2007

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A VALUE FLOW MODEL FOR THE EVALUATION OF AN e-LEARNING SERVICE

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Abstract

Information Systems (IS) evaluation has been one of the most important and widely researched topics for more than two decades. The evaluation of e-Learning is of critical importance in order to maximize the benefits from the huge investments made in this area. In this paper is presented a method for e-learning multi-layer evaluation and value flow model estimation. It includes evaluation of e-learning using three layers of value measures (efficiency measures, effectiveness measures, and intended future behaviour measures), and also the estimation of the relations between them. In this way a model of value generation and flow is developed. This method generates rich and useful information concerning the different types of value that e-learning creates, the mechanisms of their creation and also possible interventions for increasing them. A first application of this method is presented for the evaluation of an e-learning service in the area of the European cultural heritage that has been developed in the project e-RMIONE of the eTEN Programme of the European Union. This first application gives interesting and useful conclusions concerning the various levels of value created by the above service, as well as the generation and flow of value between these levels, and also it enables the prioritization of the resources and capabilities of this service that should be improved. In this sense this application provides positive and encouraging evidence concerning the validity and the usefulness of the method.

Keywords: e-learning evaluation, IS evaluation, Value Flow Models, Technology Acceptance Models.

1 INTRODUCTION

Information Systems (IS) evaluation, defined as a process that takes place at different points in time during the IS lifecycle in order to identify and make explicit, quantitatively or qualitatively, the impacts (both the positive and the negative ones) of an IS (Farbey et al, 1999), has been one of the most extensively researched and at the same time most complicated subjects in the area of IS for more than two decades (e.g. Hirschheim and Smithson 1988, Farbey et al 1995, Smithson and Hirscheim 1998, Farbey et al 1999, Irani 2002, Gunasekaran et al 2006). The relevant literature emphasizes that IS evaluation is highly complex, because the benefits and in general the value created by most categories of IS are multidimensional, both tangible and intangible, financial and non-financial, making it difficult to decide "what to measure" for the evaluation and "how". Moreover, different categories of IS have different objectives and produce different types of benefits and value, so they require different kinds of evaluation methods. Farbey et al (1995) classify IS into eight IS categories according to the method required for evaluating them (mandatory IS, automation IS, direct value added IS, management information and decision support systems (MIS - DSS), infrastructure IS, inter-organizational IS, strategic IS and business transformation IS) and proposes different evaluation approaches and methodologies for each of them. The development therefore of a generic "best IS evaluation method" suitable for all situations is not possible, thus it is necessary to develop specialized IS evaluation methods and frameworks, which are suitable for specific types of IS. Smithson and Hirschheim (1998) classify the existing IS evaluation methods into three basic categories and discuss their basic characteristics. The first category are the efficiency-oriented methods, which evaluate the performance or quality of an IS with respect to some predefined technical and functional specifications, being focused on whether the IS is functioning properly, and aiming to answer the question "is it doing things right?". The second category consists of effectiveness-oriented methods, which have been influenced mainly by management science approaches; they evaluate how much an IS supports the execution of business-level tasks or the achievement of business-level objectives, being focused on its impact on achieving business-level objectives, and aiming to answer the question "is it doing the right things?". The third category consists of understanding-oriented approaches, which aims at a deeper understanding of the mechanisms of value generation by IS and their association with the organizational context.

A highly important category of IS that has recently attracted much interest, both from the research & development and the practical implementation viewpoint, are the ones supporting learning in various ways, usually referred as e-learning systems. In order to maximize the benefits from the huge investments made in e-learning, it is necessary to develop and use appropriate methods for its systematic evaluation. The purpose of this evaluation is to assess the educational value generated by e-learning, and its main determinants, to identify good and bad practices, to detect problems and finally to improve the effectiveness of e-learning. However, due to the above radical differences between the e-learning and the "traditional" education, the evaluation of e-learning cannot be performed using the methods that have been developed for the evaluation of the traditional education (Hoyt and Cashin 1977, Marsch 1982, Cashin and Downey 1992): e-learning has brought up big innovations in the way courses are taught, the role of the teacher, the interaction between teachers and learners and the interaction between the learner and the content, so it requires different and appropriate evaluation methods. A lot of research has been conducted in this area; however there is an "absence of a widely established and practiced methodology by which to rigorously evaluate e-learning, and through which to develop the secure body of knowledge on which to build learning technology as a discipline" (Dempster, 2004). Therefore further research is required in this area in order to develop practically applicable e-learning evaluation methods that generate rich and useful

information concerning the different types of value that e-learning creates, the mechanisms of their creation and also possible interventions for increasing them.

In this direction this paper proposes a method of multi-layer e-learning evaluation, consisting of value measures structured in the following three layers: a) "efficiency evaluation" measures (evaluating the basic resources and capabilities offered by an e-learning system, such as the educational content, the technical quality of the system, the usability of the system, the capabilities it offers for customizing the learning process to e-learners particular needs and preferences, the instructor support and the degree of electronic community development), b) "effectiveness evaluation" measures (evaluating the extent of usage of the e-learning system and its educational effectiveness), c) "intended future behavior" measures (evaluating the intention to use the e-learning system in the future and to recommend it to colleagues). Furthermore this method provides estimations of the relations between the value measures of the above three layers. Those multiple layers of value measures as well as the relations among them constitute a "value flow model", which includes: i) the value created by the basic resources and capabilities offered by an e-learning system (at the first layer), ii) how this (first level) value results in higher level value (concerning the accomplishment of various higher-level objectives), and finally iii) how the above levels of value result in value related to future intended behavior (i.e. intention to use in the future or recommend it to colleagues). This approach constitutes an extension to the "classical" technology acceptance models approach with additional measures of IS value and is theoretically founded on the process theories of IS value creation (e.g. Soh and Markus 1995) and on the multi-dimensional and multi-layer approaches of IS success literature (e.g. DeLone and McLean 1992, 2003, Seddon 1997).

In section 2 a review of the relevant literature is presented. In section 3 follows a description of the value model estimation approach proposed for the evaluation of an e-learning service, which has been developed in the e-RMIONE project of the eTEN Programme of the European Union (www.ermione-edu.org). In section 4 the results of a first application of this approach are presented. Finally in section 5 the reader can find a summary of the conclusions and a proposal of future research directions.

2 LITERATURE REVIEW

Extensive research has been conducted concerning the evaluation of the traditional education and especially concerning students" evaluation of "traditional" teaching effectiveness (SETE) (Marsch, 1982, Marsh 1987, Hoyt & Cashin, 1977, Cashin and Downey, 1992). Wang (2003) mentions the following six SETE instruments as the most important ones: the Instructional Development and Effectiveness Assessment (IDEA), the Students' Evaluations of Educational Quality (SEEQ), the Endeavor 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 & Cashin 1977, Cashin & Downey 1992) consists of 38 evaluation criteria, which are grouped in the following four evaluation dimensions: instructor methods, students' ratings on course objectives, course content and students' self-ratings. The SEEQ instrument (Marsh 1982, Marsh 1987) is longer and has the following nine evaluation dimensions: learning/value, enthusiasm, organization, group interaction, individual rapport, breadth of coverage, exams/grades, assignments and workload. As we have already mentioned in the Introduction, those SETE instruments cannot be used for

the evaluation of e-learning, since e-learning is characterized by significant differences from the traditional teaching.

Considerable amount of research has also been conducted in the e-learning evaluation area, which has resulted in the development of some high-level e-learning evaluation frameworks. The most well-known and widely used framework for measuring the effectiveness of training programs, which has been used both for traditional training and e-learning, has been developed by D. Kirkpatrick in the late 1950s, and has been adapted and modified subsequently, through its basic structure has not changed significantly (Kirkpatrick, 1983). It consists of the following four levels of evaluation: Learners Reaction, Learning, Workplace Behavior and Organizational Results. Jackson"s framework (1998) 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); furthermore, it provides a systematic way for evaluation of outcomes based on the "Structure of the Observed Learning Outcome" (SOLO) taxonomy developed by Biggs & Collins (1982). A more detailed framework is the "Evaluating Learning Technology" (ELT) (Oliver and Conole 1998), which provides systematic guidance for the six e-learning evaluation stages it proposes: 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 & 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 higher-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.

The research work that has been performed in the area of e-learning quality is also interesting from the e-learning evaluation viewpoint. Lorenzo and Moore (2002) proposed the following basic determinants of on-line education quality, which they call the "Five Pillars of Quality Online Education": Learning Effectiveness, Student Satisfaction, Faculty Satisfaction, Cost Effectiveness and Access. Ehlers (2004, 2005) argues that quality in e-learning should be viewed as a co-production by the learner and the learning environment, identifying 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. Additionally, Euler (2006) follows a similar holistic approach to e-learning quality by suggesting six quality dimensions known as "CEL Quality Dimensions": program strategy, pedagogy, economics, organization, technology and culture. Wang (2003), developed a global instrument for measuring the total e-learner satisfaction with asynchronous e-learning systems (a global satisfaction index), consisting of 17 relevant variables, in order to support mainly summative evaluation of e-learning. He concluded that e-learner satisfaction is determined by four major constructs: content, learner interface, learning community, and personalization. Quite useful information could also provide the ISO/IEC 19796-1 reference framework for the description of quality approaches in learning, education and training.

Another research stream in the area of e-learning evaluation is based on the Technology Acceptance Model (TAM) and its extensions (Davis 1989, Venkatesh et al 2003), and deal with the identification of the factors affecting either the extent of use of an e-learning system by the learners, or their intention 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. In this direction Selim (2003) used the TAM in order to investigate empirically the acceptance of course web-sites by students and identify its main determinants. For this purpose he developed the "Course Website Acceptance Model" (CWAM) consisting of the three constructs of the TAM (perceived usefulness, perceived ease of use, and use), which were elaborated for the case of a course web-site; using structural equation modelling (SEM) he validated his model and revealed the most important factors of the course web-site acceptance. Saade and Bahli (2005) conducted an empirical study aiming at explaining the acceptance (measure as intention to use in the future) of Internet-based learning systems, based on an extension of the TAM, which included the concept of cognitive absorption as antecedent of perceived usefulness and perceived ease of use; the results of this study, which used data collected from students, provided support for this model as explaining the acceptance of the Internet-based learning system and for cognitive absorption as an important variable affecting the above TAM variables. Another extension of the TAM has been developed by Ngai et al (2005), including Technical Support as an additional construct, for the empirical examination of the adoption of Web Course Tools (WebCT), measured through current system use and intention to use in the future. This e-learning acceptance research based on the TAM and its extensions provides useful elements that should be taken into account for the development of e-learning evaluation methods, however its main dependent variables, such as "use" or "intention to use", do not necessarily reflect the magnitude of the value created by e-learning, since there are occasions where the use of a particular e-learning system is simply better than the other existing options, or even mandatory (i.e. there are no other options), so we can have e-learning systems with equal use but offering very different levels of value.

The conclusions of the research regarding e-learning critical success factors (CSFs) should be taken into account as well for the development of e-learning evaluation methods. Volery and Lord (2000) identified three main e-learning CSFs: 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) concluded that the main CSFs of e-learning are: 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 of collaboration, user-friendly and sufficiently supported technical infrastructure. In a more recent study Selim (2005) investigated what do university students perceive as CFSs for e-learning acceptance, identifying eight major CSF categories: attitude towards and control of technology, teaching style, computer competency, interactive collaboration, e-learning course content/design, ease of access, infrastructure and support.

Summarizing, from this literature review it is concluded that for the evaluation of e-learning only a number of high-level frameworks have been developed, which are quite abstract and include only evaluation stages and directions. Therefore further research is required for the development of practically applicable and useful e-learning evaluation methods, which generate rich and useful information concerning the different types of value that e-learning creates, the mechanisms of their creation and also possible interventions for increasing them, and also for investigating and validating such methods in "real-life" conditions and situations. For this purpose it is necessary to combine elements from previous research on the evaluation of the traditional education, on the evaluation of e-learning (e.g. from the existing e-learning evaluation frameworks), on the e-learning acceptance on the e-learning CSFs, etc., and also take into account the multi-dimensional and multi-layer approaches of IS success literature (e.g. DeLone and McLean 1992, 2003, Seddon 1997).

3 A VALUE FLOW MODEL ESTIMATION APPROACH

Taking into account the above conclusions of the literature review we developed a method for e-learning multi-layer evaluation and value flow model estimation, in order to use it for the evaluation of an e-learning service in the area of European cultural heritage, created for the e-RMIONE (E-Learning Resource Management Service for InterOperability Networks in the European Cultural Heritage Domain) project of the eTEN Programme of the European Union (www.ermione-edu.org). The proposed method incorporates elements from: i) the IS evaluation and success research, ii) the traditional education evaluation research, iii) the TAM-based e-learning research and iv) the e-learning CSFs research. Its basic evaluation measures and the hypothesized relations among them are shown in Figure 1.

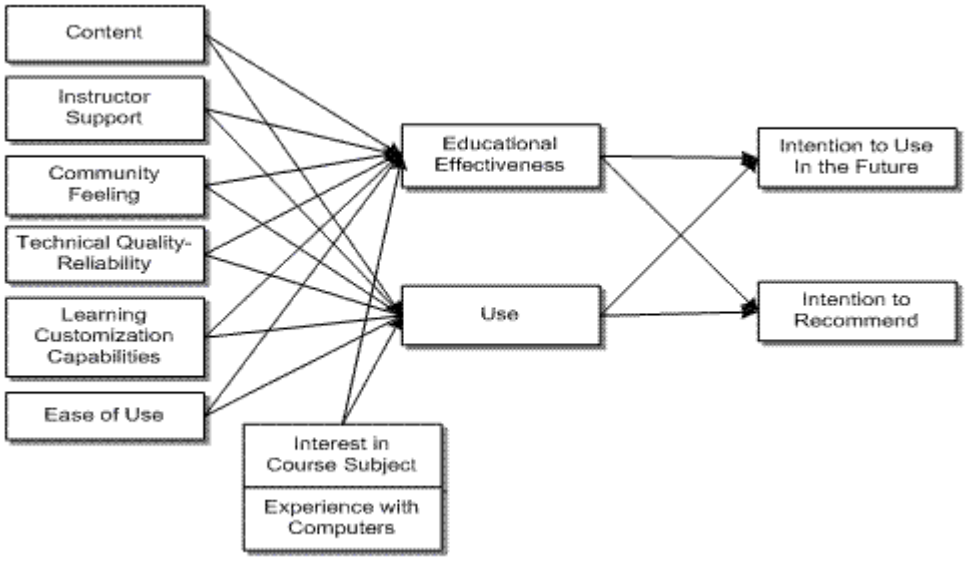

Figure 1: Structure of the e-learning multi-layer evaluation and value flow model estimation method.

The measures are structured in three layers. The first layer includes evaluation measures of the e-learning resources and capabilities offered to the user: content (CONT), electronic support by the instructor (INSUP), development of a community feeling (COMM), technical quality and reliability (TREL), capability to customize the learning process to ones" learning style and needs (CUST) and ease of use (EUSE); the evaluations of these e-learning resources and capabilities by the users constitute a measure of the first level efficiency-oriented value created by the e-learning service. The second layer includes higher level evaluation measures of e-learning effectiveness: extent of usage of the e-learning system (USE) and degree of educational effectiveness (i.e. how effective the e-learning system was for learning new concepts, facts, methods, technologies, theories, etc.) (EDEFF); the evaluations of system use and educational effectiveness constitute a measure of the higher effectiveness-oriented value created by this e-learning service. The third layer includes evaluation measures of user's intended future behaviour

concerning this e-learning service: the degree of intention to use it in the future (FUTUSE) and to recommend it to other colleagues (FUTREC), which constitute a measure of future behaviour – oriented value. Additionally another context-oriented layer has been added with measures of personal characteristics of each learner, such as his/her degree of interest in the course subject (INTSUB) and his/her degree of experience with computers (COMPEXP), in order to examine to what extent they affect e-learning effectiveness, and compare their impact with the impact of the e-learning resources and capabilities (of the first layer).

The users of an e-learning service are asked to evaluate all the above aspects of these four layers through a structured questionnaire, which includes, for each of the measures of these layers, either only one question (in the simple version of the method), or several questions (in the more complex version of the method), from which a corresponding synthetic factor has been constructed using factor analysis techniques. From the ratings given by the users as a first step is calculated the average rating for each measure, then for each layer (over all the measures of it) and finally the global average rating (over all three layers). In this way are produced estimates of the value created by the e-learning service at each layer (i.e. of the efficiency-oriented value, the effectiveness-oriented value and the future behavior-oriented value) and also in total, while we can also identify the measures and layers that constitute strengths and weaknesses of the service. As a second step the relations between each measure and all the measures of the previous layer have been calculated, so that we can determine which of the measures of the previous layer have higher impact on it. For a basic estimate of these relations we can calculate the correlations among these measures, while for a more accurate estimation of them we can use structural equation modeling (SEM) techniques (Diamantopoulos 1994, Gefen et al 2000). In this way a "value flow model" is constructed, which enables the location and understanding of the value generation sources (first layer), the higher level value creation process (second layer) based on these value generation sources, and, finally, the way in which first and second stage value is transformed into future behavior-oriented value (third layer). So this approach enables not only the identification of the strengths and weaknesses of an e-learning service, but also the identification of their origins in previous layers and their consequences for the next layers. Moreover, it offers the capability to define priorities for improvements of the resources and capabilities (of the first layer), based on their average ratings by the users and also on their impact on the creation of higher layers' value (e.g. value concerning educational effectiveness or intended future behavior).

The above e-learning evaluation method 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 organizational performance. For the case of e-learning an appropriate mix of "IT-Assets" should be provided to the learner, so this basic concept has to be analyzed into the six e-learning resources-capabilities of the first layer of Figure 1. Also, according to the technology acceptance models (Davis 1989, Venkatesh et al 2003) the usefulness and the ease of use that users perceive are the main determinants of their intended future behavior (e.g. their intention to use it in the future, to recommend it to other colleagues, etc.)

4 RESULTS

For an initial validation of the above e-learning multi-layer evaluation and value flow model estimation method we collected ratings of all these measures from 65 students from the University of Leuven

(Belgium) and the University of the Aegean (Greece), who have used the e-RMIONE service for a period of two months attending e-courses during the spring semester of 2006. For this purpose a questionnaire was distributed to them in paper form and was completed in "physical" meetings, organized immediately after the end of the corresponding e-courses. It included one question for each of the above measures, which the students had to answer in a 4 or 6-point scale for most of the questions (these 4 or 6 point scales have been preferred, since they do not include an "intermediate" point of "neutral" or "medium" type - as it happens in the usual 5 or 7-point scales - so that we avoid "neutral" ratings by the students). A first version of this questionnaire had been previous pre-tested by all the partners of the e-RMIONE project and also by three final year students of the Department of Information and Communication Systems Engineering of the University of the Aegean, and their remarks were taken into account for producing the final version of the questionnaire.

Based on the ratings given by the students, as a first step, we calculated the average rating for each measure, then for each layer and finally the global average over all three layers (Table 1).

MEASURE	SCALE	AVERAGE RATING
Content (CONT)	1 to 6	4.36
Electronic support by instructor (INSUP)	1 to 6	4.53
Development of a community feeling (COMM)	0 to 1	0.58
Technical quality and reliability (TREL)	1 to 6	4.36
Capability to customize the learning process to ones" learning style and needs (CUST)	1 to 6	3.92
Ease of use (EUSE)	1 to 6	3.58
Efficiency measures average		4.04
Usage of the e-learning system (USE)	1 to 6	4.05
Degree of educational effectiveness (EDEFF)	1 to 6	4.47
Effectiveness measures average		4.26
Intention to use it in the future (FUTUSE)	1 to 6	3.52
Intention to recommend it to colleagues (FUTREC)	1 to 6	3.70
Future behaviour measures average		3.61
Total average		3.97
Interest in the course subject (INTSUB)	1 to 4	2.93
Degree of experience with computers (COMPEXP)	1 to 4	3.95

Table 1: Average ratings for all value measures

We can see that the average rating over the six efficiency-oriented value measures of the first layer is 4.04, therefore the users perceive a moderately high value of the service concerning its efficiency (i.e. the e-learning resources and capabilities it offers). By comparing the average ratings of the measures of this first layer we remark that the highest average ratings have been given for the electronic support by instructor (INSUP) (4.53), the content (CONT) (4.36) and the technical quality and reliability (TREL) (4.36), which constitute the strengths of the service, while the lowest average ratings have been given for the ease of use (EUSE) (3.58), the development of a community feeling (COMM) (1+0.58*5=3.90) and the capability to customize the learning process to ones' learning style and needs (3.92), which constitute the weaknesses of the service. Concerning the second layer we can see that the average rating over the two effectiveness–

oriented value measures is 4.26, therefore the users perceive a moderately high to high value of the service concerning its effectiveness; by comparing the average ratings of the two measures of this layer we remark that the highest average rating has been given for the degree of educational effectiveness (EDEFF) (4.47), which constitutes another strength of the service. Finally the average rating over the two future behavior-oriented value measures of the third layer is 3.61; the rating given for the intention to recommend the service to colleagues (FUTREC) (3.70) is higher than the one for the intention to use it in the future (FUTUSE) (3.52), but both constitute weaknesses of the service. As far as the measures of personal characteristics of the users is concerned, the average degree of their experience with computers (COMPEXP) is very high (3.95 in the 1 to 4 scale), while moderately high to high is their interest in the subject of the course they attended (INTSUB) (2.93 in the 1 to 4 scale).

As a second step we calculated the correlation coefficients initially between each of the six value measures of the first layer (efficiency-oriented measures) and each of the two value measures of the second layer (effectiveness-oriented measures), which are shown in the second and the third column of Table 2, as basic estimates of the impact of the former on the latter; in this Table are shown the statistically significant correlation coefficients at the 5% level (i.e. with significance lower than 5%), and also with an asterisk (*) the ones that are statistically significant at the 10% level but not at the 5% level, while with "NS" are denoted correlation coefficients that are not statistically significant. Also in the same columns of this Table (in the last two rows) we can see the correlation coefficients between each of the two measures of personal characteristics of the users and each of the two value measures of the second layer. We remark that the development of a community feeling (COMM) and the capability to customize the learning process to ones' learning style and needs (CUST) are characterized by the higher correlation coefficients with the two effectiveness measures, followed by the content (CONT) and the electronic support by instructor (INSUP); all these four efficiency measures have a medium level (around 0,5) of statistically significant correlation coefficients with both effectiveness measures of the second layer. Also the degree of experience with computers (COMPEXP) has statistically significant correlation coefficients of lower level with both effectiveness measures.

	USE	**EDEFF**	**FUTUSE**	**FUTREC**
CONT	0.465	0.412	0.600	0.637
INSUP	0.440	0.473	0.365	0.372
COMM	0.551	0.486	0.270	0.289
TREL	NS	0.197*	NS	NS
CUST	0.482	0.521	0.362	0.483
EUSE	NS	NS	0.469	0.476
INTSUB	NS	NS	0.374	NS
COMPEXP	0.348	0.323	NS	NS

Table 2: Correlation coefficients between efficiency-oriented value measures-personal characteristics measures and effectiveness-oriented value measures-future behavior value measures

For each of the effectiveness measures (USE and EDEFF) we constructed a regression model, which had this effectiveness measure as dependent variable and the six efficiency measures and the two personal characteristics measures as independent variables. The R^2 values of these models were 0.51 for the model of the system usage (USE) and 0.49 for the model of the degree of educational effectiveness (EDEFF).

Therefore we conclude that the six efficiency-oriented value measures of the first layer and the two personal characteristics can explain about 50% of the variation of the effectiveness-oriented value measures. Next we calculated the correlation coefficients between each of the two effectiveness-oriented value measures of the second layer and each of the two future behavior-oriented value measures of the third layer, as basic estimates of the impact of the former on the latter. We remark that both effectiveness measures and future behavior measures have statistically significant correlation coefficients of medium level (0.507 and 0.534 for USE with FUTUSE and FUTREC respectively, as well as 0.407 and 0.5 for EDEFF with FUTUSE and FUTREC). As a conclusion, system usage (USE) has higher levels of correlation with both future behavior measures than the degree of educational effectiveness (EDEFF).

Furthermore, for each of the two future behavior measures (FUTUSE and FUTREC) we constructed a regression model, which had this future behavior measure as dependent variable and the two effectiveness measures as independent variables. The R^2 values of both these models were very low: 0.29 for the model of the intention to use the service in the future (FUTUSE) and 0.35 for the model of the intention to recommend it to colleagues (FUTREC). So we proceeded with adding to each of these two modes the six efficiency measures of the first layer as additional independent variables. The R^2 values of both these two new models (each of them having eight independent variables in total) were much higher than the first two models: 0.59 for the model of the intention to use the service in the future (FUTUSE) and 0.64 for the model of the intention to recommend it to colleagues (FUTREC); by adding to the independent variables the two personal characteristics (therefore estimating models with ten independent variables in total) the R^2 values of both these two new models increase by another 5%. Therefore we conclude that the two effectiveness-oriented value measures of the second layer can explain about 30% of the variation of the future behavior-oriented value measures; however, together the six effectiveness-oriented value measures of the first layer and the two effectiveness-oriented value measures of the second layer can explain a much higher percentage of about 60% of the variation of the future behavior-oriented value measures, while by adding the two personal characteristics the percentage of their variation we can explain rises to about 65%. For this reason we also calculated the correlation coefficients between each of the six efficiency-oriented value measures of the first layer and each of the two future behavior-oriented value measures of the third layer; also we calculated the correlation coefficients between each of the personal characteristics and each of the future behavior-oriented value measures; they are all shown in the fourth and the fifth column of Table 2. We remark that the content (CONT) has the highest correlation coefficients with the two future behavior measures (of medium to high level: 0.600 and 0.637 respectively), followed by the ease of use (EUSE) (0.469 and 0.476 respectively) and the capability to customize the learning process to ones' learning style and needs (CUST) (0.362 and 0.483 respectively).

According to the above results, the educational content, instructor's support and technical quality of this e-learning service seem to be its strengths. On the other hand, we have identified two critical resources and capabilities that have to be improved, since they are both characterized by low average ratings by the users (Table 1) and by high impact on the creation of second and third layers' value (Table 2): 1) Community feeling (i.e. we should further develop tools and functions enabling communication and interaction between the e-learners (forums, chats, e-mail, etc)), and 2) Customization capabilities, (i.e. we should further develop the capabilities offered to the users for personalizing (customizing) the e-learning platform according to their particular needs, preferences and learning style).

5 CONCLUSIONS, LIMITATIONS AND FURTHER RESEARCH

The purpose of the research described in this paper was to develop a method for e-learning multi-layer/multi-perspective evaluation and value flow model estimation, by synthesizing elements of the IS evaluation and success research, the traditional education evaluation research, the TAM-based e-learning research and the e-learning critical success factors research. This method includes evaluation of the e-learning using three layers of value measures (efficiency measures, effectiveness measures, and intended future behavior measures), as well as estimation of the relations between the value measures of these three layers. In this way a useful model of e-learning value generation and flow has been developed. This approach enables: i) the identification of the strengths and weaknesses of e-learning, not only in the final outcomes, but also throughout all layers of the e-learning value creation process, ii) the location of the origins (in previous layers) and their consequences (in the next layers) of each strength and weakness, and iii) the prioritization of improvements that should be made in the resources and capabilities of the e-learning service. It should be noted that this approach could be used for the evaluation of e-learning services not only in university environments, but also in working environments as well (by adding one more layer of organizational impact measures), or even adjusted and used for evaluating any kind of electronic service.

A first application of this method has also been presented, for the evaluation of an e-learning service in the area of the European cultural heritage providing positive and encouraging evidence concerning the validity and the usefulness of the method. The main limitation of this study was the small sample size. However, the basic objective of it was to get some first evidence about the validity of this proposed multi-layer evaluation and value-flow model estimation method. The positive results encourage us to continue our research with a bigger sample and more sophisticated modeling techniques. In this direction further research is in progress by the authors, based on a much bigger sample, using for each construct (measures) several items (questions), from which a corresponding synthetic factor will be constructed. For the construction of the value flow model and the calculation of the relations between the measures structural equation modeling (SEM) techniques (Diamantopoulos 1994, Gefen et al 2000) will be employed, allowing for a more reliable model estimation. Finally, the impact of more personal characteristics (e.g. different learning styles) on the value generation process throughout the various levels will be investigated.

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