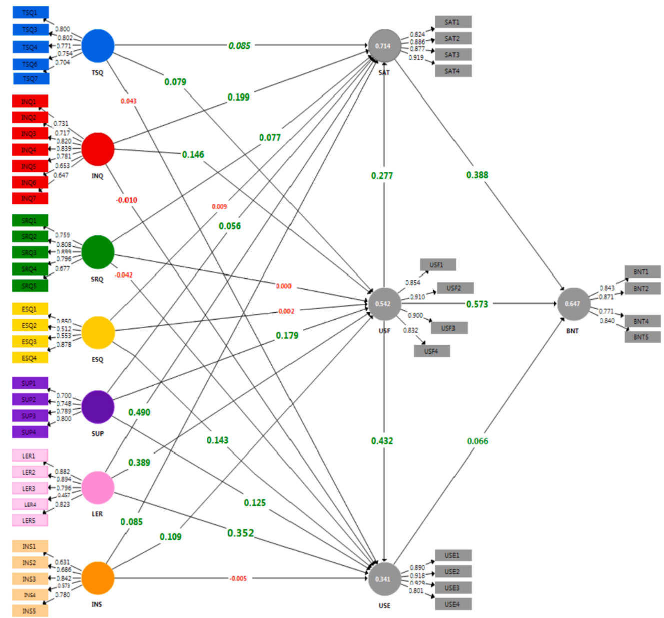

Fig. 4. Structural model path coefficients.

Table 5
Results of path analysis and hypothesis testing.

H	Path	β coefficients	T Statistics	P Values	Support
H1a	TSQ → SAT	0.085	2.160	0.020	Accepted
H1b	TSQ → USF	0.079	1.750	0.040	Accepted
H1c	TSQ → USE	0.043	0.690	0.250	Rejected
H2a	INQ → SAT	0.199	4.760	0.000	Accepted
H2b	INQ → USF	0.146	3.050	0.000	Accepted
H2c	INQ → USE	−0.010	0.160	0.440	Rejected
H3a	SRQ → SAT	0.077	2.940	0.000	Accepted
H3b	SRQ → USF	0.000	0.010	0.500	Rejected
H3c	SRQ → USE	−0.042	1.050	0.150	Rejected
H4a	ESQ → SAT	0.009	0.340	0.370	Rejected
H4b	ESQ → USF	0.002	0.040	0.480	Rejected
H4c	ESQ → USE	0.143	3.430	0.000	Accepted
H5a	SUP → SAT	0.056	1.900	0.030	Accepted
H5b	SUP → USF	0.179	5.330	0.000	Accepted
H5c	SUP → USE	0.125	2.600	0.000	Accepted
H6a	LER → SAT	0.490	11.860	0.000	Accepted
H6b	LER → USF	0.389	7.440	0.000	Accepted
H6c	LER → USE	0.352	5.130	0.000	Accepted
H7a	INS → SAT	0.085	2.850	0.000	Accepted
H7b	INS → USF	0.109	2.880	0.000	Accepted
H7c	INS → USE	−0.005	0.100	0.460	Rejected
H8	SAT → BNT	0.388	8.900	0.000	Accepted
H9a	USF → SAT	0.277	6.650	0.000	Accepted
H9b	USF → USE	0.432	8.040	0.000	Accepted
H9c	USF → BNT	0.573	16.130	0.000	Accepted
H10	USE → BNT	0.066	2.260	0.010	Accepted

Table 6
Results of Q^2 level assessment.

Constructs	Predictive Relevance Q^2			
	Construct Crossvalidated Communality		Construct Crossvalidated Redundancy	
BNT	0.47	Strong predictive power	0.42	Strong predictive power
INQ	0.40	Strong predictive power	–	
INS	0.28	Moderate predictive power	–	
SAT	0.57	Strong predictive power	0.52	Strong predictive power
LER	0.44	Strong predictive power	–	
ESQ	0.26	Moderate predictive power	–	
USE	0.59	Strong predictive power	0.25	Moderate predictive power
SRQ	0.43	Strong predictive power	–	
SUP	0.30	Moderate predictive power	–	
TSQ	0.38	Strong predictive power	–	
USF	0.56	Strong predictive power	0.39	Strong predictive power

instructor quality, and support system quality. These five constructs together explained 54.2% of the variance in perceived usefulness, which is considered moderate. Finally, educational system quality, support system quality, learner quality, and perceived usefulness explained moderately 34.4% of the system use construct, with perceived usefulness being the strongest determinant followed by learner quality, educational system quality, and support system quality respectively.

Fourth, assessment of the predictive relevance Q^2 results was done using Blindfolding in SmartPLS, the omission distance D was 7. Table 6 illustrates the results.

All values of Q^2 exceeded the cut-off point (larger than zero). The crossvalidated redundancy measures the capability of the path model to predict the endogenous measuring items indirectly from the prediction of their own latent variables using the related structural relations. It is only computed for the endogenous variables. Table 6 shows that the model has strong predictive relevance for the endogenous constructs SAT, BNT, and USF (the cut-off value for strong predictive is $Q^2 \geq 0.35$) (Hair et al., 2010). Finally, USE has a moderate predictive power with $Q^2 = 0.250$.

In terms of the predictive relevance of the cross-validated communality, Q^2 values were calculated through the measurement model's capability to assess the path model directly from their own latent variable. The Q^2 values in Table 6 above show 8 with strong prediction power and three with moderate prediction power. Results from both procedures suggest that the model has considerable predictive power.

Finally, the last step after examining the predictive power of the model is to assess the model fit. Model fit addresses the issue of how well the model that best represents the data reflects the underlying theory (Hooper, Coughlan, & Mullen, 2008). In PLS-SEM, the model fit assessment was done using the following three criteria.

1. Standardised Root Mean Square Residual (SRMR) which is an absolute measure of model fit proposed to avoid model misspecification (Henseler et al., 2014). The cut-off value used for SRMR is ≤ 0.08. Using SmartPLS software, the SRMR for the current study is 0.070 which is less than the cut off value suggested in the literature.
2. Root Mean Square Residual (RMS_{theta}) assesses “the degree to which the outer model residuals correlate” (Henseler et al., 2014). This measure should be ≤ 0.12 to indicate a good model fit (Hair et al., 2010; Henseler et al., 2014). Using SmartPLS RMS_{theta} is 0.11 which indicates a good model fit.
3. The model's Goodness-of-Fit (GoF) is our last criterion to assess the overall fit of the model. It is defined as “how well the specified model reproduces the observed covariance matrix among the indicator items” (Hair et al., 2010) The purpose of GoF is to account for the model at both levels, that is, the measurement model and the structural model with a focus on the overall performance (Henseler & Sarstedt, 2013). There is no global fit measure in PLS. Nevertheless, researchers suggest a global GoF defined as the geometric mean of the average communality and average R^2 for endogenous constructs (Tenenhaus, Vinzi, Chatelin, & Lauro, 2005) given using this formula:

$$\mathrm{GoF} = \sqrt{R2_{*} average communality}$$

The GoF cut off values used in this study are (Wetzels, Odekerken-Schröder, & Van Oppen, 2009):

- GoF less than 0.1	No fit;
- GoF between 0.1 and 0.25	Small;
- GoF between 0.25 and 0.36	Medium;
- GoF greater than 0.36	Large.

The model's Goodness-of-Fit for the current study as calculated using the formula is 0.49 which is deemed large.

6. Discussion

Hypotheses H1 and H2a gained empirical support. Thus, aspects related to the technical quality of the system such as ease of using the e-learning system, capability of the system to meeting users' requirements, flexibility of the system to interact with, integration and consistency between the different components of the system, and the existence of features and functions the users need are all important aspects and contribute to the overall satisfaction and perceptions toward the usefulness of the system. The results support the studies of Al-Sabawy (2013), Cidral et al. (2018) and Islam (2011). The results of testing hypothesis H1c showed that this hypothesis is not supported. In other words, technical system quality did not significantly affect the use of the e-learning system. This suggests that students still use the specific e-learning platform the university adopted regardless of its quality. A similar insignificant relationship was found by Aparicio (2017) and Cidral et al. (2018). A possible reason for the non-significant relationship could be that aspects of system quality are less important for using the system, in contrast to the importance of making students more satisfied and impacting their belief about the usefulness of the system.

Hypotheses H2a and H2b were accepted. This confirms that information quality is a determinant of perceived satisfaction and perceived usefulness. For example, information quality aspects such as providing students with sufficient and required information, concise and clear information, updated content, and providing students with attractive design of content are important to make students have an enjoyable and pleasant experience with e-learning and contribute to their overall satisfaction. In addition, organizing the content and information into logical and understandable components in the e-learning system allows students to accomplish their learning tasks quickly. These results corroborate the results obtained by Hassanzadeh et al. (2012), who found that information quality has the most direct effect on user satisfaction. H2c was rejected, and this is interpreted as evidence that providing users with high quality information does not influence their use of the e-learning system. One reason for that could be because students depend on the system to access the Lecture Capture tool available via Moodle and to use the online submission system to submit their assignments. Others do some exams in class and depend on the system to access learning materials during revision periods. Students also need access to lecturers' handouts and resources which are only available through the system.

Statistical results showed that there is a positive relationship between service quality and perceptions of satisfaction (H3a). This result suggests that providing quality services to students may potentially increase their level of satisfaction toward the e-learning system. Thus, it is crucial to have technical personnel who are available when needed, have control over the technology, support students by providing guidance and training on how to use the system, and able to provide solutions for technical issues students face with the e-learning system, and who can consequently satisfy their needs, generate positive feelings, and influence their overall satisfaction about the system. This result supports other researchers for example, Al-Sabawy (2013), Almarashdeh, Sahari, Zin, and Alsmadi (2010), Mtebe and Raphael (2018), Roca et al. (2006), Sun et al. (2008), Sandjojo and Wahyuningrum (2015). H3b and H3c did not gain support, in other words, the quality of services delivered to students by IT personnel does not contribute to students' feeling toward the usefulness of the e-learning system and the utilization of the system. This result was consistent with several studies where researchers did not find any link between service quality and usefulness, for example, Gorla and Somers (2014), Lwoga (2014), Motaghian, Hassanzadeh, and Moghadam (2013) and Zaidi, Siva, and Marir (2014).

Contrary to our prediction, H4a and H4b failed to receive support. This result is inconsistent with the result obtained by Hassanzadeh et al. (2012) who argued, however, that this construct influences users' satisfaction less than the other quality factors. The same results were obtained by Mohammadi (2015). However, H4c was accepted. Thus, aspects of educational system quality such as the existence of communication tools and interactivity features, diversity of learning styles, and providing assessment materials to students (e.g., quizzes and assignments) have a strong influence on utilizing the e-learning system, thus students are more likely to use the e-learning system. This is in parallel with the findings of Pituch and Lee (2006).

H5a, H5b, and H5c were supported. Thus, providing information about ethical and legal issues prior to using the e-learning system can increase their awareness and significantly influence the success of the system. H5b and H5c were not empirically tested in prior studies, however, evidence from the literature (Khan, 2005; Navimipour & Zareie, 2015; Ozkan & Koseler, 2009) can be compared to our results.

H6a, H6b, H6c were supported. The results are in parallel with previous studies of Üstünel (2016), Ozkan and Koseler (2009), Sun et al. (2008) and Chen and Yao (2016), who employed learner construct in their models of e-learning systems evaluation. The finding confirms the vital role the learner plays in the success of e-learning. Learners, who have a positive attitude toward using e-learning systems in their study, are more satisfied with the system. Students' experience and familiarity with the system, and ability to use the system and perform tasks (self-efficacy), can stimulate their positive attitudes toward the e-learning system, thus their overall satisfaction about it. The relationship between the learner as a stand-alone construct and system use has not been tested before, although similar results were reported in several studies between learner sub-dimensions and use of the system or intention to use the system (Kim & Park, 2018; Mohammadi, 2015; Sánchez & Hueros, 2010; Teo, Zhou, Fan, & Huang, 2019, pp. 1–18).

Statistical results support hypotheses H7a and H7b. Since the instructor is the key person who is important to learners in the e-learning environment (Cheng, 2012), students' satisfaction with e-learning is positively influenced by the instructor quality. In the study conducted by Kim et al. (2012), researchers stated that "The instructor is the most important success factor in e-learning … Instructors increase user satisfaction and encourage students to become engaged in various learning opportunities". However, the instructor's communication, responsiveness, and attitude toward the e-learning system did not affect students' usage of the system. This result contradicts prior studies where support was found on the relationship between the instructor and usage or intention to use the e-learning system (Abbas, 2016; Lee et al., 2009; Nair, Ali, & Leong, 2015). However, it is consistent with Zhao, Bandyopadhyay, and Bandyopadhyay (2019) where no support was found between instructor and continued use intention. A possible reason for this insignificant relation could be because students are very dependent on Moodle to access the resources instructors upload and to submit assignments using the online submission system. Thus, aspects related to instructors were strongly related to their perceived satisfaction and usefulness of the system but not their utilization of it.

H8 was supported, thus, the more satisfied the user is, the greater the benefits and impacts on students will be achieved. The significant relationship is in line with studies on e-learning (Aparicio, Bacao, & Oliveira, 2017; Cidral, Oliveira, Di Felice, & Aparicio, 2018; Seta, Wati, Muliawati, & Hidayanto, 2018; Urbach, Smolnik, & Riempp, 2010; Wu & Wang, 2006). The results of the study strongly support H9a, H9b, and H9c. As a result, perceived usefulness is a key determinant of students' perceived satisfaction, perceived usefulness, and system use. Clearly, students would feel satisfied if they feel that the system enhances their learning performance and activities, help them to accomplish their tasks easily and smoothly with less effort, hence learn more effectively. Also, if students perceive that the e-learning system is useful to them, they are more likely to use it. The results overlap with several e-learning studies that investigated this relationship (Almarashdeh, Sahari, Zin, & Alsmadi, 2010; Al-Sabawy, Cater-Steel, & Soar, 2013; Ghazal, Al-Samarraie, & Aldowah, 2018; Islam, 2013; Lwoga, 2014; Sun, Tsai, Finger, Chen, & Yeh, 2008).

In view of the fact that benefits are achieved if learners use the e-learning systems hypothesis H10 has gained empirical support. However, it has less effect on benefits. If using the e-learning system is in line with students' needs, then students will be more successful in the modules, interaction and communicant are easier, and learning goals are achieved. Furthermore, the e-learning system will save their time in searching for materials and cut down expenditure such as paper. Thus, the higher the usage of the e-learning system the more benefits are achieved. The result is in line with literature (Aparicio et al., 2017; Cidral et al., 2018; Urbach et al., 2010, 2010).

7. Conclusion and implications

This research aims to investigate the factors that are considered for the evaluation of e-learning system success and has led to the development of an e-learning success model that incorporates these factors. To test the model, an empirical study was conducted. The contribution of this research is multifaceted and provides theoretical contributions as well as practical contributions as follows.

7.1. Theoretical implications

The first contribution of this study revolves around developing a multi-dimensional, comprehensive model for evaluating the success of e-learning. The model was developed based on an intensive review of literature and analysis of four approaches for evaluating the success of e-learning: the DeLone and McLean information systems success model, the Technology Acceptance Model (TAM), user satisfaction models, and e-learning quality models. This new model is believed to be comprehensive because different perspective have been considered in relation to different aspects of quality, social factors, acceptance, usefulness, satisfaction, and benefits of using the e-learning systems, and these encompass the main components of the existing approaches. Second, this study took a step forward and offers an empirical investigation of the model developed incorporating the factors that influence the success of e-learning systems. Seven types of quality factors, as antecedents of perceived satisfaction, perceived usefulness, use, and benefits, are proposed and empirically examined, namely technical system quality, information quality, service quality, educational system quality, support system quality, learner quality, and instructor quality. Collectively, all these factors are valid and important measures and contribute to the identification of e-learning success factors which is the second contribution of this research. The current research has also investigated new relationships which have not been empirically tested before (e.g., the relationship between learner quality, instructor quality, educational system quality and support system quality, with system use and perceived usefulness). Prior studies have referred to the relation with satisfaction only. As far as we know, however, this is one of the first studies to provide a comprehensive identification of e-learning success factors and empirically examine the relationships between the measures in one single model, which is the third contribution of this study.

The fourth contribution revolves around the performance of the developed model. The model showed a strong predictive power among perceived usefulness, perceived satisfaction, and benefits, and moderate predictive power for use. The model has substantially explained 71.4% of the variation of e-learning perceived satisfaction, moderately to substantially explained the variance of benefits and perceived usefulness with the amounts of 65% and 54.2% respectively. It has moderately explained 34.1% of the variation of e-learning use, which compared to prior models considered a novelty.

Finally, the research presents important theoretical contributions in the information systems field and e-learning success theories. It contributes to the DeLone and McLean model literature, TAM, and e-learning satisfaction and success theories by proposing an extension of the original DeLone and McLean information systems success model. Additionally, this study confirms the validity of DeLone and McLean information systems success model for evaluating the success of e-learning systems in the context of the UK.

7.2. Practical implications

Considering the fact that approximately 99% of higher education institutes use an LMS (e.g., Moodle, Blackboard, WebCT, Desire2Learn) on the one hand, and the considerable investments in the use and delivery of these systems to support and facilitate learning process on the other hand (Fathema et al., 2015), the study results shed light on important issues and recommendations that should be taken into consideration to improve the perceptions of satisfaction and usefulness, use, and benefits of the e-learning systems. The study provides practitioners with several practical contributions as follows.

1. With respect to the fact that many universities start with a commercial or open source LMS, the study results stress the necessity for periodically surveying their students. As a result, continuous improvement of these systems is required to address any issues and shortfalls.
2. The study revealed that the existence of communication and interactivity features, assessment and evaluation materials, and the diversity of learning styles positively influence utilization of the e-learning system, and aid students to be more engaged in their learning. Therefore, more efforts should be directed toward effectively using these tools to exploit the full capabilities of the e-learning system.
3. The study reveals that instructor quality has a significant effect on the perceptions of satisfaction and usefulness of the system. As a result, proper and extensive training of instructors prior to using the e-learning system is vital. This will aid instructors to gain an in-depth understanding and confidence using the e-learning system, in addition to increasing their awareness of the full features of the system.
4. The findings of this study suggest increasing awareness among students about the usefulness and benefits of the e-learning system to increase its usability and popularity. This can be achieved by delivering workshops and training. Therefore, learners' attitudes toward the e-learning system, learners' self-efficacy, and their experience with the e-learning system, are all increased, thus increasing the perceptions of usefulness and satisfaction, and the usage of the e-learning system.
5. Our results indicate that supportive issues in the e-learning system have a significant and positive influence on all of the following: system use, perceived usefulness, and perceived satisfaction of the e-learning system. Considering the wealth of resources and information available on the Internet, these results indicate that faculty members and administrators should provide sufficient information to students regarding plagiarism rules and regulations when submitting assignments. This can be delivered by providing extra modules on this matter through the e-learning system. Furthermore, copyright issues, accessibility of content, permission for viewing the course materials, and intellectual property issues, all should be clearly delivered to students using the e-learning system.
6. The results of this study draw the attention of universities to concentrating considerable effort on providing students with sufficient, concise and clear information, which is well organized into logical and understandable components, in addition to regularly updating the content. In turn, this will increase the perceptions of usefulness and satisfaction of the system, thereby achieving the benefits of using the e-learning system.
7. The study results can assist the universities and other institutions in recognizing that system characteristics such as, ease of using the system, reliability of the system, personalization, integration between system components, should be improved to make the system more reliable, user-friendly, more personalised, attractive and more intuitive, and easier to navigate. These aspects should positively increase the perceived usefulness and satisfaction with the system.
8. This study provides universities and higher education institutes with a valid, reliable, comprehensive model and an instrument to evaluate the success of their learning management systems. In summary, the study model introduces 11 dimensions that consider the evaluation of e-learning in all phases, from the design phase, to system usage and user belief, to the outcome phase. This will greatly help those engaged in e-learning, in general, and LMS, in particular, to better understand how the use of the system can be increased and how perceptions of satisfaction, usefulness, and outcomes of the system can be improved.

8. Limitations and recommendations for future studies

Although respondents of the survey were students from different background, cultures, and countries, attending one of the UK universities, the validity and reliability of the model would improve if different universities within the UK were surveyed. A future study would also consider extending the investigation to universities in developing countries.

In addition, this study was based on students' perceptions. Different groups of e-learning stakeholders (e.g., instructors and administrators) could enrich the research with different points of view and provide a better understanding of the issues facing e-learning systems success.

On the other hand, the proposed model has explained 71.4%, 54.2%, 34.1%, and 65% of perceived satisfaction, perceived usefulness, use, and benefits respectively of e-learning success, however, it does not fully capture the determinants of these factors. In other words, there is approximately 29% of the variance of e-learning perceived satisfaction, 46% of the variance of e-learning perceived usefulness, 66% of e-learning use, and 35% of e-learning benefits coming from other variables not examined in the model. Thus, there is still room to investigate the quality factors that determine the success of e-learning.

The EESS model proposed in this study provides researchers with the basis for future research. Researchers can explain, justify, and compare the differences among the results. Finally, with technology and e-learning continuously evolving, longitudinal research to examine how the e-learning quality factors revealed in this study change over time may reveal additional interesting results.

Declarations of interest

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Appendix 1

Measure		Aspect	Code	Related studies
Technical System Quality				
1.	It is easy to use Moodle	Ease of use	TSQ1	Sedera, Gable, and Chan (2004); Davis et al. (1989); Delone and McLean (2003)
2.	It is easy to understand the structure of Moodle and how to use it	Ease to learn	TSQ2	Sedera et al. (2004); Delone and McLean (2003)
3.	Moodle meets my requirements and I can find the information I need	User requirements	TSQ3	Sedera et al. (2004)
4.	Moodle includes the necessary features and functions I need	System features	TSQ4	Sedera et al. (2004)
5.	Moodle is always available for me to perform learning activities	System availability	TSQ5	Delone and McLean (2003)
6.	Moodle is flexible to interact with	Flexibility	TSQ6	Sedera et al. (2004); Selim (2003)
7.	All components within Moodle are fully integrated and consistent	Integration	TSQ7	Sedera et al. (2004); Selim (2003)
8.	Moodle launches and runs right away	System reliability	TSQ8	Sedera et al. (2004); Delone and McLean (2003)
9.	Moodle does not crash frequently	Fulfilment	TSQ9	Sedera et al. (2004)
10.	Moodle protects my information from unauthorized access by logging only with my account and password	Security	TSQ10	Holsapple and Lee-Post (2006)
11.	Moodle provides me with a personalised entry page (e.g. showing my modules, recommending additional modules and courses)	Personalization	TSQ11	Delone and McLean (2003); Ozkan and Koseler (2009)
Information Quality				
12.	Moodle has provided me with sufficient and required information	Sufficiency	INQ1	Delone and McLean (2003)
13.	Information and resources needed from Moodle are always accessible	Accessibility	INQ2	Ozkan and Koseler (2009); Selim (2003)
14.	Information from Moodle is in a form that is readily useable	Usability	INQ3	Ozkan and Koseler (2009); Sedera et al. (2004)
15.	Information in Moodle is concise and clear	Conciseness	INQ4	Sedera et al. (2004)
16.	The structure of Moodle is well organized into logical and understandable components	Understandability	INQ5	Sedera et al. (2004); Selim (2003)
17.	The content of Moodle is up to date	Up to date content	INQ6	Ozkan and Koseler (2009)
18.	I perceive the design of Moodle (e.g. fonts, style, colour, images, videos) to be good and meets the quality standards	Content design quality	INQ7	Roca et al. (2006);
Service Quality				
19.	There are enough and clear instructions/training about how to use Moodle	Providing guidance services	SRQ1	Hassanzadeh et al. (2012); Chang and King (2005)
20.	Moodle provides proper online assistance and help	Providing help	SRQ2	Holsapple and Lee-Post (2006); Ozkan and Koseler (2009)
21.	The IT services staff is available and cooperative when facing an error at Moodle	Staff Availability	SRQ3	Holsapple and Lee-Post (2006)
22.	The IT services staff understands the specific needs of students	Fair understanding	SRQ4	Delone and McLean (2003); Holsapple and Lee-Post (2006)
23.	I receive a satisfactory and timely response from the IT services staff	Responsiveness	SRQ5	Delone &McLean (2003)
Educational System Quality				
24.	Moodle provides interactivity and communication facilities such as chat, forums, and announcements.	Interactivity and communication	ESQ1	Hassanzadeh et al. (2012); Sun et al. (2008); Selim (2003)
25.	I believe that communication facilities have been effective learning components in my study	Effective communication	ESQ2	Hassanzadeh et al. (2012); Sun et al. (2008); Selim (2003)
26.	Moodle provides me with different learning styles (e.g. flash animation, video, audio, text, simulation, etc.) and they are interesting and appropriate in my study	Diversity of learning styles	ESQ3	Hassanzadeh et al. (2012); Sun et al. (2008); Selim (2003)
27.	Moodle provides evaluation components and assessment materials (e.g., quizzes, assignments)	Evaluation components	ESQ4	Hassanzadeh et al. (2012); Sun et al. (2008); Selim (2003)
Support System Quality				
28.	Moodle provides appropriate information about plagiarism issues when submitting assignments through the system,	Ethical issues	SUP1	Khan (2005); Ozkan and Koseler (2009)
29.	Moodle provides information about behavioural considerations when communicating with students or with instructors	Behavioural considerations	SUP2	Khan (2005); Ozkan and Koseler (2009)
30.	Moodle provides information about the accessibility of content, permission for viewing course materials, and any other personal data in the system	Legal issues	SUP3	Khan (2005); Ozkan and Koseler (2009)
31.	If it is optional, I would still prefer to use Moodle as a supportive tool in the module	Promotion of the e-learning system	SUP4	Ozkan and Koseler (2009)
Learner Quality				
32.	I believe it is good to use Moodle	Learner's behaviour	LER1	Davis et al. (1989)
33.	I have a positive attitude toward using Moodle	Learner's attitude	LER2	Davis et al. (1989); Sun et al. (2008)
34.	I am not intimidated by using Moodle	Learner's anxiety	LER3	Sun et al. (2008); Piccoli, Ahmad, and Ives (2001)
35.	My previous experience with e-learning systems and computer applications helped me in using Moodle	Learner's previous experience	LER4	Ozkan and Koseler (2009); Selim (2007)
36.	I am able to perform tasks in Moodle successfully	Learner's self-efficacy	LER5	Roca et al. (2006); Sun et al. (2008)
Instructor Quality				
37.	I use Moodle as recommended by my instructors	Subjective norm	INS1	Roca et al. (2006)

38. I think an instructor's enthusiasm about using Moodle stimulates my desire to learn	Instructor's enthusiasm	INS2	Sun et al. (2008)
39. I receive a prompt response to questions and concerns from my instructors in Moodle	Instructor's responsiveness	INS3	Sun et al. (2008); Ozkan and Koseler (2009)
40. I think communicating and interacting with instructors are important and valuable in Moodle	Instructor's interactive communication	INS4	Sun et al. (2008); Ozkan and Koseler (2009)
41. Generally, my instructors have a positive attitude to the utilization of Moodle	Instructor's attitude	INS5	Sun et al. (2008); Lee et al. (2009)
Perceived Satisfaction			
42. I am satisfied with the performance of Moodle	Satisfaction with system performance	SAT1	Arbaugh (2000); Hassanzadeh et al. (2012)
43. I enjoy using Moodle in my study	Enjoyable experience	SAT2	Arbaugh (2000)
44. Moodle satisfies my educational needs	Providing educational needs	SAT3	Hassanzadeh et al. (2012)
45. Overall, I am pleased with the experience of using Moodle	Overall satisfaction	SAT4	Cidral et al. (2018)
Perceived Usefulness			
46. Using Moodle enables me to accomplish my tasks more quickly	Accomplishing tasks quickly	USF1	Selim (2003); Venkatesh and Davis (2000) and Pituch and Lee (2006); Rai et al. (2002)
47. Using Moodle improves my learning performance	Improving learning performance	USF2	Selim (2003); Roca et al. (2006); Rai et al. (2002)
48. Using Moodle helps me learn effectively	Effective learning	USF3	Venkatesh and Davis (2000) and Pituch and Lee (2006); Roca et al. (2006); Selim (2003)
49. Overall Moodle is useful	Overall usefulness	USF4	Roca et al. (2006); Selim (2003)
Use			
50. I use Moodle frequently	Frequency of use	USE1	Delone and McLean (2003); Selim (2003)
51. I depend on Moodle in my study	Dependence on system	USE2	Delone and McLean (2003); Selim (2003); Rai et al. (2002)
52. I use Moodle regularly	Regular use	USE3	Delone and McLean (2003); Selim (2003)
53. On average, I spend a long time on using Moodle	Duration of use	USE4	Delone and McLean (2003); Selim (2003)
Benefits			
54. Using Moodle has increased my knowledge and helped me to be successful in the module	Increasing knowledge	BNT1	Hassanzadeh et al. (2012)
55. Moodle is a very effective educational tool and has helped me to improve my learning process	Improving learning process	BNT2	Hassanzadeh et al. (2012); Holsapple and Lee-Post (2006); Rai et al. (2002)
56. Moodle makes communication easier with the instructor and other classmates	Easier interaction and communication	BNT3	Almutairi and Subramanian (2005); Selim (2003)
57. Moodle saves my time in searching for materials and cuts down expenditure such as paper cost	Time and cost saving	BNT4	Delone and McLean (2003); Holsapple and Lee-Post (2006); Hassanzadeh et al. (2012)
58. Moodle has helped me to achieve the learning goals of the module	Achieving learning goals	BNT5	Hassanzadeh et al. (2012); Selim (2003)

Appendix 2. Cross Loadings

	BNT	ESQ	INQ	INS	LER	SAT	SRQ	SUP	TSQ	USE	USF
BNT1	**0.840**	0.300	0.430	0.490	0.550	0.600	0.260	0.390	0.420	0.430	0.620
BNT2	**0.870**	0.330	0.570	0.510	0.670	0.710	0.330	0.420	0.520	0.440	0.690
BNT4	**0.770**	0.210	0.410	0.410	0.480	0.530	0.220	0.380	0.410	0.310	0.530
BNT5	**0.840**	0.300	0.450	0.460	0.570	0.600	0.240	0.450	0.460	0.410	0.650
ESQ1	0.320	**0.850**	0.330	0.300	0.300	0.330	0.180	0.370	0.300	0.270	0.320
ESQ2	0.120	**0.510**	0.130	0.250	0.130	0.120	−0.040	0.040	0.160	0.060	0.100
ESQ3	0.110	**0.550**	0.130	0.150	0.120	0.100	−0.030	0.070	0.100	0.130	0.070
ESQ4	0.320	**0.880**	0.350	0.330	0.290	0.290	0.140	0.360	0.280	0.300	0.270
INQ1	0.470	0.340	**0.730**	0.340	0.530	0.530	0.280	0.400	0.520	0.330	0.450
INQ2	0.390	0.220	**0.720**	0.280	0.460	0.450	0.280	0.310	0.490	0.210	0.390
INQ3	0.450	0.260	**0.820**	0.370	0.550	0.570	0.340	0.350	0.570	0.260	0.470
INQ4	0.480	0.270	**0.840**	0.360	0.580	0.570	0.360	0.340	0.630	0.250	0.500
INQ5	0.410	0.280	**0.780**	0.350	0.500	0.520	0.380	0.290	0.580	0.240	0.420
INQ6	0.320	0.270	**0.650**	0.320	0.370	0.420	0.290	0.240	0.490	0.170	0.360
INQ7	0.390	0.290	**0.650**	0.260	0.430	0.480	0.310	0.260	0.460	0.290	0.430
INS1	0.430	0.290	0.360	**0.630**	0.430	0.450	0.230	0.290	0.380	0.230	0.390
INS2	0.340	0.160	0.230	**0.690**	0.340	0.330	0.200	0.290	0.240	0.140	0.320
INS3	0.460	0.330	0.350	**0.840**	0.420	0.380	0.200	0.290	0.340	0.280	0.350
INS4	0.250	0.200	0.170	**0.570**	0.270	0.200	0.090	0.090	0.210	0.090	0.200
INS5	0.440	0.280	0.370	**0.780**	0.420	0.410	0.260	0.290	0.380	0.210	0.400
LER1	0.670	0.300	0.570	0.490	**0.880**	0.710	0.330	0.530	0.540	0.460	0.690
LER2	0.620	0.280	0.640	0.500	**0.890**	0.770	0.350	0.460	0.600	0.410	0.670
LER3	0.480	0.270	0.540	0.370	**0.800**	0.600	0.210	0.380	0.500	0.360	0.460
LER4	0.290	0.110	0.220	0.290	**0.460**	0.270	0.220	0.210	0.190	0.160	0.260
LER5	0.550	0.280	0.530	0.460	**0.820**	0.590	0.250	0.400	0.490	0.360	0.510
SAT1	0.570	0.280	0.540	0.400	0.630	**0.820**	0.340	0.430	0.460	0.370	0.550
SAT2	0.650	0.280	0.610	0.490	0.690	**0.890**	0.390	0.410	0.560	0.400	0.640
SAT3	0.670	0.310	0.600	0.460	0.670	**0.880**	0.380	0.440	0.570	0.460	0.660
SAT4	0.680	0.300	0.650	0.480	0.750	**0.920**	0.350	0.430	0.600	0.370	0.680
SRQ1	0.250	0.090	0.340	0.220	0.290	0.330	**0.760**	0.300	0.280	0.150	0.280
SRQ2	0.290	0.120	0.360	0.190	0.280	0.340	**0.810**	0.280	0.350	0.140	0.290
SRQ3	0.300	0.110	0.380	0.250	0.320	0.360	**0.900**	0.270	0.380	0.120	0.280
SRQ4	0.220	0.110	0.330	0.270	0.250	0.330	**0.800**	0.210	0.330	0.100	0.230

SRQ5	0.200	0.140	0.310	0.220	0.240	0.270	**0.680**	0.170	0.270	0.080	0.170
SUP1	0.250	0.280	0.200	0.240	0.250	0.190	0.160	**0.700**	0.140	0.180	0.220
SUP2	0.280	0.210	0.210	0.230	0.240	0.230	0.260	**0.750**	0.200	0.130	0.230
SUP3	0.330	0.230	0.260	0.260	0.300	0.280	0.300	**0.790**	0.210	0.160	0.300
SUP4	0.500	0.340	0.450	0.340	0.570	0.550	0.240	**0.800**	0.390	0.430	0.570
TSQ1	0.510	0.240	0.550	0.370	0.590	0.560	0.260	0.330	**0.800**	0.360	0.500
TSQ3	0.420	0.290	0.570	0.330	0.490	0.450	0.270	0.240	**0.800**	0.290	0.390
TSQ4	0.430	0.200	0.570	0.390	0.460	0.450	0.300	0.260	**0.770**	0.240	0.420
TSQ6	0.370	0.290	0.540	0.340	0.420	0.470	0.380	0.280	**0.750**	0.190	0.360
TSQ7	0.330	0.230	0.540	0.300	0.390	0.450	0.380	0.270	**0.700**	0.130	0.370
USE1	0.400	0.320	0.330	0.240	0.420	0.410	0.150	0.330	0.300	**0.890**	0.460
USE2	0.450	0.260	0.330	0.240	0.440	0.440	0.140	0.310	0.310	**0.920**	0.540
USE3	0.430	0.280	0.300	0.220	0.420	0.400	0.120	0.300	0.290	**0.930**	0.490
USE4	0.430	0.230	0.250	0.320	0.370	0.370	0.140	0.330	0.260	**0.800**	0.460
USF1	0.640	0.280	0.500	0.410	0.570	0.640	0.330	0.480	0.490	0.470	**0.850**
USF2	0.680	0.270	0.470	0.420	0.580	0.620	0.270	0.440	0.430	0.500	**0.910**
USF3	0.680	0.260	0.480	0.440	0.570	0.600	0.280	0.440	0.450	0.470	**0.900**
USF4	0.640	0.290	0.590	0.440	0.680	0.670	0.250	0.430	0.520	0.470	**0.830**

Appendix 3. Results Summary of the Measurement Model

Latent Variable	Indicators	Reliability			Validity	
		Indicator Reliability	Internal Consistency Reliability		Convergent Validity	Discriminant Validity
		Factor Loadings	Cronbach's Alpha	Composite Reliability CR	AVE	HTMT
		Loading ≥ 0.70 or > 0.40 & has no impact on AVE and CR	**α ≥ 0.70**	**CR ≥ 0.70**	**AVE ≥ 0.50**	**HTMT ≤ 0.90**
TSQ	TSQ1	0.800	0.830	0.880	0.590	Yes
	TSQ3	0.802				
	TSQ4	0.771				
	TSQ6	0.754				
	TSQ7	0.704				
INQ	INQ1	0.731	0.860	0.900	0.550	Yes
	INQ2	0.717				
	INQ3	0.820				
	INQ4	0.839				
	INQ5	0.781				
	INQ6	0.653				
	INQ7	0.647				
SRQ	SRQ1	0.759	0.850	0.890	0.630	Yes
	SRQ2	0.808				
	SRQ3	0.899				
	SRQ4	0.796				
	SRQ5	0.677				
ESQ	ESQ1	0.850	0.710	0.800	0.520	Yes
	ESQ2	0.512				
	ESQ3	0.553				
	ESQ4	0.878				
SUP	SUP1	0.700	0.800	0.850	0.580	Yes
	SUP2	0.748				
	SUP3	0.789				
	SUP4	0.800				
LER	LER1	0.882	0.840	0.890	0.620	Yes
	LER2	0.894				
	LER3	0.796				
	LER4	0.457				
	LER5	0.823				
INS	INS1	0.631	0.750	0.830	0.510	Yes
	INS2	0.686				
	INS3	0.842				
	INS4	0.573				
	INS5	0.780				
SAT	SAT1	0.824	0.900	0.930	0.770	Yes
	SAT2	0.886				
	SAT3	0.877				
	SAT4	0.919				
USF	USF1	0.854	0.900	0.930	0.770	Yes
	USF2	0.910				
	USF3	0.900				
	USF4	0.832				

USE	USE1	0.890	0.910	0.940	0.790	Yes
	USE2	0.918				
	USE3	0.929				
	USE4	0.802				
BNT	BNT1	0.843	0.850	0.900	0.690	Yes
	BNT2	0.871				
	BNT3	0.771				
	BNT5	0.840				

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