Evaluating e-courses based on value flow models estimation

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Abstract: Information Systems (IS) evaluation is of critical importance for assessing the value they generate and its main determinants, and identifying weaknesses and improvements priorities. This paper proposes a new approach for the multidimensional evaluation of IS in the domain of e-learning, which enables the assessment of the value generated at various levels and dimensions, and also the identification of the whole mechanism of value creation and flow. The proposed approach has been applied for evaluating an e-learning course in the domain of cultural heritage developed as part of the ERMIONE Project. By using Structural Equation Modelling (SEM), and in particular the Partial Least Squares (PLS) approach, the value flow model of this e-course has been estimated and used for drawing conclusions concerning the value generated at various levels and improvements priorities.

Keywords: IS evaluation; e-learning evaluation; value flow models; SEM; structural equation modelling; PLS; partial least squares.

Reference to this paper should be made as follows: Pazalos, K.A., Loukis, E.N. and Georgiou, S.D. (2009) 'Evaluating e-courses based on value flow models estimation', *Int. J. Applied Systemic Studies*, Vol. 2, No. 4, pp.376–394.

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1 Introduction

Organisations make large investments for various kinds of Information Systems (IS), from which they expect positive impacts both in their functions and processes and also at the financial level (e.g., cost reduction, profitability increase, etc.). Therefore it is of critical importance for organisations to estimate the 'real value' generated by their IS investments and compare it with the 'expected value' and also to find ways to maximise the value generated by their IS investments. Highly important in this direction is IS evaluation, which is defined as a process that takes place at different points in the lifecycle of an IS in order to identify and make explicit, quantitatively or qualitatively, all the impacts of it (both the positive and the negative ones) (Farbey and Targett, 1999). IS evaluation is regarded as a highly difficult and complex problem, because the benefits and, in general, the value created by most categories of IS are multi-dimensional, tangible and intangible, financial and non-financial, so it is difficult to decide 'what' or 'how' to measure for their evaluation (Hirschheim and Smithson, 1988; Farbey et al., 1995, 1999; Smithson and Hirscheim, 1998; Irani, 2002; Gunasekaran et al., 2006). Moreover, different categories of IS have different objectives and produce different types of benefits and value, so they require different kinds of evaluation methods. For this reason the development of a general IS evaluation method, which is suitable for all types of IS is not possible; therefore it is necessary to develop specialised IS evaluation methods and frameworks, which are suitable for specific types of IS. Recently there has been considerable research interest not only in the assessment of the multi-dimensional value generated by IS, but also in identifying its main determinants and in finding ways of increasing it (e.g., Ramirez, 2003; Melville et al., 2004; OECD, 2004; Arvanitis, 2005; Loukis et al., 2008).

This paper proposes a new approach for the multi-dimensional evaluation of a very interesting and rapidly growing category of IS, the e-learning IS, which is regarded as IS that support acquisition of new skills and knowledge by individuals. E-learning is defined as "the acquisition and use of knowledge distributed and facilitated primarily by electronic means" (Whallen and Wright, 1999). E-learning systems play a crucial role nowadays, not only in pure educational environments (schools, universities, etc.), but also in organisations competing in knowledge-intensive industries, which invest great amounts of financial resources in upgrading the skills and knowledge of their employees, both in ‘off-line’ (traditional) and ‘online (e-learning) mode. For this reason the evaluation of e-learning is highly important. Evaluation is a key aspect of any educational activity and aims at assessing the effectiveness, and also the possible improvements upon it. E-learning has brought in big innovations in the way courses are taught, in the role of the teacher, in the interaction between teachers and learners and in the interaction between the learner and the content in comparison with the traditional education. For this reason the evaluation of e-learning cannot be performed using the methods mentioned that have been developed and used for the evaluation of the traditional education (Hoyt and Cashin, 1977; Marsh, 1982; Cashin and Downey, 1992).

In this direction the research objective of this study is to develop a new multi-level approach for e-learning IS evaluation, which can capture the multidimensionality of e-learning value by including three layers of value measures: ‘efficiency measures’, ‘effectiveness measures’ and measures of ‘intended future behaviour’, and also estimations of the relations between the value measures of the above three layers, finally resulting in a model of value generation and flow. For this purpose we are using a quantitative methodology: based on the e-learners’ assessments collected through a questionnaire-based survey, a Structural Equation Model (SEM) is estimated, which allows the identification of the importance of each layer and its impact on the following layers, and finally the formulation of a prioritisation strategy for improvements in the e-learning system. It should be noted that the proposed evaluation approach has wider applicability, and can be used for evaluating any type of IS, after appropriate adaptation (i.e., definition of appropriate efficiency, effectiveness and intended future behaviour measures for the particular type of IS).

The paper is structured in six sections. In Section 2 the background is presented, which consists of the findings and conclusions of previous relevant research. Then, Section 3 presents the value flow model – based approach for e-learning IS evaluation and the structure of the model. Section 4 describes the research and data analysis method used for the construction of the value flow model (SEM – Partial Least Squares (PLS)). Section 5 presents and discusses the results of a first application of the proposed e-learning evaluation approach for the evaluation of an e-learning course in the domain of cultural heritage, which has been developed as part of the ERMIONE Project of the eTEN Program of the European Union. Finally, Section 6 includes a summary, conclusions and further research directions.

2 Background

For many decades, long before the emergence of e-learning, extensive research has been conducted concerning the evaluation of traditional education, especially in the area of students’ evaluation of (traditional) teaching effectiveness (SETE) (Marsh, 1982; Marsh, 1987; Hoyt and Cashin, 1977, Cashin and Downey, 1992). Wang (2003) mentions the following six most important SETE instruments: the Instructional Development and Effectiveness Assessment (IDEA), the Students’ Evaluations of Educational Quality (SEEQ), the Endeavour Instrument, the Student Instructional Rating System (SIRS), the Instructor and Course Evaluation System (ICES) and the Student Description of Teaching (SDT) Questionnaire; the first two of them are the most widely used ones. The IDEA instrument (Hoyt and Cashin, 1977; Cashin and Downey, 1992) consists of

38 evaluation criteria, which are grouped in four evaluation dimensions: instructor methods, students' ratings on course objectives, course content and students' self-ratings. The SEEQ instrument (Marsh, 1982, 1987) is longer and includes nine evaluation dimensions: learning/value, enthusiasm, organisation, group interaction, individual rapport, breadth of coverage, exams/grades, assignments and workload. However, because of the abovementioned important differences between e-learning and traditional education, it is not possible to use the above SETE instruments for evaluating e-learning, even though some elements of them can be used in e-learning evaluation methods.

Some research has been conducted in the e-learning evaluation area, which has resulted in the development of a number of high-level e-learning evaluation frameworks. The most well-known framework for measuring the effectiveness of training programmes, which has been used both for traditional training and e-learning, has been developed by Kirkpatrick (1983). It includes four levels of evaluation dealing with Learners Reaction, Learning Outcome, Workplace Behaviour and Organisational Results. Another e-learning evaluation framework has been developed by Jackson (1998); it is based on the evaluation of e-learning objectives (intentions), implementation and outcomes, and suggests that it is necessary to take into account also the context (previous knowledge, attitudes and conceptions of the e-learners). A more detailed framework is the 'Evaluating Learning Technology' (ELT) (Oliver and Conole, 1998), which provides proposes six e-learning evaluation stages and includes guidance for implementing them: identification of stakeholders, formulation of questions to each group of stakeholders, selection of a research approach (quantitative or qualitative), selection of data capture techniques, selection of data analysis techniques and choice of presentation format. Garrison and Anderson (2003) propose that e-learning evaluation should include seven stages: determination of strategic intent of the e-learning program, examination of the courses' content, examination of the design of the interfaces, identification of amount of interactivity supported, evaluation of student assessment methods, measurement of the degree of student support and evaluation of outcomes. However, the existing e-learning evaluation frameworks are at a very high-level and much more abstract than the SETE instruments, since they propose only evaluation stages and directions, so they need further development, improvement, elaboration and also empirical investigation in 'real life' settings. Also, according to Dempster (2004), this area is characterised by the

> "absence of widely established and practiced methodology by which rigorously to evaluate e-learning, and through which to develop the secure body of knowledge on which to build learning technology as a discipline."

Another relevant research stream applies the Technology Acceptance Model (TAM) (Davis, 1989; Venkatesh and Davis, 2000; Venkatesh et al., 2003), usually with some extensions, for investigating the acceptance of e-learning and its main determinants. These TAM extensions deal with the identification of factors affecting either the extent of use of e-learning, or the intention of e-learners to use it in the future or recommend it to colleagues (as measures of user acceptance), which are regarded as the basic surrogate measures of the value that e-learning generates (Selim, 2003; Martins and Kellermans, 2004; Saade and Bahli, 2005; Ngai et al., 2005; Chiu et al., 2005). However, this research stream focuses on drawing general conclusions and developing theory concerning the acceptance of e-learning (in general or by particular target groups) and its main determinants and not on the evaluation of particular e-learning IS or courses.

Also, interesting research has been conducted in the area of e-learning programmes (courses) quality, which has produced quality frameworks with elements that can be used in e-learning evaluation methods. Lorenzo and Moore (2002) proposed five basic quality determinants of online education ("Five Pillars of Quality Online Education"): Learning Effectiveness, Student Satisfaction, Faculty Satisfaction, Cost Effectiveness and Access. Ehlers (2004, 2005) identified seven basic fields of e-learning quality from the e-learners' viewpoint: tutor support, cooperation and communication in the e-course, technology, costs-expectations-value relation, information transparency concerning the e-course and its provider, e-course structure and didactics. Euler and Seufert (2006), following a holistic approach to e-learning quality propose six quality dimensions: programme strategy, pedagogy, economics, organisation, technology and culture.

Another research stream has focused on the identification of the e-learning Critical Success Factors (CSFs). Volery and Lord (2000) concluded that the main CSFs in e-learning are technology (ease of access and navigation, interface design, level of interaction), instructor (attitudes towards students, technical competence, and classroom interaction) and previous use of technology by the students. Soong et al. (2001) identified the following CSFs of e-learning: human factors concerning the instructors (motivational skills, time and effort investment), technical competency of instructors and students, constructivist mindset of instructors and students, high level collaboration, user-friendly and sufficiently supported technical infrastructure. Selim (2005) investigated what university students perceive as CFSs for e-learning acceptance, and identified eight major CSF categories: attitude towards and control of technology, teaching style, computer competency, interactive collaboration, e-learning course content and design, ease of access, infrastructure and support. Lim et al. (2007) investigate the factors affecting the learning performance in corporate e-learning and the extent of application of the acquired knowledge and skills to daily work for improving job performance. They found that learners' motivation and computer self-efficacy, content, face-to-face meeting with between instructor and learners, ease of access to and use of the web-site, support from supervisors and encouraging environment affect positively learning performance. Also learners' motivation, content, support from supervisors and learning performance positively affect the extent of application of the acquired knowledge and skills for daily work.

The conclusion from the above literature review is that a complete and widely applicable e-learning evaluation method, which offers practically applicable and useful information concerning all the types of value generated by e-learning and the relations among them, is missing. However, the abovementioned relevant research streams (dealing with evaluation of traditional education, e-learning evaluation, TAMs, e-learning quality, e-learning CSFs) provide elements that can be useful in this direction. Therefore, further research is required for the development of practically applicable, useful and mature methods for evaluating the variety of types and forms of e-learning activities that take place in 'real-life' (i.e., are conducted by universities and other educational organisations, enterprises, etc.), as well as for investigating and validating such methods in 'real-life' conditions and situations. Such mature e-learning evaluation methods should generate rich and useful information concerning the different types of value that e-learning generates, their main determinants, the mechanisms of their creation and also guidance for possible interventions/improvements for increasing this value.

3 A value flow model – based method for e-learning evaluation

By synthesising elements from the above-mentioned relevant research streams a new multilevel and value flow model – based method for e-learning evaluation has been developed. As we can see in Figure 1 it consists of three layers of value measures:

- 'efficiency measures' (for the evaluation of the basic resources and capabilities offered by an e-learning system: educational content, electronic support by the instructor, development of a learning community during the e-course, system technical quality and reliability, capabilities for customisation of each e-learner's learning style and needs and Perceived Ease of Use (PEOU))
- 'effectiveness measures' of higher level (such as the extent of usage of the e-learning system and its educational effectiveness – accomplishment of e-learners' educational objectives (ACEO))
- measures of 'intended future behaviour' (for the evaluation of the intention of the e-learners to use the e-system in the future and recommend it to colleagues).

Figure 1 Structure of the e-learning multi-layer evaluation and value flow model estimation method

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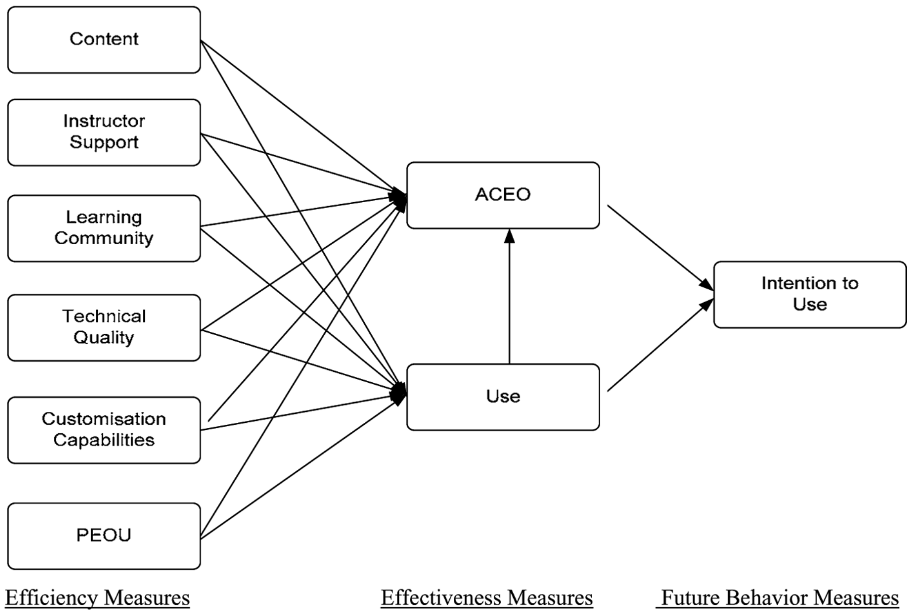


These value measures have been selected based on an extensive review of the relevant literature, which is outlined in the previous Section 2. In particular, PEOU, Use and Intention to Use are the main elements of the TAM (Davis, 1989), which have been used in e-learning acceptance literature (Selim, 2003; Chiu et al., 2005). Educational content is the basic element of education, and its evaluation is of critical importance, so it has been used extensively in the evaluation of traditional education (Hoyt and Cashin, 1977; Cashin and Downey, 1992), as well as of e-learning (Selim, 2005; Lim et al., 2007).

The Accomplishment of the Educational Objectives (ACEO) has been conceptualised from the SEEQ instrument of traditional education evaluation (Marsh, 1982), as well as from the work of Kirkpatrick (1983), as a major indicator of e-learning effectiveness. The importance of the electronic support by the instructor has been emphasised both by e-learning quality literature (Ehlers, 2005) and by the e-learning critical support factors literature (Volery and Lord, 2000; Lim et al., 2007). Also, Selim (2005) and Volery and Lord (2000) mentioned that the degree of 'interaction' between students and instructor influences the effectiveness of an e-learning course, so in this study this interaction is assessed through the 'Learning community' measure. Finally, due to the fact that this study evaluates a new e-learning IS, we added a measure of 'Technical quality' (ISO/IEC 9126, 2001) in order to assess the quality of it from a technical viewpoint and its technical reliability.

The proposed evaluation method includes the assessment of all these value measures for the particular e-learning course by the e-learners through a questionnaire-based survey; each value measure can be measured either through one question/item (for the clear and directly understandable ones), or through multiple questions/items as a multi-item construct (for the unclear and not easily understandable ones). Then the average is calculated for each value measure and also for each layer. Finally the relations between the value measures of the above three layers are estimated, either simply by calculating correlations between them, or by using more sophisticated techniques, such as regression (using as dependent variables the value measures of layer N and as independent variables the value measures of the previous layer N–1) or Structured Equations Modelling (SEM) (as described in more detail in Sub-sections 4.1 and 4.2). The assessment of the averages of the multiple value measures of the above three layers as well as the estimation of the relations among them crates a 'value flow model' (Loukis et al., 2007), which includes:

- the value created by the basic resources and capabilities offered by an e-learning system (at the first layer)
- how this value results in higher layers' value associated the accomplishment of educational objectives
- how the above layers of value result in value associated with intended future behaviour (i.e., with intention to use in the future or recommend it to colleagues).

This approach constitutes an extension to the 'classical' TAMs approach (mentioned in the previous section) with additional measures of IS value. It is theoretically founded on the process theory of Soh and Markus (1995). According to this theory, the process of value creation from IS starts from 'IT Expenditures', which through a conversion sub-process result in 'IT-Assets'; then these IT-Assets through a usage process produce 'IT-Impacts', which finally affect the organisational performance. For the case of e-learning an appropriate mix of 'IT-Assets' should be provided to the learner, so this basic concept has been analysed into the six e-learning resources-capabilities of the first layer of Figure 1. These assets produce 'IT-Impacts' associated with use of the e-learning system and finally learning and accomplishing e-learners' educational objectives; also they produce second level 'IT-Impacts' as well, which are associated with intention to use the e-system in the future and recommend it to colleagues. It should be noted that the proposed e-learning evaluation approach is also theoretically founded on the multi-dimensional and multi-layered approaches of the IS success literature (e.g., DeLone and McLean, 1992, 2003; Seddon, 1997).

The final step of the proposed method is the definition of priorities concerning the e-learning resources and capabilities (of the first layer) that should be improved based on two criteria:

- the average rating by the e-learners,
- and the effect on higher layers value measures

In particular, our limited resources (e.g., human resources, financial resources, etc.) should be focused on the improvement of the e-learning resources and capabilities that have lower average ratings by the e-learners and, at the same time, strong effects on the creation of higher layers' value.

4 Research and data analysis method

The above approach has been applied for the evaluation of an e-learning course titled "Electronic Management of Digital Cultural Heritage Resources", which has been developed as part of the ERMIONE Project of the eTEN Program of the European Union. The e-learners were 68 students from the Universities of Aegean (Greece) and Leuven (Belgium), who participated in the above e-course through the ERMIONE e-learning platform (http://ermione.eurodyn.com). After the end of this e-course the e-learners were asked to evaluate it by answering a structured questionnaire comprising 20 questions related to all the above value measures. The choice of the number of questions/items included for each e-learning value measure was based mainly on how clear and directly understandable it was, taking also into account existing questionnaire length limitations. The questionnaire had to be kept at a reasonable size, so that the above students can quickly and easily read and fill it. For this reason for the clear and directly understandable value measures only one question/item has been included in the questionnaire; on the contrary, for the more complex and ambiguous value measures several questions/items have been included (as items reflecting the corresponding construct). The single-item value measures were Content, Instructor's Support, Customisation Capabilities, System Use and Accomplishment of Course Educational Objectives (ACEO); on the contrary several items were included for the value measures concerning Learning Community, Technical Quality, PEOU and Intention to Use. In the following Table 1 are shown the nine value measures as well as their related items and questions (20 in total). Due to the fact that the questionnaires were completed during face-to-face sessions after the end of the e-course, the response rate was very high at the level of (96%) receiving a total of 65 valid responses.

For estimating the parameters of the above value flow model shown in Figure 1 (including nine constructs and 20 items) we used Structural Equation Modelling (SEM) and, in particular, the PLS approach. Subsection 4.1 provides a brief introduction in SEM focusing on the PLS approach used in the present study.

Table 1 Value measures and corresponding items of the initial value flow model

Value measures	*Items*	*Questions*
Content	EdCont	The educational content of the e-course you participate in was very good
Instructor's support	InSup	The overall electronic support provided by the instructor (e.g., electronic answers to questions, the use of the forum tool among students and the instructor to share common interest, etc.) was very good
Learning community	ComDev	In your opinion, was the development of a community feeling possible thanks to the 'Forum functionality' and the exchange of information between students and instructors?
	ComBel	If you answered positively to the previous question, to which extent did you feel you belonged to a remote community of online learners sharing the common goal of learning a specific topic?
	ComImpro	If you answered positively to the same question, was the community feeling helpful to improve the learning process of eRMIONE functionalities?
Technical quality	RespTime	To which degree are you satisfied with the eRMIONE response time to the users' input?
	SysErrors	Did you experience system errors while using eRMIONE?
	ErRel	To which degree are you satisfied with the reliability of the eRMIONE service as far as errors are concerned?
	CrashExp	Did you experience unexpected crashes of the eRMIONE system?
	CrashRes	In case of a crash, was the restart easy?
Customisation capabilities	ProCus	eRMIONE offers the opportunity to customise the learning process according to your wishes and learning needs
Perceived Ease of Use (PEOU)	LearnDif	Was it difficult to learn how to use the basic functionalities of eRMIONE?
	GUISat	Are you satisfied with the user interface (screens, menus, toolbars, buttons, etc.)?
	GuideUse	Did you often use the 'Help service'?
	GuideSat	Are you satisfied with the supporting level of the provided system guides to use the software?
	OperSeq	To which degree the sequences of operations to perform the basic tasks of eRMIONE are easy to remember and repeat?
USE	SysUse	I have profusely used the eRMIONE e-learning system and services while participating in the e-course
Educational effectiveness	KnowIm	The eRMIONE service offered me the opportunity to improve knowledge on a specific topic through the e-course I took part in (e.g., the acknowledgement of new concepts, terms, methods, technologies, etc.)
Intention to use	FutAtt	I would attend another e-course on a similar subject provided by eRMIONE
	Recom	I would recommend eRMIONE to other students

4.1 Structural Equation Modelling (SEM)

SEM is a combination of factor analysis and path analysis (Hox and Berger, 1998; Kline, 2005). It constitutes a 'second generation' statistical technique that offers several important advantages over the 'first generation' techniques (such as Multiple Regression Analysis, Analysis of Variance (ANOVA), Principal Components Analysis, etc.), enabling:

- the modelling of complex relationships among multiple predictor (independent) and criterion (dependent) variables, in which one variable can be at the same time dependent and independent (e.g., a 'mediating' variable)
- the construction of unobservable Latent Variables (LV), which are estimated from observed variables
- error modelling in measuring the observed variables
- the simultaneous testing of structural and measurement assumptions using empirical data.

There are two kinds of SEM techniques (each of them supported by a different family of software tools): the covariance-based ones (supported by software tools such as LISREL, EQS, AMOS, etc.) (Byrne, 2001) and the variance-based (or component-based) ones (supported by the PLS-GRAPH software tool) (Chin, 1998; Haenlein and Kaplan, 2004). Covariance-based SEM constitutes a 'hard modelling' approach, which is characterised by several distributional assumptions and necessitates large samples. An advantageous alternative is the PLS variance-based SEM approach, which was first introduced by Wold (1975), being a 'soft modelling' approach with very few distributional assumptions and can be performed even with smaller samples.

The basic difference between the two SEM techniques is that in the covariance-based SEM the model parameters are calculated through minimisation of the difference between the covariance matrix of the observable variables and the one predicted by the hypothesised model, while in PLS model parameters are calculated through maximisation of the percentage of the variance of the dependent variables explained by the independent ones (Haenlein and Kaplan, 2004). Also, PLS can simultaneously model the structural paths (i.e., relationships among unobservable variables, called LVs) as well as the measurement paths (i.e., relationships between a LV and its corresponding items/observable variables, called MVs), while it also includes a third component, the weight relations, which are used to estimate case values for the LVs as linear combinations of their corresponding MVs. Another difference is that, in covariance-based SEM the first step is the estimation of the model parameters and then as a second step the values of the LVs for all cases are calculated. On the contrary, in PLS the first and basic step is the estimation of the weights linking each LV with its MVs, using a complex two-step algorithm (Tenenhaus et al., 2005). Then, as a second step, using those weights the values of the LVs for all cases are calculated. Finally, these LV values are used for the estimation of the structural paths between them though a number of regressions.

The PLS approach has a lot of advantages that make it more preferable than other existing SEM approaches. As mentioned above, it has very few assumptions concerning the distributions of the data. It is quite robust with regard to several inadequacies (skewness, multi-collinearity, mis-specifications of the structural model, etc.), as concluded by several studies based on simulations (e.g., Cassel et al., 1999).

It can model both reflective and formative MVs and is particularly useful in situations where constructs are measured by a very large number of items**.** Each MV varies in how much it contributes to the composite score of the LV and the weights provide a linear combination of the MVs for forming an LV score, which is not only maximally correlated with its own set of MVs, as in Principal Components Analysis, but also correlated with other LVs, according to the structural or theoretical model (Chin, et al., 2003). MVs with weaker relationships with other MVs and with their LVs are given lower weightings, so that higher reliability for the LV estimate can be achieved. The standard errors of the estimated paths can be estimated via several resampling procedures, such as the 'Jack-knife' or the 'Bootstrap' ones (Tenenhaus et al., 2005). The PLS approach can also assess the reliability of the estimated LVs with Composite Reliability (CR) indices, which do not assume equal loadings among the items (e.g., as it happens with Cronbach Alpha), so they are more accurate estimates of CR (Chin et al., 2003).

5 Results

As a first step, for each of the 20 items – value measures of the above model the average rating given for it by the e-learners has been calculated, and are shown in Table 2, together with the corresponding scale. Even though these items are all ordinal variables their averages are meaningful as comparative indicators of the value perceived the e-learners in each of these 20 value dimensions.

Table 2 Averages and standard deviations of the items-value measures

Value measure	*Item*	*Average*	*Scale*
Perceived Ease of Use (PEOU)	OperSeq	4.49	1–6
	LearnDif	2.92	1–4
	GUISat	3.05	1–6
	GuideUse	0.38	0–1
	GuideSat	4.30	1–6
Technical quality	Resptime	4.05	1–6
	Syserrors	0.57	0–1
	ErRel	4.12	1–6
	CrashExp	0.26	0–1
	CrashRes	3.09	1–4
Instructor support	InSup	4.48	1–6
Customisation capabilities	ProCus	3.84	1–6
Learning community	ComDev	0.56	0–1
	ComBel	2.75	1–4
	ComImro	4.31	1–6
Educational content	EdCont	4.30	1–6
Accomplishment of Educational Objectives (ACEO)	KnowIm	4.44	1–6
Use	SysUse	4.03	1–6
Intention to use	FutAtt	3.52	1–6
	Recom	3.70	1–6

We observe that from the e-learning resources and capabilities offered to the e-learners (first layer of the model) the main weaknesses (having the lowest average ratings) according to the e-learners concern the graphical user interface (GUISat), the customisation capabilities (ProCus) and the development of the e-learning community (ComDev). On the contrary the e-learners perceive a moderately high level of "Accomplishment of Course Educational Objectives" (KnowIm), which has been achieved through a moderately high level of usage of the e-learning system; also, they have a medium intention to attend another e-course on a similar subject provided by the same e-learning platform or recommend it to colleagues.

As a second step the value flow model shown in Figure 1 has been estimated through the PLS approach using the PLS-Graph software (Chin, 2001); it has nine constructs (LVs) and 20 items (MVs) (reflective indicators of the constructs), which are shown in Table 1. Initially, the measurement model and the factorial validity were assessed according to the guidelines proposed by the relevant literature (e.g., Gefen et al., 2000; Gefen and Starub, 2005). An examination of the standardised items loadings showed that some of them were below the recommended cutoff level of 0.6 (Chin, 1998); those items with loadings below this cutoff level (ComDev, RespTime, SysError, ErRel, GUISat, GuideUse and GuideSat) were removed and the new model was estimated to now have 13 items. All the item loadings of the 'outer model' were, this time, far above 0.6, as shown in Table 3. Additionally, convergent validity was tested by examining the *t*-values of these item loadings; all of them were above the recommended 1.96 value.

Table 3 PLS outer model loadings

Construct	*Item*	*Loading*
Perceived Ease of Use (PEOU)	OperSeq	0.787
	LearnDif	0.972
Technical quality	CrashExp	–0.817
	CrashRes	0.999
Instructor support	InSup	1.000
Customisation capabilities	ProCus	1.000
Learning community	ComBel	0.976
	ComImro	0.975
Educational content	EdCont	1.000
Accomplishment of Educational Objectives (ACEO)	KnowIm	1.000
Use	SysUse	1.000
Intention to use	FutAtt	0.999
	Recom	0.999

Then, in order to examine the reliability of the above constructs for each of them the CR was calculated, which constitutes a better internal consistency index than Cronbach's Alpha as mentioned in the relevant literature (e.g., Chin and Gopal, 1995). These CR values are shown in the last column of Table 4; we can see that all of them are above the recommended minimum acceptable level of 0.7 (Fornell and Larcker, 1981), so it is concluded that each construct of the model and their reflective indicators are reliable. Finally, the discriminant validity was examined by comparing the square root of the Average Variance Extracted (AVE) of each construct with its correlations with the other constructs according to the relevant literature (e.g., Gefen and Straub, 2005). In Table 4 we can see that the square root of the AVE of each construct was larger than any correlation between this construct and any other construct, which proves the discriminant validity of the constructs of the model. Note that for the single-item constructs the AVE receives its highest possible value (1.00).

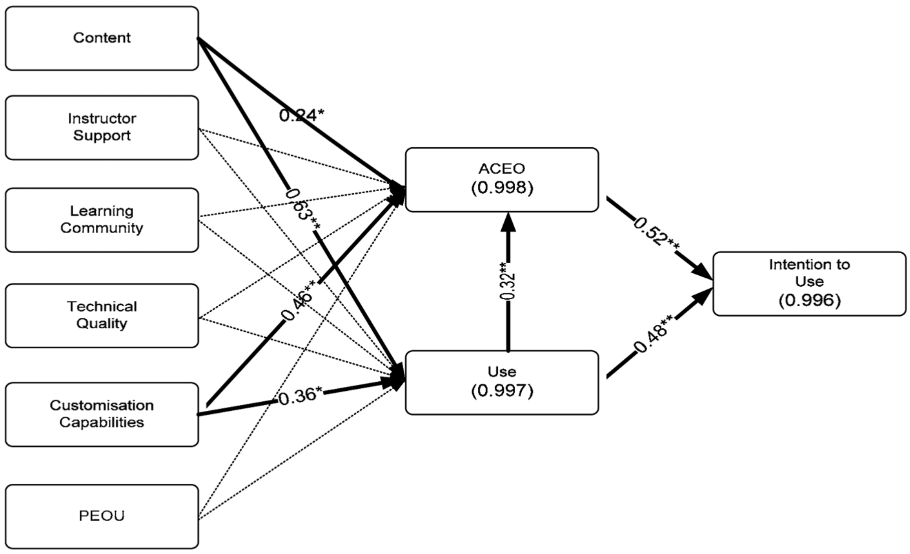
Table 4 Correlations, squared root of AVE and composite reliabilities

	PEOU	*LC*	*TQ*	*IU*	*U*	*ACEO*	*EC*	*IS*	*CC*	*SQAVE*	*CR*
PEOU	1.000									0.885	0.712
LC	–0.174	1.000								0.976	0.976
TQ	–0.173	–0.193	1.000							0.913	0.862
IU	–0.203	0.175	0.149	1.000						0.999	1.000
U	–0.207	0.162	0.135	0.997	1.000					1	1.000
ACEO	–0.212	0.177	0.141	0.997	0.998	1.000				1	1.000
EC	–0.215	0.186	0.139	0.998	0.998	0.998	1.000			1	1.000
IS	–0.290	0.142	0.164	0.814	0.813	0.807	0.808	1.000		1	1.000
CC	–0.211	0.172	0.133	0.997	0.998	0.998	0.998	0.814	1.000	1	1.000

EC: Educational Content; IS: Instructor Support; LC: Learning Community;
CC: Customisation Capabilities; TQ: Technical Quality; PEOU: Perceived Ease Of Use;
U: Use; ACEO: Accomplishment of Course Educational Objectives; IU: Intention to Use.

Next, in order to test the estimated structural model we employed the bootstrap resampling procedure (Chin, 2001; Tenenhaus et al., 2005), which enables testing the statistical significance of the PLS path coefficients. Figure 2 shows the standardised coefficients of the statistically significant paths, as well as the explained variance of the endogenous LVs (constructs) of the second and third layer of the value flow model. We observe that between the constructs of the first and the second layer of the value flow model the only statistically significant paths were those from the Educational Content to ACEO (0.24) and to Use (0.63), and also from Customisation Capabilities to ACEO (0.46) and to Use (0.36). Between the constructs of the second and the third level of the value flow model all the paths are statistically significant: from Use to ACEO (0.32) and to Intention to Use (0.48), and from ACEO to Intention to Use (0.52). Furthermore, we observe that the R^2 values of the second layer constructs are very high at the level of 0.998 and 0.997 for ACEO and Use, respectively, which means that most of the variance in ACEO and Use is explained by the value flow model. Similarly the R^2 of the third layer construct Intention to Use is very high at the level of 0.996, which means that most of the variance in users' intentions to use is explained by this model.

Figure 2 Structural model – significant paths and explained variance of the Latent Variables (LV)



*Significant at the 0.05 level.

**Significant at the 0.01 level.

From the above results it is concluded that from the e-learning resources and capabilities offered to the e-learners (first layer) only two have a statistically significant effect on the value creation of the second layer (i.e. value associated with the extent of usage of the e-learning system and its educational effectiveness – accomplishment of educational objectives):

- the completeness and structure of the educational content uploaded onto the platform has a strong effect both on the Use (direct effect 0.63) and on the ACEO (direct effect 0.24 and total effect $0.24 + 0.63 \times 0.32 = 0.44$)
- the capability offered to e-learners to customise the e-learning environment according to their needs and preferences has a medium effect on the Use (direct effect 0.36) and a strong effect on the ACEO (direct effect 0.46 and total effect $0.46 + 0.36 \times 0.32 = 0.58$).

Also, both the second layer constructs (use and ACEO) have a statistically significant effect on the creation of third layer value associated with intention for future usage:

- use has a strong effect on Intention to Use (direct effect 0.48 and indirect effect $0.48 + 0.32 \times 0.52 = 0.65$)
- ACEO has a strong effect on Intention to Use (direct effect 0.52).

Finally based on the above results we can prioritise the necessary improvements in the e-learning resources and capabilities based on the two criteria mentioned in Section 3: the average rating by the e-learners and the effect on the creation of higher levels value. Taking into account the results of Table 2 (looking at the average ratings by the e-learners for all item – value measures of the first layer) and Figure 2 (effects of the constructs of the first layer on the ones of the second layer) it is concluded that the designers of this cultural heritage e-learning course should focus:

- on reconsidering and improving the functionalities of the e-learning systems associated with the customisation/personalisation capabilities offered to users, and also
- on the quality and structure of the educational content.

6 Summary: conclusions and further research directions

In this paper we presented a multidimensional value flow model – based approach for the evaluation of e-learning IS, which is theoretically founded on conclusions and elements from various research areas, such as IS evaluation, traditional learning evaluation, e-learning evaluation, e-learning quality, e-learning CSFs, TAM and IS success and quality. The proposed evaluation approach can capture the various levels, dimensions and mechanisms of value creation in e-learning. The e-learning resources and capabilities are regarded as the basis of value creation, resulting in the use of the system and the accomplishment of the course's educational objectives, and then to a positive future behaviour concerning usage and recommendation to colleagues. The importance of these factors in general depends on the nature and the characteristics of each particular e-course.

The proposed value flow model – based approach for the evaluation of e-learning enables us to prioritise the necessary improvements in the e-learning resources and capabilities based on these two criteria: the average rating by the e-learners and the effect on the creation of higher levels value. This means that we should focus our limited resources (e.g. human resources, financial resources, etc.) on the improvement of the e-learning resources and capabilities that have lower levels of evaluation by the e-learners and, at the same time, a strong effect on higher level value measures.

For the investigated cultural heritage e-learning course developed as part of the ERMIONE Project, it has been found that from the e-learning resources and capabilities offered to the e-learners the main weaknesses concern the graphical user interface, the customisation capabilities and the development of the learning community. From its estimated value flow model it has been concluded that the quality of the course educational content and the customisation capabilities are the main resources and capabilities that have a strong statistically significant effect on the usage and accomplishment of educational objectives, while the latter have strong statistically significant effect on future usage intention. On the contrary, instructor support, technical quality, learning community and PEOU of the e-learning platform were not found to play a crucial role in the value flow model, which is in contrast with previous research findings (e.g., Soong et al., 2000, Selim, 2005); this difference is probably due to particular characteristics of the investigated cultural heritage e-learning course. Therefore, taking into account the above improvements prioritisation criteria, the designers of the investigated cultural heritage e-learning course should reconsider and improve the functionalities of the e-learning systems associated with the customisation/personalisation capabilities offered to users; also they should place emphasis on the quality and structure of the educational content.

The findings of this research offer a first validation of the "value flow model approach" in IS evaluation, which can be used as a 'guide' for an effective and applicable evaluation of not only e-learning IS, but also of any other type of IS by appropriate adaptation and definition of the basic value measures of each layer and their operationalisations, based on previous research and theory. Its basic advantage is that it enables a multi-dimensional evaluation and identification of the value creation and transformation-flow mechanisms; by knowing the roots of value creation we can focus our attention on the most important system functionalities/capabilities/resources that play the most crucial role for the users, and rationally set priorities for system improvements.

The most important limitation of the first application/validation of the "value flow model approach" presented in this paper was the small sample size. Also, there was a conscious effort by the authors to keep the questionnaire as small as possible, in order to construct a relatively simple value flow model in this first validation of this concept, as well as to achieve a high response rate among the participating students in this e-course. Future research directions include the examination of the value flow model concept and its usefulness for IS evaluation in different types of IS, with bigger samples, a more extended questionnaire, including several items for each construct, as well as the use of covariance-based SEM approaches.

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