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ORIGINAL ARTICLE

Developing a model to assess the success of e-learning systems: evidence from a manufacturing company in transitional economy

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Abstract This paper examines the success of an e-learning system in a company from the perspective of employees by using a multimethod approach. For this purpose Moodle learning management system was used. The success of e-learning as an information system was evaluated using four constructs of the updated DeLone and McLean IS success model—system quality, use, user satisfaction and net benefits, and adding one more construct—user performance. In this research a combination of observation and survey as two different research methods was used, which allowed the new measure to be incorporated into the model. Empirical assessment was carried out by exploratory factor analysis, confirmatory factor analysis and structural equation modeling. The research model was found to be valid and reliable. The results provide an expanded understanding of the constructs that measure the success of an e-learning system, helping to more deeply understand the key success dimensions and their interrelationships. The implications of our work were discussed. The DeLone and McLean IS success model applied equally well. However, the use of observation as a method of data collection revealed the weaknesses of the original model.

Keywords IS success · IS success model · E-learning systems · Moodle · Multimethod research · SEM

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1 Introduction

Today, the growing appetite of companies for swift profit is clashing with the deliberate pace at which many employees acquire knowledge. Bearing in mind that each organization is striving to become a learning organization, the use of technology in the process of learning is becoming inevitable. Organizations have invested heavily in information and communication technology in order to increase strategic advantages and gain or hold the competitive edge (Zhang 2008). Online learning or electronic learning, referring to independent reading of material posted on the Internet and subsequent testing of the acquired knowledge, is becoming the strategy of many industry actors (e.g. Cisco Inc., Dell Inc.) (Zhang and Nunamaker 2003). Electronic learning "eliminates the barriers of time and geographical distance, so continuing staff development can accommodate diverse learning environments such as homes, offices, and offsite conference rooms" (Zhang and Nunamaker 2003, p. 208). In addition, e-learning systems provide a cost- and time-effective approach to employee training (Chen 2012). Not only that organizations perceive e-learning as an important resource, but also the results reported by academics consider e-learning systems to be a valuable tool for solving various business problems (Wang et al. 2007; Report by Means et al. 2010). It is certainly clear that industry should not underestimate the potential of technology.

The e-learning systems have received excessive attention in information systems (IS) literature and are mainly examined from the standpoint of effectiveness (successfulness). Over the last 25 years researchers have been discussing information system success issues. To address early problems in defining the IS success due to the complex, interdependent, and multi-dimensional nature, DeLone and McLean (1992) constructed an IS success model. Technology Acceptance Model (TAM) by Davis (1989) explained why some IS are better accepted by users than others. Acceptance, however, is not the same as success, although acceptance of an information system is a necessary element for measuring success (Petter et al. 2008). That is why this research will be focused only on DeLone and McLean (D&M) IS success model as a measurement for e-learning assessment.

Even as researchers vie to explain the IS success model, some theorists (Holsapple and Lee-Post 2006; Wang et al. 2007; Lin 2007; Lee and Lee 2008; Ozkan and Koseler 2009; Chen 2012; Hassanzadeh et al. 2012) are trying to explain it away in the context of electronic learning. While IS success models have received much attention among researchers, few studies (e.g. Wang et al. 2007; Eom et al. 2012) have been conducted aimed at assessing the success of e-learning systems by using DeLone and McLean IS success model in the context of an organization and, to the best of our knowledge, no research has been conducted using a combination of different data collection methods. In all this research, only survey quantitative data collection approach was used. Venkatesh et al. (2013) suggested the use of a combination of different methods when conducting research in the IS field since it can create synergy and reveal important details of the advancement of the IS discipline. In addition, Mingers (2001) underlined that "it is both desirable and feasible to combine together different research methods to gain richer and more reliable research results".

This study presents an empirically validated model for measuring the success of an e-learning system in a company by using the D&M IS success model. The focus is on developing a model to assess the success of e-learning systems by using a multimethod approach—the combination of observation and survey as two different research methods. The combination of objective parameters (i.e. technical characteristics of the system) and subjective opinions will lead to more accurate and reliable results (Mingers 2003). The proposed instrument can be used to assess the success of enterprise e-learning systems from the perspective of the employees.

The rest of the paper is organized as follows. First, the theoretical foundation of e-learning systems and IS success models is discussed. Then the used research methodology, measures and results are presented. Finally, a discussion of theoretical and managerial implications and directions for future research is provided.

2 Background and related work

2.1 E-learning system

An e-learning system is a type of information system based on Internet technology that provides training of the learner in an independent and flexible way (Wang et al. 2007; Lee and Lee 2008). This technology based system serves as a platform to facilitate teaching and learning (Hassanzadeh et al. 2012). Users or e-learners access the system through Internet or intranet portals in order to acquire information, knowledge and skills (Chen 2012). E-learners can independently read material posted on the Internet and then test the acquired knowledge. This makes the e-learning system an effective learning environment. During the learning process, users can interact with other participants, such as the instructor or other users (Kong 2011).

With the popularization of e-learning systems, many companies have developed web-based training programs for their employees. In this way, employees have greater control over learning, which makes learning self-paced. Compared to the conventional learning process, where learners usually learn in a group by sitting in the same room with the instructor or other learners, the e-learning process is usually designed for studying by sitting in front of the computer and the learners are given control over learning elements (DeRouin et al. 2005). These two features, self-pacing and control over learning, are providing new opportunities for companies. In the process of design and delivery of e-learning training programs, enterprises have to consider both effectiveness and success of e-learning systems.

E-learning systems have received excessive attention in IS literature from the point of view of evaluation. The most cited models are the D&M models and TAM which were developed to assess the success or effectiveness of information systems. TAM, originally developed by Davis (1989), was extended and modified into TAM2 (Venkatesh and Davis 2000) and United Theory of Acceptance and Use of Technology (Venkatesh et al. 2003). It has found applications in the research of e-learning just from the approach of acceptance (Lee et al. 2005; Roca et al. 2006; Escobar-Rodriguez and Monge-Lozano 2012). Since acceptance is not the same as success, although it is a necessary element for measuring success, it will not be the subject of this study.

By using the D&M model, Chen (2012) found that e-learning system use has a high impact on new entrants in the company in regard to their organizational socialization and overall job adaptation outcome. Another study conducted in an organizational context developed a comprehensive and multidimensional instrument for measuring e-learning systems success based on an updated D&M IS success model (Wang et al. 2007). Hassanzadeh et al. (2012) added a few more dimensions (i.e. system loyalty and goals achievement) to the updated D&M model and empirically proved that all dimensions are suitable for measuring e-learning systems success in an educational environment. Lin (2007) also tested the IS success model in the context of e-learning at the academic institutions and found that the D&M model is a valid instrument for success measurement. In another study conducted in the academic context it was found that the e-learning success model, based on the updated D&M model, is useful for defining, assessing and promoting e-learning success (Holsapple and Lee-Post 2006). In a study by Ozkan and Koseler (2009), a different approach was used in order to assess e-learning from the student perception. They examined only technical dimensions from the D&M model and added two more dimensions concerning social entity (i.e. learner perspective and instructor attitude) and proved that all dimensions of the e-learning model are important for e-learning effectiveness. Lee and Lee (2008) also developed and tested a modified IS success model, considering information system attributes and self-regulated learning attributes supporting education engineering in e-learning. They verified the new research model theoretically and empirically in a higher education setting.

2.2 IS success modeling

The DeLone and McLean IS success model was first introduced back in 1992 (DeLone and McLean 1992) and remains one of the main reference sources for IS effectiveness. Mason's (1978) information influence theory, a modification of Shannon and Weaver's (1949) mathematical theory of communication, also known as information theory, served as the basis for the first D&M IS success model. The taxonomy consisted of six interdependent constructs: information quality, system quality, system use, user satisfaction, individual impact, and organizational impact, (DeLone and McLean 1992). During the first 10 years, the D&M IS success model was referenced 285 times in refereed papers in journals and proceedings, underlining research that applied, confirmed, questioned, and critiqued it (Holsapple and Lee-Post 2006). Today, after more than two decades, the original model has been referenced 3164 times and it has been a foundation for numerous researches. Many critiques for modification or extension of the original model were proposed by numerous IS researchers (Pitt et al. 1995; Seddon and Kiew 1996; Seddon 1997). In 2003, DeLone and McLean updated their IS success model in order to fit the Internet era, especially the dawn of electronic commerce (DeLone and McLean 2003).

Quality gained the third dimension—service quality, as suggested by Pitt et al. (1995), and individual impact and organizational impact were grouped into a single construct—net benefit, as proposed by Seddon (1997). Thus, the updated D&M IS success model's categories are: system, information, and service quality, system use, user satisfaction, and net benefits. The updated model consists of six interrelated and interdependent dimensions of IS success. The model is applicable to the assessment of IS effectiveness in the Internet environment.

In their review, Petter et al. (2008) found that the D&M model is applicable in a variety of contexts and serves as a significant basis for imminent studies. In another review, Urbach et al. (2009) concluded that the dominant research analyzes the impact that a specific type of IS has by means of users' evaluations obtained from surveys and structural equation modeling (SEM).

2.3 Multimethod research

Researchers who employ two or more research methods, either quantitative or qualitative analysis in the same research enquiry are using multimethod research (Mingers 2001, 2003; Creswell and Plano Clark 2011; Davis et al. 2011). A combination of two quantitative analyses, such as survey and direct observation analysis will lead to multimethod research. On the other hand, the use of critical research and case study as a qualitative analysis for the collection and data analysis of the same phenomenon is considered multimethod research as well. A combination of quantitative and qualitative data collection methods can lead to the development and use of new measures in the research (Kaplan and Duchon 1988). Mingers (2003) urged that the multimethod research approach is inevitable for overcoming obstacles if IS research is to develop effectively. Insights that help extend theory and practice by mixing quantitative and qualitative will be important for the advancement of IS field (Venkatesh et al. 2013).

To understand the interdependent relationships among the D&M IS success model's categories further and to develop a new measure that can be incorporated into the model, the authors used survey and direct observation for the collection of data.

2.4 Hypotheses development

In this section, the rationale for each of the proposed hypotheses, stating connections between constructs from the proposed e-learning success model (Fig. 1) is explained. Since e-learning systems are a specific type of IS, the D&M IS success model can be used for measuring the success of e-learning systems. Therefore, besides potential relationships found in the e-learning literature, several assumptions from the D&M IS success model were also used to hypothesize relationships in the proposed e-learning success model at the individual (employee) unit of analysis. The hypotheses about the relationships in the model, with corresponding discussions, are presented below.

Lin (2007) observed the success of an online learning system and found a positive correlation between the system quality and the use of the online learning system. Balaban et al. (2013) also reported a positive influence of the system quality

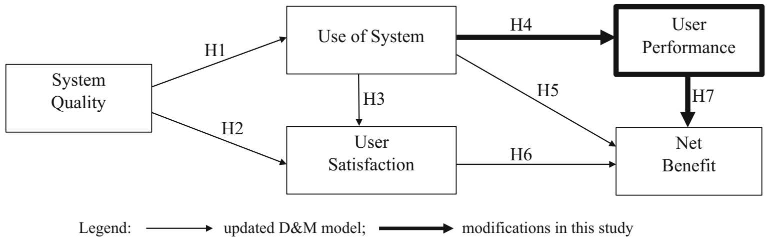


Fig. 1 Research model

on use. Garcia-Smith and Effken (2013) analyzed the effects of system quality on the use of the system and reported that the former construct influenced the latter. We therefore expect that higher technical quality of an e-learning system will make it easier to use. For that reason, the following hypothesis is proposed:

H1 System quality has a positive influence on the use of an e-learning system.

For e-learning systems, system quality was found to be strongly related to user satisfaction (Eom et al. 2012; Hassanzadeh et al. 2012). Petter et al. (2008) analyzed 21 papers in IS studies that addressed the relationship between system quality and user satisfaction. All found strong support for the relationship between system quality and user satisfaction. For employee portals, system quality was also found to be strongly related to user satisfaction (Urbach et al. 2010). Thus, we believe that, among users or e-learners, higher technical quality will make an e-learning system more compatible with the requirements of all users. Therefore, the following hypothesis is proposed:

H2 System quality has a positive influence on user satisfaction with an e-learning system.

In the e-learning context, Hou (2012) found that the duration of use and frequency of system usage as part of the use construct has, in this case, positive effects on user satisfaction. In an ePortfolio context, Balaban et al. (2013) identified a significant relationship between intention to use and user satisfaction. Urbach et al. (2010) also reported a high positive influence of the use of the system on user satisfaction. In measuring the IS success, Petter et al. (2008) found moderate support for the relationship between use, as an independent variable, and user satisfaction, as a dependent variable. These findings affirm the notion that satisfaction is enhanced through use. Hence, we propose that the use of an e-learning system will influence users' satisfaction within a company since the more users are using the system in the process of delivery of an online training course, the more the users (employees) are satisfied with the system. Therefore, the following hypothesis about system use and user satisfaction is proposed:

H3 The use of an e-learning system has a positive influence on user satisfaction.

Avouris et al. (2001) reported a direct positive influence of the use of an e-learning system on user performance. In their study, the users that used the system more frequently performed significantly better than the users with less frequent usage. Similarly, Eom et al. (2012) established that the use of an e-learning system directly influences test scores, where test scores is part of the user performance construct. Lopez-Fernandez and Rodriguez-Illera (2009) also reported a strong positive impact of use on users' performance. Thus, we believe that if employees use an e-learning system more frequently, their performance will improve. Given the theoretical support and prior research on such a link, the present study proposes the following hypothesis:

H4 The use of an e-learning system has a positive influence on user performance.

In measuring the e-learning system success, Chen (2012) showed that the use of e-learning systems, as an important training source for new entrants in a company, directly and positively influences net benefits. Hou (2012) and Garcia-Smith and Effken (2013) showed a similar effect, indicating that the use of IS directly and positively influences net benefits. Petter et al. (2008) indicated the existence of a relationship between use and net benefits. We therefore also expect that the higher levels of IS use can create significant benefits for employees, even in the case of an e-learning system. Thus, the present study proposes the following hypothesis:

H5 The use of an e-learning system has a positive influence on net benefits.

Hassanzadeh et al. (2012) investigated the success of e-learning systems, reporting a strong positive impact of user satisfaction on the increased knowledge as part of net benefits. Urbach et al. (2010) showed a similar effect, indicating that user satisfaction directly and positively influences net benefits. Petter et al. (2008) found a strong positive relationship between user satisfaction and net benefits. In their analysis, all 14 papers reported a positive relationship between the two constructs. We also believe that if knowledge dissemination needs of employees are met satisfactorily by an e-learning system, the impact of the system on employees will improve leading to business performance. Similarly, the impact and benefits of an e-learning system are likely to be achieved through the increased knowledge and improved attitude towards the organization, which are significantly mediated by internal users' satisfaction. Thus, the present study develops the following hypothesis:

H6 E-learning system user satisfaction has a positive influence on net benefits.

Means et al. (2010) performed a meta-analysis and review of online learning studies and indicated the existence of a relationship between user performance and net benefits. The case of user performance, which is important for the assessment of an e-learning system and the impact that it has on employees, has not yet been explored with the same level of attention. It is our belief that the higher performance of employees after experiencing an e-learning system, the greater the impact of the e-learning system on the employees of the company, and the company itself. We thus derive the following hypothesis:

H7 User performance of an e-learning system has a positive influence on net benefits.

Based on these hypotheses, we propose the research model presented in Fig. 1. We transformed the theoretical model into a structural equation model, which we tested empirically.

3 Materials and methods

3.1 Measures

Following previous research in IS success, constructs and indicators of the conceptual model were determined. A total of five dimensions with 25 indicators were used for measurement. Four constructs were adopted from the updated D&M IS success mode—system quality, use of system, user satisfaction, and net benefits—and the fifth construct, user performance, was added based on the analysis of review process and findings from the literature (i.e., Lee and Lee 2008). To make sure that no important indicators were omitted, personal interviews on company's e-learning system success were conducted with the assistance of five university professors, four professionals, two IT professionals and four IS managers. They were all asked to review the initial indicators. After the review process, they recommended eliminating 12 indicators because of redundancy and adding two new indicators. Upon careful analysis of the recommendations, the revised 15 indicators were further adjusted and can be considered to constitute the final model. The indicators and constructs are presented in Table 1 and operational definitions of each construct are described below.

3.2 System quality

System quality represents the technical quality of an e-learning system and measures technical success (DeLone and McLean 2003). This construct is oriented towards technical specifications and was measured with the following indicators: easy to use, user-friendly and response of the system. The first two variables are ordinal and measured with five-point Likert (Nunnally and Bernstein 1994) scale, while the third variable (numeric) was measured using direct observation from system logs. Numeric data were recorded into five-point scale to be analyzed.

3.3 Use of system

This construct measures the actual use of the system (Petter and McLean 2009). Previous research indicated that the nature of this use must be considered in order to measure the success of the system (DeLone and McLean 2003). Three indicators (numeric) were adopted to measure this construct: number of visits, frequency of use and duration of system use. The data of these three indicators were recorded into five-point scale to be analyzed. In addition, a new indicator (nominal) was added—the use of the system after business hours.

Table 1 Construct measures

Construct	Indicator	References
System quality	(1) User-friendly	Wang et al. (2007), Wang and Liao (2008)
	(2) Easy to use	DeLone and McLean (2003), Ozkan and Koseler (2009)
	(3) Responsiveness	DeLone and McLean (2003)
Use of system	(4) Number of visits	DeLone and McLean (2003)
	(5) Frequency of use	Wang et al. (2007), Wang and Liao (2008)
	(6) Duration of use	Ozkan and Koseler (2009), Hassanzadeh et al. (2012)
	(7) Use after business hours	New*
User satisfaction	(8) Reaction to content	Kirkpatrick and Kirkpatrick (2006)
	(9) Reaction to instructions	Kirkpatrick and Kirkpatrick (2006)
	(10) Reaction to environment	Kirkpatrick and Kirkpatrick (2006)
	(11) Overall satisfaction	Wang et al. (2007)
User performance	(12) Test results	Lee and Lee (2008)
	(13) Degree of progress	New*
Net benefits	(14) Increased knowledge	Hassanzadeh et al. (2012)
	(15) Improved attitude	DeRouin et al. (2005)

Added based on experts' opinions

3.4 User satisfaction

User satisfaction is users' attitude towards the system (DeLone and McLean 1992). It measures the users' reaction to content, instructions, online environment and overall satisfaction with the system. Since the end users of an e-learning system have become e-learners, it is necessary to measure e-learning satisfaction with the system (Wang 2003). All indicators are ordinal and measured with five-point Likert scale (Nunnally and Bernstein 1994).

3.5 User performance

This dimension measures the performance of each user after experiencing the e-learning system (Lee and Lee 2008). Since every user interacts with the e-learning system and acquires a certain amount of information, knowledge and skills and then tests the acquired knowledge, two numeric indicators for user performance were used—test results and degree of progress. The data were recorded into five-point scale to be analyzed.

3.6 Benefits of using e-learning system

Net benefit is the impact of the e-learning system on users or employees of the company, and company itself (DeLone and McLean 2003). Every user experiences certain effects after using the system and these need to be measured in order to evaluate the e-learning system success. To measure net benefit construct, two ordinal indicators were used and measured with five-point Likert scale (Nunnally and Bernstein 1994) (increased knowledge and improved attitude towards organization).

4 Sample and data collection procedure

The data in the study were collected from one of the largest vertically integrated energy companies in Eastern Europe. For the purpose of the study presented here, an e-learning system was developed and implemented in the company, using open-source software Moodle (Romero et al. 2008). Moodle has a flexible selection of module activities and resources to create different types of static course material, interactive course material and activities where participants interact with each other. Moodle keeps detailed logs of all activities that participants perform (Rice 2006). Logging is record keeping that can keep track of what materials participants have accessed (Romero et al. 2008). Moodle logs every click that participants make for navigational purposes and has a log viewing system built into it (Romero et al. 2008). In addition, Moodle provides a lot of information about the students' usage of the platform and also about their performance (Martín-Blas and Serrano-Fernández 2009). The training program that was delivered via the e-learning system was Health, Safety and Environment. Within this company, our sampling design focused on selecting employees on all levels. Out of 9000 employees, 1100 employees were randomly selected. The same e-learning training was delivered to all selected participants.

Creswell and Plano Clark (2011) proposed that the data collection procedure for two different methods should occur in the same time frame, but independently when the data of two different methods are not dependent. For this study, the data collection process occurred in one phase by using survey (see "Appendix") and observation as two different methods. This was an attempt to get both the subjective interpretations of the participants and an objective view of the events. Benbasat et al. (1987) suggested outlining the constructs to be gathered using direct observation before collection of data. Table 2 indicates which indicators were

Table 2 Methods of data collection for each indicator

Indicator	Method	Indicator	Method
(1) User-friendly	Survey	(9) Reaction to instructions	Survey
(2) Easy to use	Survey	(10) Reaction to environment	Survey
(3) Responsiveness	Direct observation	(11) Overall satisfaction	Survey
(4) Number of visits	Direct observation	(12) Test results	Direct observation
(5) Frequency of use	Direct observation	(13) Degree of progress	Direct observation
(6) Duration of use	Direct observation	(14) Increased knowledge	Survey
(7) Use after business hours	Direct observation	(15) Improved attitude	Survey
(8) Reaction to content	Survey		

collected by using each method. The Internet tool SurveyMonkey (www.surveymonkey.com) was used as the survey method. Available e-mail addresses were used to contact potential respondents directly after the training delivery of the e-learning course. There are three benefits when using Internet surveys: (a) there is no time limitation of accessibility by participants (Birnbaum 2004), (b) it is flexible for design and implementation (Dillman 2007), and (c) it is convenient for data coding and entry (Bartlett 2005). The remainder of the data was collected by using the direct observation method in which we looked at the user logs from the e-learning system. For this research, only data from the participants who responded to the survey were included in the analysis.

279 employees in various positions in the company, who successfully completed the training process, replied to the survey (response rate of 25 %). The responses were voluntary. The respondents were identified as top-level managers (1.1 %) middle managers (13.4 %), lower managers (9.5 %), professional employees (43.2 %) and general employees (32.8 %). From the above respondents, 44.2 % were men. Age distribution is approximately normal: under 20 (0.0 %), between 21 and 30 (14.1 %), between 31 and 40 (40.3 %), between 41 and 50 (31.8 %), between 51 and 60 (11.7 %), and over 61 (2.1 %). Invariance tests showed no differences between groups.

5 Results

5.1 Identifying the factor structure

The 15-indicator instrument was refined using the pooled data. The data collected by using the direct observation method were recorded into five categories before analysis. The data for the number of visits indicator, which represent the number of clicks, were recorded into five categories as (1 = over 250), (2 = 201–250), (3 = 151–200), (4 = 101–150), (5 = fewer than 100). Similarly, the data for the indicator frequency of use, representing the number of days the user spent on the e-learning system, were recorded as (1 = 5–7), (2 = 4), (3 = 3), (4 = 2), (5 = 1), and the data for the indicator duration of use, representing the number of hours the user spent on the e-learning system, were recorded for analysis as (1 = over 8), (2 = 6–8), (3 = 4–6), (4 = 2–4), (5 = fewer than 2). The original values for the indicator test results were recorded to one of five values in the same way as the other indicators since they were collected by using direct observation (1 = less than 94), (2 = 94–95), (3 = 96–97), (4 = 98–99), (5 = 100). And finally, the data for the indicator degree of progress, which represent additional test attempts, were recorded as (1 = 4 and more), (2 = 3), (3 = 2), (4 = 1), (5 = 0). Descriptive statistics for all indicators is presented in Table 3.

The data from all participants were considered together. The researchers conducted exploratory factor analysis (EFA) using M*plus* software to examine the factor structure of the 15-indicator instrument. Even though the authors had a priori factor structure of the measured variables based on previous literature and studies, they conducted EFA to test the instrument in the environment of Eastern Europe,

Table 3 Descriptive statistics, rotated factor loadings for 14-indicator model, and reliability of latent constructs

Indicator	Mean (SD)	System quality (SQ)	Use of system (US)	User satisfaction (SA)	User performance (UP)	Net benefit (NB)
(1) User-friendly	3.98 (1.17)	0.955				
(2) Easy to use	3.89 (1.23)	0.933				
(4) Number of visits	3.38 (0.97)		0.846			
(6) Duration of use	4.02 (1.07)		0.748			
(5) Frequency of use	3.90 (1.12)		0.694			
(7) Use after business hours	1.28 (0.45)		0.388			
(9) Reaction to instructions	4.57 (0.87)			0.912		
(11) Overall satisfaction	4.32 (0.93)			0.904		
(8) Reaction to content	4.38 (0.92)		−0.132	0.856		
(10) Reaction to environment	4.46 (0.88)			0.828		
(12) Test results	3.58 (1.13)				0.729	
(13) Degree of progress	3.44 (1.35)				0.643	
(14) Increased knowledge	4.35 (0.76)					0.904
(15) Improved attitude	4.43 (0.77)					0.710
Cronbach's alpha		0.925	0.638	0.922	0.636	0.771

Indicators with $|t| < 1.96$ were deleted. Significant at 95 % level

where previous research is scarce, to compare the results with theory and empirical findings. The sample of data consisting of 279 responses was examined using a common factor model and weighted least square (WLS) as the extraction method, and geomin rotation method (the default in M*plus*). WLS in M*plus* is known as WLS mean-and-variance adjusted (WLSMV) and is recommended when data are with different types of measurement level (Schmitt 2011). To improve the validity of the model through EFA, the following decision rules were employed: (1) using the eigenvalue-greater-than-one, (2) screen test—visual plot of eigenvalues, (3) deleting indicators with t-value lower than 1.96, (4) Chi-square (χ^2) goodness-of-fit test (Hair et al. 2009). In addition, model fit was further analyzed by model fit indices (i.e. root mean square error of approximation-RMSEA, comparative fit index-CFI found in M*plus*)(Asparouhov and Muthén 2009). Hu and Bentler (1999) recommended limits for RMSEA to be lower than 0.08 and for CFI to be greater than 0.95.

An iterative sequence of factor analysis was executed. Eigenvalues of the explained variances for these factors ranged from 1.187 to 9.490.At the end of the factor analysis procedure, one indicator was deleted—responsiveness—since it had t-value lower than 1.96, and obtained 5-factor, 14-indicator model. The five-factor solution indicated adequate fit, $\chi^2(51) = 76.751$, $p < .01$; RMSEA = 0.052, CFI = 0.992. The factors were interpreted as system quality, use of system, user satisfaction, user performance, and net benefit. Table 3 summarizes the descriptive statistics and rotated factor loadings for the 14-indicator model.

The significant loadings of all indicators on the single factor indicate unidimensionality. Indicator 8 belongs to factor User Satisfaction more than Use of system for a couple of reasons. First, statistical significance shows a higher degree of belongings. Secondly, subsequent literature review showed it is not justifiable to have indicator 8 in construct use of system.

5.2 Reliability and validity assessment

Reliability was evaluated by calculating Cronbach's alpha coefficients. As indicated in Table 3, the reliability of each factor was as follows: system quality = 0.925; use of system = 0.638; user satisfaction = 0.922; user performance = 0.636; net benefit = 0.771. All the Cronbach's alpha coefficients satisfied the minimum criterion value of 0.60 or greater, as suggested by Hair et al. (2009).

For the purpose of validity testing of the research model, the confirmatory factor analysis (CFA) was conducted by Exploratory Structural Equation Modeling (ESEM) (Asparouhov and Muthén 2009). Convergent and discriminant validity was tested by ESEM technique in M*plus*. Convergent validity tests cohesiveness of a set of indicators in measuring their underlying construct and it can be assessed with Tucker-Lewis index (TLI; Bentler and Bonett 1980) using ESEM. One of the advantages of ESEM is that small cross-loadings do not need to be eliminated from the model (Asparouhov and Muthén 2009) as it was the case in our EFA. Convergent validity assessment criteria are met for all constructs and TLI value for the measurement model is presented in Table 5.

Discriminant validity represents distinctiveness of the factors measured by different sets of indicators. The difference between Chi-square value for pairs of constructs in the model and Chi-square value when the correlation between these constructs is fixed at 1 must be statistically significant ($p \leq 0.01$; Ahire et al. 1996; Delic et al. 2013). This criterion is met for all the constructs. Table 4 lists the correlations among the constructs.

In this analysis the following goodness of fit tests were conducted as well: Chi-square, RMSEA, CFI, TLI, and Weighted root mean square residual (WRMR). The recommended values for fit statistics according to several authors (Hu and Bentler 1999; Asparouhov and Muthén 2009; Schmitt 2011) are provided in Table 5.

5.3 Structural modelling

As Table 5 shows, all fit indices values are in the acceptable range, indicating a good fit of the model. Path coefficients are shown in Fig. 2.

Table 4 Correlation of latent constructs

Construct	SQ	US	SA	UP	NB
SQ	0.860[a]				
US	0.301	0.777[a]			
SA	0.392	0.051	0.732[a]		
UP	0.045	0.243	0.226	0.709[a]	
NB	0.342	0.050	0.556	0.153	0.859[a]

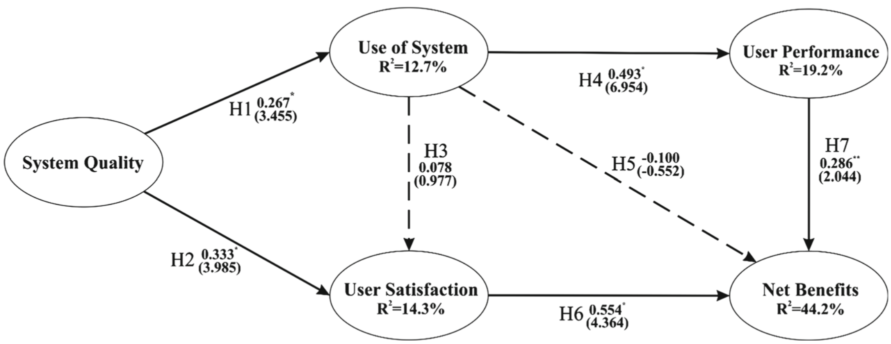
SQ system quality, *US* use of system, *SA* user satisfaction, *UP* user performance, *NB* net benefit

[a] It indicates the square root of average variance extracted (AVE) of the construct

Table 5 Summary of goodness of fit statistics for EFA, ESEM and SEM

Model	χ^2	df	RMSEA	CFI	TLI
EFA	76.751*	51	0.052	0.992	0.980
ESEM (CFA)	76.799*	50	0.052	0.992	0.980
SEM	86.761*	47	0.062	0.979	0.970
Recommended	less, the better		<0.08	>0.95	>0.90

* *p* value <.001; RMSEA = root-mean-square error of approximation; CFI = comparative fit index; TLI = Tucker-Lewis index



Note. statistically significant ————; statistically non-significant -----------; $^{*}p < 0.01$, $^{**}p < 0.05$, () z-score

Fig. 2 Structural model

The relationship between the system quality construct and the use of the system was found to be strong and significant (H1, path coefficient = 0.267; t = 3.455). System quality was also significantly associated with user satisfaction (H2, path coefficient = 0.333; t = 3.985). Regarding the relationship between the use of the system and user satisfaction, there was no statistical significance (H3, path coefficient = 0.078; t = 0.977), nor with the relationship between the use of the system and net benefits (H5, path coefficient = −0.100; t = −0.552). The strongest and the most significant relationship in the model was found between the use of the system and user performance (H4, path coefficient = 0.493; t = 6.954). There was a strong statistically significant relationship between user satisfaction and net benefits (H6, path coefficient = 0.554; t = 4.364), and a moderate relationship between user performance and net benefits (H7, path coefficient = 0.286; t = 2.044).

6 Discussion

Based on our model and structural equations, it can be said that technical system quality is one component of measuring the success of an e-learning system in an enterprise and, through a direct effect on user satisfaction and the use of the system, it can also affect the success of these systems. Hence, whenever the technical quality of an e-learning system is higher, user satisfaction and the use of the e-learning system is higher. Instructors and system designers should make full use of user friendliness and ease of use of the system to increase user satisfaction and the use of the system when it comes to e-learning systems. Higher user satisfaction and higher use of the system leads to an increased success of e-learning systems. Due to the direct impact of user satisfaction and user performance on the benefits of using the system, the benefits will be higher. More satisfied users and higher user performance will result in increased knowledge and improved attitude towards the organization. Instructional designers should make full use of the content, instruction and online environment of the e-learning system, as well as of the use of tests and tracking the progress of participants to increase the benefits of using the system. System quality, through the impact on user satisfaction can influence net benefits of using the e-learning system indirectly. When the use of an e-learning system is higher, user performance will increase (direct effect). Hence, the use of the system, through a direct effect on user performance, can also affect the success of these systems. In addition, the use of the system through user performance will indirectly increase the benefits of the system and make it more effective. The more e-learners use the e-learning system, this will have a direct impact on their test results and their rate of progress and an indirect effect on increased knowledge and improved attitude towards the organization.

It was found that the relationships between the use of the system and user satisfaction, and between the use of the system and net benefit are not statistically significant. These results are not unusual since there are other studies that found no statistically significant relationship between the use of the system and user satisfaction (e.g. Hassanzadeh et al. 2012; Seddon and Kiew 1996), and the use of the system and net benefit (e.g. McGill et al. 2003; Wu and Wang 2006). Such results revealed the weaknesses of the original IS success model since our results showed the presence of a high degree of validity of the quantitative analysis. Moreover, weaknesses are evidenced even in the case of observation as a data collection method.

On the other hand, the suggestion made by Venkatesh et al. (2013) to use different data collection methods led to the development and use of a new measure in the research model. These findings are also in line with the suggestion made by

Kaplan and Duchon (1988). The multimethod approach gave useful results and all constructs in the model applied equally well. The relations between constructs within the different data collection method (i.e. survey, direct observation) showed a high degree of significance (i.e. system quality on the use of the system and user performance on net benefits). Even though subjective measures are convenient and easy to measure, it is necessary to use objectively measured dimensions of IS success to understand the relations and measurement dimensions better.

This study presented an empirically validated model for measuring an e-learning system success. Our instrument can be utilized to assess the success of enterprise e-learning systems from the employee perspective. This evaluation will provide fast and prompt feedback to the company. IS managers that are handling e-learning processes within the company can use taxonomy that consists of system quality, use of system, user satisfaction, user performance and net benefits, to improve their understanding of the level of e-learning success and take corrective actions for enhancement if necessary. Furthermore, this research is the first one to consider evaluating the success of IS by using a multi-method, combining observation and survey as two different research methods which led to the development of a new measure in the research model.

7 Conclusion

This research paper examined the IS success of an e-learning system on the individual level of analysis. In this research, synergy was created and important details in the advancement of IS discipline revealed by using a multi-method of data collection. The combination of different data collection methods helped to extend the original DeLone and McLean model. By adding one new construct, the extended D&M IS success model applied equally well and helped to deeper understand the key success dimensions and their interrelationships, as well as the weaknesses of the original model. This implies that firms should focus not only on subjective parameters but also on objective ones. For example, they may benefit from focusing on the observation of an e-learning system by looking at the system logs and combining the data with the subjective experience of e-learners. This concept enables IS managers to better leverage investments in company's information systems, in particular e-learning systems. This is particularly true if the firm is building the success measures of their IS only on subjective opinions and neglecting objective data.

Based on the previous research on IS success, this study has conceptually defined a modified D&M IS success model, operationally designed an initial indicator list, and empirically validated the general instrument. The final model indicates adequate validity of the company's e-learning system. This research has proven to be a valid and reliable step towards the improved IS success measurement and either our instrument or our approach for creating and validating instruments should be adopted and further tested in different contexts. The model developed in this study can be used for evaluating the system for e-learning and the impact of this system on the performance of the company from the perspective of the employee. For example, IS development teams responsible for e-learning systems should take full advantage of the technical system quality (i.e. easy to use and user friendly) to increase employee satisfaction and the use of the system. This assessment will enable companies to quickly come up with feedback on the effectiveness of the implemented information system.

Information technology managers responsible for developing and implementing e-learning systems in the company can use the proposed model which consists of the system quality, use of system, user satisfaction, user performance and net benefits, to improve their understanding of the success of these systems and, if necessary, successfully undertake corrective measures for improvement. Based on the relationships in the model, companies can assess to which dimensions they need to pay close attention to improve the success of the implementation and use of the e-learning system. For example, if the instrument indicates satisfaction as a problematic dimension, the company can take advantage of that to improve the quality of the system in order to improve customer satisfaction and make the system more effective.

The audit process and its application to the example of the e-learning system does not differ greatly from other IS in the company. All IS within the company should be fully integrated, that is routinized into the organizational processes, to produce the expected benefits (Armstrong and Sambamurthy 1999). Bearing in mind that the audit process usually takes from 6 months to 1 year after initial implementation (Markus and Tanis 2000), IS success assessment is twice recommended in the first year. Afterwards, if the results are satisfactory, the instrument could be administered on an annual basis.

Limitations to this study are in the areas of sampling. The sample was drawn from a highly homogenous group belonging to a single company, probably lacking the diversity that can be expected from a comparable sample chosen from across the entire industry or different industries. Future studies should be conducted to evaluate the resulting models, using a sample from the entire industry or different industries. In addition, this model can be tested in different institutional settings, including primary and secondary schools and universities. Another limitation is within the characteristics of the sample population. We selected only a subset of the population who were interested in e-learning and were motivated to participate in the survey not taking into consideration the rest of the participants from the initial population. Hence, this research does not take into account the logs of the participants who did not complete the online training. The question is what would be the results of the study if the logs of the participants who did not answer the survey were incorporated into the analysis. Thus, the primary focus in future research will be on the comparative analysis of the research model between groups.

Appendix: Survey items used in this study

System quality

SQ1 The eGovernment system is user friendly
SQ2 The eGovernment system is easy to use

User satisfaction

US1 You are satisfied with the content of the e-learning system
US2 You are satisfied with the instructions on how to use the e-learning system
US3 You are satisfied with the e-learning environment
US4 Overall, you are satisfied with this e-learning system

Net benefits

NB1 The e-learning system helped me to improve my knowledge
NB2 The e-learning system helped me to improve my attitude towards the organization

Note This appendix presents only survey items. Observation items are not presented here.

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