STRUCTURING E-SERVICES EVALUATION BASED ON MULTI-LEVEL VALUE FLOW MODELS

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Abstract

The high penetration of the Internet/WWW has led to the development of various types of e-services, such as e-business, e-banking, e-government and e-learning; however, their usage and quality have been lower than expected. Since this is a relatively new area, there is a need for intensive learning and improvement, and this can be achieved through deep and sophisticated evaluation of existing e-services that will produce extensive knowledge on their value generation mechanism and provide guidance for improvement interventions. In this direction this paper describes and validates a methodology for structuring and enhancing e-services evaluation based on the estimation of multi-level value flow models, which enable a better understanding of their value generation mechanisms and provides improvement decisions support. It is founded on well established theoretical frameworks from previous research in the areas of IS evaluation, technology acceptance models (TAM), IS success models and e-services evaluation. The proposed methodology has been validated for an e-learning service provided by the National Technical University of Athens (NTUA) to ICT professionals.

Keywords: e-service, e-service quality, e-service evaluation, Technology Acceptance Model (TAM), IS Success Models.

1 INTRODUCTION

The high penetration of the Internet/WWW has led to the development of numerous e-services, such as e-business, e-banking, e-government and e-learning. These e-services provide to their users various electronic resources (e.g. useful e-content) and capabilities (e.g. to perform various tasks and transactions with private and public organizations electronically over the Internet anytime and from anywhere). However, despite the high investments that have been made for setting up and running such e-services, their usage and quality have been much lower than expectations (Parasuraman et al, 2005; European Commission, 2008; Sumak et al, 2009) and improvements are required in order to reach higher levels of maturity in this area. The design and delivery of e-services is a relatively new area, so there is a need for intensive learning and improvement, and this can be achieved through deep and sophisticated evaluation of existing e-services that will produce extensive knowledge on their value generation mechanisms and provide support for improvement decisions. In this direction can greatly contribute the development of more sophisticated e-service evaluation methods, which can produce more value-related knowledge and insight, and also provide better improvement decisions support than the existing ones; such methods can significantly intensify learning and improvement in this still immature e-services area.

As described in more detail in the following section, previous research has produced various e-services evaluation frameworks (good reviews of them are provided by Rowley, 2006; Halaris et al, 2007; Sumak et al, 2009). These frameworks usually propose sets of heterogeneous evaluation measures, with each of them assessing a particular quality aspect of the e-service, such as the quality of one capability or resource provided to the users, or to what extent the e-service assists users in performing a particular task or achieving a particular objective, or even to what extent it influences their future behaviour. Some of these aspects are 'independent' variables under the direct control of the e-service provider (e.g. the quality of the capabilities and resources provided to the users), while some other aspects are 'dependent' variables (i.e. outcomes), which are not under the direct control of the e-service provider (e.g. the extent of assisting users to perform particular tasks or achieve particular objectives), and to some extent depend on (i.e. are shaped by) the independent ones. However, these relations among the various types of evaluation measures are neglected and are not exploited by existing e-services evaluation frameworks. The analysis and exploitation of these relations would result in more structured and sophisticated e-service evaluation methods that can provide more knowledge and insight on an e-service than previous ones, and also better guidance and support for its improvement.

In this direction this paper describes and validates a methodology for structuring and enhancing e-services evaluation based on the estimation of multi-level value flow models of them incorporating the above relations, which enables a better understanding of value generation mechanisms and provides support for a rational identification of improvement priorities. It is founded on well established theoretical frameworks from previous research in the areas of IS evaluation, Technology Acceptance Models (TAM), IS Success Models and e-services evaluation (briefly reviewed in the following section). In particular, the proposed methodology is based on the estimation of a three layers value flow model of the e-service, initially at a high level and then at a lower more detailed level, which includes its main value dimensions and measures and the relations among them. These value dimensions and measures are associated with the resources and capabilities the e-service provides to its users (efficiency measures – at the first layer), the support it provides to them for performing various tasks and achieving various objectives (effectiveness measures – at the second layer) and its impact on users' future behaviour (future behaviour measures – at the third layer). Both this high and low level value flow model are estimated using evaluation data collected from users of the e-service (e.g. through an online questionnaire on the e-service website). Based on them conclusions are drawn concerning the strengths and weaknesses of the e-service, its value generation mechanism, and its improvement priorities.

This paper consists of five sections. The following section 2 outlines the theoretical foundations of the proposed methodology. A description of the methodology is provided in section 3. In section 4 an application-validation of it is presented for an e-learning service provided by the National Technical University of Athens (NTUA) to ICT professionals. Finally, in section 5 the conclusions are outlined.

2 THEORETICAL FOUNDATIONS

The extensive research that has been conducted on the evaluation of information systems (IS) (Hirschheim and Smithson, 1988; Willcocks, 1994; Willcocks, 1996; Willcocks and Graeser, 2001; Smithson and Hirscheim, 1998; Farbey et al, 1999; Irani, 2002; Irani et al, 2006; Gunasekaran et al, 2006) has concluded that it is a highly complex task, because the benefits and in general the value created by most categories of IS are multidimensional and complex, both financial and non-financial and also both tangible and intangible. For this reason the usual financial investment appraisal methods are insufficient for conducting IS evaluation, and a more sophisticated approach is required. Furthermore, different categories of IS have different objectives and produce different types of benefits and value, so they require different types of evaluation methods and measurements. For the above reasons it is not easy to decide "what to measure" for the evaluation of an IS and "how". Smithson and Hirschheim (1998) classify the existing IS evaluation methods into two basic categories. The first category are the 'efficiency-oriented' methods, which have been influenced mainly by engineering sciences and evaluate the performance of an IS with respect to some predefined technical

and functional specifications, being focused on answering the question 'is it doing things right?'. The second category consists of 'effectiveness-oriented' methods, which have been influenced mainly by management science approaches and evaluate how much an IS supports the execution of business-level tasks or the achievement of business-level objectives, being focused on answering the question 'is it doing the right things?'. So they finally recommend that the evaluation of a particular IS type should include both efficiency and effectiveness measurements and evaluation. Willcocks (1994 and 1996) suggests that appropriate evaluation of IS should be performed at all stages of their life cycle, e.g. during the initial feasibility study, during and at the end of the development and also during productive exploitation; however, it is recognized that most firms limit themselves only to the former and neglect the latter ones, and this has a negative impact on the benefits and value obtained from IS.

Also, extensive research has been conducted on IS user acceptance, regarding it as a major measure of IS value, aiming to identify the characteristics and factors affecting the attitude towards using an IS, the intention to use it and finally the extent of its actual usage. It is based on the Technology Acceptance Model (TAM) and its various subsequent extensions (Davis, 1989; Venkatesh and Davis, 2000; Venkatesh et al, 2003). According to the (initial) TAM theory, the attitude towards using an IS, which determines the intention to use it and its actual use, is determined mainly by two characteristics of it: its perceived 'ease of use' (= the degree to which potential users believe that using it requires minimal effort) and its perceived 'usefulness' (= the degree to which potential users believe that using it will enhance their job performance) (Davis, 1989); each of these two factors can be further elaborated into a detailed set of variables for each particular type of IS we want to study. Based on this framework extensive research has been conducted for understanding better and predicting user acceptance of various types of IS; comprehensive reviews of this research stream are provided by Legris, Ingham and Collerette (2003), Schepers and Wetzels (2007), Turner et al (2010), Holden and Karsh (2010), and Hsiao and Yang (2010). From this research stream it is concluded that the evaluation of a particular IS type should focus on its ease of use, usefulness, actual usage and users' intention to use it in the future.

Another research stream that can provide useful elements for the evaluation of IS is the IS success models research. The most widely used of them is the DeLone and McLean model of IS success (1992, 2003). It proposes seven interrelated IS success measures structured in three layers: 'information quality', 'system quality' and 'service quality' (first layer), which affect 'user satisfaction' and also the 'actual use' of the IS (second level); finally these two variables determine the 'individual impact' and the 'organizational impact' of the IS (third layer). Seddon (1997) proposed a re-specification and extension of this model, which includes the 'perceived usefulness' instead of 'actual use'. Many researchers have used and validated this model, either in its basic form or with some modifications or extensions, in order to investigate the success of various types of IS; other researchers have used the left-hand part of the model, which assumes that information, system and service quality are the main determinants of system use and user satisfaction (e.g. Igbaria & Tan, 1997; Garrity and Sanders, 1998; Rai, Lang and Welker, 2002; Avlonitis & Panagopoulos, 2005; Wu and Wang, 2006; Bernroider, 2008; Park, Kim and Koh, 2010). From this research stream it is concluded that IS evaluation should adopt a layered approach based on the above interrelated IS success measures (information quality, system quality, service quality, user satisfaction, actual use, perceived usefulness, individual impact and organizational impact) and on the relations among them.

More recently, by combining frameworks from the general IS evaluation research and the 'traditional' services quality research (such as the SERVQUAL framework (Parasuraman et al, 1988; Berry et al, 1990)), many e-service evaluation frameworks have been developed. Only a few of them are generic, providing guidance for the evaluation of e-services in general (Madu and Madu, 2002; Lu and Zhang, 2003; Fassnacht and Koese, 2006; Rowley, 2006), while most of them are more specific and focus on particular types of e-services, such as informational web sites (Loiacono et al, 2000; Aladwani and Palviab, 2002; Zeitmhal, 2002; Schubert, 2003; VanIwaarden et al, 2003; Ivory and Megraw, 2005; Kuo et al, 2005), e-shops/e-business (Turban and Gehrke, 2000; Barnes and Vidgen, 2002; Janda et al, 2002; Wolfinbarger and Gilly, 2003; Parasuraman et al, 2005; Caruana and Ewing, 2006; Behkamal et al, 2009), e-government (Barnes and Vidgen, 2003; Sukasame, 2004; Ancarani, 2005; Horan et al, 2006; Halaris et al, 2007) and e-learning (Jackson, 1998; Wang, 2003; Selim, 2003; Douglas and Van

Der Vyver, 2004; Ngai et al, 2005; Shee and Wang, 2008; Ozkan and Koseler, 2009; Paechter et al, 2010); a more detailed review of them is provided by Rowley (2006), Halaris et al (2007) and Sumac et al (2009). These frameworks propose sets of e-services evaluation dimensions and measures, which assess mainly the quality of the resources and capabilities that the e-service provides to its users (focusing on the abovementioned efficiency-oriented IS evaluation), and some of them assess also the support it provides to users for performing various tasks and achieving various objectives, or users' overall satisfaction (focusing on the abovementioned effectiveness-oriented IS evaluation). Also, we remark that the former measures (efficiency-oriented) are 'independent' variables under the direct control of the e-service provider (i.e. the provider can take direct actions for improving them if necessary); on the contrary, the latter (effectiveness-oriented) are 'dependent' variables (i.e. outcomes), which are not under the direct control of the e-service provider (i.e. the provider cannot improve them directly), and to some extent depend on (i.e. are shaped by) the independent ones. The existing e-services evaluation frameworks neglect and do not exploit these relations among the efficiency and effectiveness evaluation measures and dimensions, though they can lead to interesting conclusions as to the value generation mechanism of the e-service and the improvement priorities. From this research stream it is concluded that in order to evaluate an e-service it is necessary to combine efficiency and effectiveness evaluation dimensions and measures from several existing frameworks, adapt them to the particular objectives, characteristics, resources and capabilities of the particular e-service, and also examine and exploit the relations among them.

3 METHODOLOGY DESCRIPTION

Based on the above conclusions of previous research in the areas of IS evaluation, Technology Acceptance Models (TAM), IS Success Models and e-services evaluation a methodology for a more structured e-services evaluation has been developed. The basic characteristics of the methodology have been defined so that they exploit these fundamental recommendations of previous research in order to generate more value-related knowledge and insight on the e-service under evaluation. In particular our methodology:
- has a layered structure, including evaluation dimensions and measures organized in layers, and assessing both each layer separately and also the relations among them, as recommended by the IS success models research,
- it includes both an 'efficiency' and an 'effectiveness' layer, as recommended by both the IS and the e-services evaluation research,
- and also a 'users' future behaviour' layer, as recommended by the TAM-related research,
- it includes both 'ease of use' and 'usefulness' evaluation dimensions and measures, as recommended by the TAM-related research,
- and it can be used during the productive exploitation of the e-service as well, as recommended by the IS evaluation research.

The proposed methodology is based on the estimation of a value flow model of the e-service, which includes the main dimensions and measures of the value it generates structured in several layers, and the relations among them. In particular, as we can see in Figure 1, the value flow model of an e-service can consist of three layers:

(i) The first layer includes efficiency dimensions and measures, which assess the quality of the resources and capabilities offered by the e-service to its users (including the quality of the information and the services it provides, and also its technical performance).

(ii) The second layer includes usage and effectiveness dimensions and measures, which assess respectively the extent of use of the e-service and also its outcomes (e.g. to what extent the e-service assists the users for completing some tasks, achieving some objectives, offers them fun and enjoyment, or in general satisfies them).

(iii) The third layer includes users' future behaviour dimensions and measures, which assess to what extent the e-service influences the future behaviour of its users (e.g. to what extent they intend to use the e-service again in the future, or recommend it to friends and colleagues).

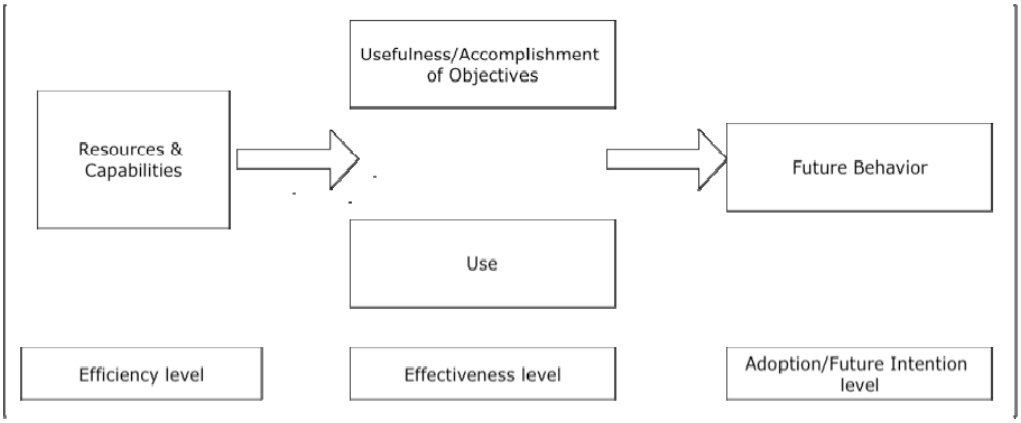

Figure 1. Structure of an e-service value flow model

It should be noted that only the value dimensions and measures of first layer (efficiency-oriented) are 'independent variables' under the direct control of the e-service provider, who can take direct actions for improving the resources and capabilities offered by the e-service. On the contrary, the dimensions and measures of the other two layers (oriented towards usage, effectiveness and future behaviour) are 'dependent variables', since they are not under the direct control of the service provider, and depend on (i.e. are shaped by) the independent ones.

Our methodology consists of the following stages:

1. Initially the high-level value flow model of the e-service is defined. For this purpose the main dimensions of the value created by the e-service are identified for each layer. Then the low-level value flow model of the e-service is defined by identifying for each of these value dimensions a number of individual measures. The above value dimensions and measures should be defined based on previous relevant literature (e.g. describing evaluation frameworks for this type of e-services, such as the literature discussed in the final paragraph of previous section 2), and also on the particular objectives, characteristics, resources and capabilities of the e-service.

2. Based on the above value dimensions and measures an online evaluation questionnaire is formulated (with one section for each value dimension, including one question for each individual measure of it), which is uploaded on the e-service website in order to be filled by its users. The evaluation data collected are stored as a set of records and variables (one record for each response, and one variable for each question). For each value dimension an aggregate variable is calculated, which is equal to the average of the variables corresponding to its measures.

3. Average users' ratings are calculated initially for all value measures and then for all value dimensions and this allows us to identify the 'strengths' and 'weaknesses' of the e-service at a high (dimensions) level and also at a lower (measures) more detailed level.

4. For each aggregate variable of the second and third layer, which assesses one of the 'dependent' e-service value dimensions, we estimate a regression having it as dependent variable, and having as independent variables all the aggregate variables of the previous layers, in order to estimate to what extent this value dimension is affected by value dimensions of previous layers; this is quantified by the R^2 coefficient of the regression (Greene, 2003; Gujarati, 2003). If we find that all value dimensions of the second and third layer are affected to a large extent by the value dimensions of the previous layers (e.g. having $R^2 > 0.50$), then we can conclude that this value model is characterized by coherence among its layers, so we can proceed to the following stages. On the contrary, if one or some of the value dimensions of second and third layer are affected only to a small extent by the value dimensions of the previous layers, this indicates that probably some important value dimensions and measures have been omitted in the previous layers, so we have to return to stage 1 and redefine the value model of the e-service.

5. For each value dimension of the first layer we estimate its impact on all the value dimensions of the second and third layer. For this purpose we can use the corresponding standardised coefficients of

the above regressions. However, as stated in econometric literature (e.g. Greene, 2003; Gujarati, 2003), if we have high levels of correlation between the independent variables of a regression (multi-collinearity problem), then the corresponding regression coefficients are not reliable measures of the impacts of them on the dependent variable. For this reason it is better to use as measure of the impact of a first layer value dimension on a higher layer value dimension the correlation coefficient between them. In the same way for each value dimension of the second layer we estimate its impact on the value dimensions of the third layer.

6. These impact indicators, in combination with the average ratings of all value dimensions calculated in stage 3, allow the construction of a high-level value flow model of the e-service, which shows at a high level the types of value generated by the e-service and the relations among them, and enables a better understanding of its value generation mechanism.

7. Finally the value dimensions of the first layer, which are the only 'independent variables' within the control of the e-service provider, are classified, based on the average ratings they receive from the users and their impacts on the value dimensions of the second and the third layer, into four groups (Figure 2): low rating – high impact, low rating – low impact, high rating – high impact and high rating – low impact. Our highest priority should be assigned to the improvement of the value dimensions of the first group, which receive low ratings by the users and at the same time have a high impact on the generation of higher layers' value. On the contrary, our lowest priority should be assigned to the improvement of the value dimensions of the fourth group, which already receive high ratings from the users and at the same time have a low impact on the generation of higher layers' value. Medium priority should be assigned to the improvement of the value dimensions of the second and the third group.

Average rating	LOW	HIGH
HIGH	high rating – low impact	high rating – high impact
LOW	low rating – low impact	**low rating – high impact**

Impact on higher layers' value generation

Figure 2. Classification of the independent first layer value dimensions/measures

8. Stages 4, 5, 6 and 7 are repeated using the individual value measures' variables (instead of the value dimensions' aggregate variables), in order to construct a lower-level value flow model of the e-service, and produce a similar classification of first layer value measures (which corresponding to particular characteristics of the e-service resources and capabilities), based on their average ratings from the users and their impacts on the value measures of the second and the third layer, into the same four groups (Figure 2). In this way we can identify individual first layer value measures that receive low ratings by the users and at the same time have high impact on second and third layer value measures, and assign to them the highest priority for improvement.

4 APPLICATION

A first application/validation of the proposed methodology has been made for an e-learning service provided by the National Technical University of Athens (NTUA - http://www.ntua.gr/) for ICT professionals all over Greece, who very often need to enhance their skills due to the continuous emergence of new technologies in this domain, but without leaving their jobs. At the time of our study four e-courses were offered: 'Introduction to Java', 'Introduction to Dynamic Web Design Using PHP-

MySQL', 'Introduction to Web Design Using Dreamweaver 8' and 'Introduction to PC Networks and Web Technologies'. The e-learners every week access new educational content through the Internet, download it on their computers, read it, ask the responsible instructor any questions they have on it (which are accessible to all, together with instructor's answers, in the e-course space), participate in relevant e-discussions with the other e-learners and the instructor in an e-forum tool, and also do some quiz or assignment (for self-assessment purposes), which is corrected and graded by the instructor and then returned. At the end of the e-course the e-learners take a 'traditional' exam in Athens, and if they pass they are awarded a certificate.

4.1 Value Flow Model Definition

Initially the high-level and the low-level value flow model of this e-service were defined, based on previous literature on e-learning and traditional learning evaluation, and also on its particular objectives, characteristics, resources and capabilities. The high-level value flow model included the main value dimensions of this e-service per layer (shown in Figure 3), while the low-level value flow model included also for each value dimension several individual value measures. From them an online evaluation questionnaire was formulated for this e-service, which is shown in the Appendix, consisting of 10 sections corresponding to the value dimensions, and 38 questions corresponding to the selected value measures of them; also in the same Table for each value measure we can see its conceptualization literature resources (i.e. previous literature support). Each of these questions was asking the respondent to what extent he/she agreed with a particular statement concerning the e-service on a seven-point Likert scale (where 1 equals to 'totally disagree' and 7 equals to 'totally agree').

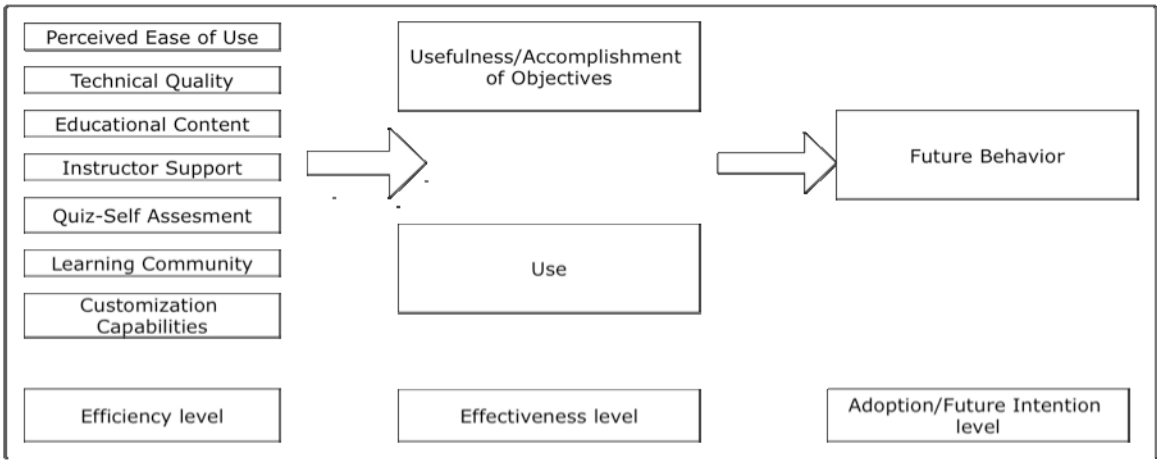

Figure 3. Definition of the high-level value flow model of the e-learning service

This questionnaire was uploaded on the website of this e-service and a relevant e-mail with a link to it was sent to 210 e-learners, who were participating or had participated in the last 6 months in one of the abovementioned e-courses. The first page of it contained several general information about the purpose of this questionnaire and instructions for filling it in, while the following pages contained one section of the questionnaire each. Finally 98 persons responded and filled the questionnaire in (response rate 46.6%); the data were processed using the SPSS 15 statistical package and the results are presented below.

4.2 Calculations of Average Ratings for Value Measures and Dimensions

Initially we calculated the average ratings for all value measures and dimensions, which are shown below in Table 1, together with the corresponding standard deviations.

	Average	Std. Deviation
PERCEIVED EASE OF USE		
1.1 Ease of learning	6.11	0.86
1.2 Ease of access and navigation	6.33	0.89
1.3 Ease of communication	6.15	1.05
1.4 Ease of performing basic actions	6.07	1.11
1.5 Comprehensive and well organized GUI	5.99	1.05
Perceived Ease of Use Average (PEOU_av)	**6.13**	**0.99**
TECHNICAL QUALITY		
2.1 Availability	6.01	1.22
2.2 Response problems	5.88	1.26
2.3 Bugs	6.12	0.93
2.4 Technical support	6.07	1.05
Technical Quality Average (TQ_av)	**6.02**	**1.11**
EDUCATIONAL CONTENT		
3.1 Clarity	5.86	1.00
3.2 Structure	5.80	1.20
3.3 Quantity	5.72	1.27
3.4 Usefulness	5.72	1.20
3.5 Completeness	5.48	1.48
Educational Content Average (EDCONT_av)	**5.71**	**1.23**
INSTRUCTOR SUPPORT		
4.1 Satisfactory answers	6.06	1.17
4.2 Interaction initiation	5.82	1.42
4.3 Subject knowledge	6.51	1.04
4.4 Provision of additional information	6.17	1.43
Instructor Support Average (ISUPP_AV)	**6.14**	**1.27**
SELF-ASSESMENT/QUIZ		
5.1 Usefulness	6.44	0.71
5.2 Instructor's response	5.93	1.35
5.3 Progress self-assessment	6.04	1.13
Self-assessment/Quiz Average (QUIZ_av)	**6.13**	**1.06**
LEARNING COMMUNITY		
6.1 Communication	5.77	1.28
6.2 Team learning	5.72	1.35
6.3 Exchange of ideas	5.72	1.22
Learning Community Average (COMMUN_av)	**5.74**	**1.28**
PERSONALIZATION		
7.1 Choice of learning pace	5.90	1.27
7.2 Choice of learning manner	5.93	1.09
7.3 Focus on personal interests	5.85	1.19
7.4 Learning process customization	5.79	1.23
Personalization Average (PERSON_av)	**5.86**	**1.19**
Average of First Layer Value Dimensions	**5.99**	
LEARNING OUTCOMES		
8.1 Concepts/principles learned	6.35	0.74
8.2 Methods/technologies learned	6.17	0.89
8.3 Ability of practical application	5.75	1.17
8.4 Ability of analysis	5.52	1.31
8.5 Ability of synthesis	5.28	1.38
Learning Outcomes Average (LOUT_av)	**5.81**	**1.10**

USE		
9.1 Time of study	5.62	1.25
9.2 Use of communication tools	5.62	1.29
9.3 Use of self-evaluation tools	5.75	1.14
Use Average (USE_av)	**5.66**	**1.23**
Average of Second Layer Value Dimensions	**5.73**	
FUTURE BEHAVIOUR		
10.1 Recommendation to others	6.06	1.31
10.2 Future participation	6.04	1.34
Future Behaviour Average (FUTBEH_av)	**6.05**	**1.28**

Table 1. Average ratings and standard deviations of all value measures and dimensions

With respect to the value dimensions of the first layer we can see that the users regard them in general as good, since the average of their average ratings is 5.99 (taking into account that 7 corresponds to 'totally agree' with the statements of the questions, and 6 corresponds to 'agree', an average of 5.99 for a value dimension means that the users find it good (but not very good)). Among them the 'Instructor Support', the 'Self-assessment/Quiz' and the 'Perceived Ease of Use' are perceived higher than good (between very good and good, with 6.14, 6.13 and 6.13 average ratings respectively), the 'Technical Quality' as good (6.02), while the 'Educational Content', the 'Learning Community' and the 'Personalization' are perceived lower than good (between good and moderately good, with 5.71, 5.73 and 5.86 respectively). With respect to the value dimensions of the second layer we can see that the users regard them in general a little lower than good (between good and moderately good, since the average of their average ratings is 5.74). Finally, concerning the third layer value dimensions, we can see that the users have positive intentions to use this e-service in the future and recommend it to people they know (average 6.05). In a similar manner by examining the average ratings of the value measures we can draw more detailed conclusions about them.

We also remark that in some value dimensions the individual value measures have received similar average ratings (e.g. in the 'Learning Community'), while in some others there are considerable differences among the value measures (e.g. in the 'Learning Outcomes' we can see that users have a higher perception for the concepts and principles they have learnt (6.35) than for the knowledge synthesis abilities they have acquired (5.28)). This shows the usefulness of performing both high and low level evaluation of the e-service.

4.3 Regressions Estimation

As a next step we examined to what extent the value dimensions of the second and third layer are affected by the value dimensions of the first layer. For this purpose initially we estimated two regression models having as dependent variables the two value dimensions of the second layer respectively (aggregate variables LOUT_av (model_1) and USE_av (model_2)) and as independent variables the seven value dimensions of the first layer (aggregate variables PEOU_av, TQ_av, EDCONT_av, ISUPP_AV, QUIZ_av, COMMUN_av and PERSON_av). Also, we estimated another regression model having as dependent variable the value dimension of the third layer (aggregate variable FUTBEH_av) and as independent variables the two value dimensions of the second layer (model_3), and also a similar regression model having as additional independent variables the seven value dimensions of the first layer (so nine independent variables in total (model_4)). In Table 2 are shown the R^2 coefficients of these four regression models.

We can see that the R^2 coefficients of model_1 and model_2 are 0.617 and 0.640 respectively, indicating that both second layer value dimensions (use and learning outcomes) are affected to a large extent by the ones of the first layer. On the contrary the R^2 coefficient of model_3 is 0.347, which is much lower, indicating that the third layer value dimension (associated with future behaviour) is affected to a smaller extent by the ones of the second layer. However, the last model (model 4) has a much higher R^2 coefficient 0.787, which indicates that both first and second layer value dimensions affect to a large extent the third layer one; this means that first layer value dimensions affect users'

future behaviour both directly and indirectly (through the second layer value dimensions). From the above results we can conclude that the high-level value flow model of this e-service is characterized by high coherence among its layers.

Regression Models	**R^2**
model_1	0.617
model_2	0.640
model_3	0.347
model_4	0.787

Table 2. Regression models of second and third layer value dimensions

In a similar manner we examined the coherence among the layers of the low-level value flow model. For this purpose for each of 8 value measures of the second layer we estimated one regression model having it as dependent variable and the 28 value measures of the first layer as independent variables; also, for each of the 2 value measures of the third layer we estimated one regression model having it as dependent variable and the 36 value measures of the first and the second layer as independent variables. All these models had R^2 coefficients higher than 0.6, so we can conclude that the low-level model as well is characterized by high coherence among its layers.

4.4 Correlation Analysis of Value Dimensions

Our next step was to investigate the impact of the first layer value dimensions on the ones of the second and the third layer. For this purpose we calculated for each of the first layer aggregate variables the correlation coefficients with the three aggregate variables of the second and the third layer, and also their average. The results are shown in Table 3 (all correlations are statistically significant). We remark that the first layer value dimensions of 'Instructor Support', 'Self-assessment/Quiz', 'Educational Content' and 'Personalization' have the highest average correlations with the higher layers' value dimensions (0.653, 0.623, 0.562 and 0.524, respectively). This indicates that those four elements of the e-service have the strongest impact on the higher layers' value generation. Furthermore, Table 3 shows also that the 'Use' of the e-service is mainly influenced by 'Instructor Support' (0.551), 'Self-assessment/Quiz' capabilities (0.545) and 'Learning Community' (0.544). On the other hand, the extent of 'Learning Outcomes' is mainly influenced by the 'Educational Content' (0.670), 'Self-assessment/Quiz' capabilities (0.666) and 'Personalization' Capabilities (0.659). In the same Table we can also see the correlation coefficients between the two second layer aggregate variables and the one of the third layer, which lead to the conclusion that the 'Learning Outcomes' have a stronger impact on 'Future Behaviour' (with a correlation coefficient of 0.548) than the 'Use' of this e-service (with a lower correlation coefficients of 0.484).

	USE_av	**LOUT_av**	**FUTBEH_av**	**AVERAGE**
PEOU_av	0.412	0.380	0.308	0.366
TQ_av	0.273	0.429	0.325	0.342
EDCONT_av	0.446	0.670	0.571	0.562
ISUPP_av	0.551	0.560	0.849	0.653
QUIZ_av	0.545	0.666	0.659	0.623
COMMUN_av	0.544	0.460	0.365	0.456
PERSON_av	0.434	0.659	0.480	0.524
USE_av			0.484	0.484
LOUT_av			0.548	0.548

Table 3. Correlations of the value dimensions across all value flow layers

4.5 High-level Value Flow Model

Based on the results of 4.2 and 4.4 the high-level value flow model of this e-service has been constructed, which is shown in Figure 4. It provides a compact view of the main dimensions/types of value generated by the e-service (appropriately quantified through the corresponding average users' ratings) and the relations among them (quantified through the corresponding correlation coefficients), which enables a better understanding of how the value of one layer is transformed to value of higher layers, and also of the origins of higher layers' value.

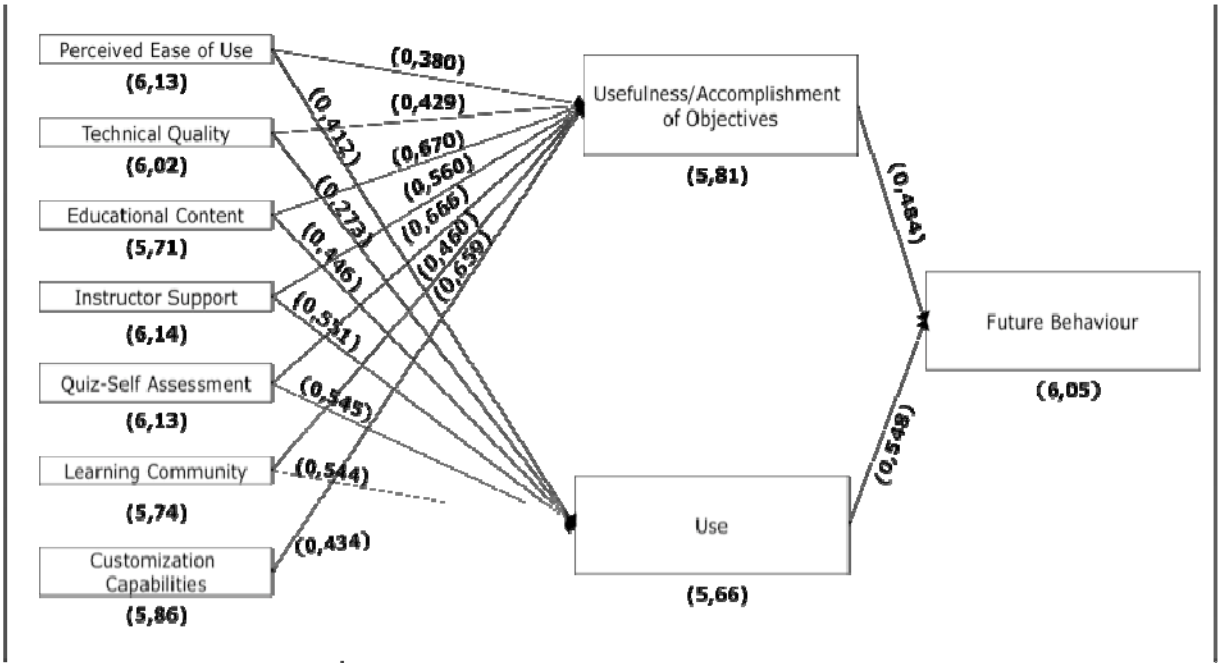

Figure 4. High-level value flow model of the e-learning service

4.6 Correlation Analysis of Value Measures

Having constructed this high-level view, we then proceeded to constructing a lower-level more detailed one based on the individual value measures that concern particular e-service characteristics. For this purpose, for every individual variable of the first layer (28 variables in total) we calculated its correlations with all the individual variables of the second layer (8 variables) and the third layer (2 variables), and also their average, which is shown in Table 4. For calculating this average only the statistically significant correlations have been taken into account, while the non-significant ones were regarded as zeros (note that for variable 2.1 (availability) the average correlation is 0 because all its correlations with the variables of the second and third layer are non-significant).

From the results it is concluded that the first layer value measures (characteristics) that seem to be more correlated with the higher layers' ones are the provision of additional information by the instructor to the e-learners about their particular needs (0.552) (since the e-learners are already ICT professionals, so, beyond acquiring general skills and knowledge on the e-course subject, they also want to focus on particular needs and questions they have), instructor's response to questions about the assignments (0.544), self-assessment/quiz usefulness (0.540) and educational content usefulness (in accordance with personal educational needs) (0.534). This indicates that these e-service characteristics have the strongest impact on higher layers' value generation. We remark that all of them belong to first layer value dimensions that have been found in 4.4 to be strongly correlated to the higher layers' ones (Instructor Support, Self-assessment/Quiz and Educational Content).

	Value dimension	**Value measure**	**Average Correlation**
1.1	Perceived Ease of Use	Ease of learning	0.255
1.2		Ease of access and navigation	0.290
1.3		Ease of communication	0.143
1.4		Ease of system basic functions	0.085
1.5		Comprehensive and well organ. GUI	0.166
2.1	Technical Quality	Availability	0.000
2.2		Response problems	0.270
2.3		Bugs	0.165
2.4		Technical Support	0.240
3.1	Educational Content	Clarity	0.362
3.2		Structure	0.447
3.3		Quantity	0.460
3.4		Usefulness	0.534
3.5		Completeness	0.422
4.1	Instructor Support	Satisfactory answers	0.472
4.2		Interaction initiation	0.527
4.3		Subject knowledge	0.417
4.4		Additional information provision	0.552
5.1	Self-Assessment/Quiz	Quiz usefulness	0.540
5.2		Instructor's response	0.544
5.3		Progress self-assessment	0.467
6.1	Learning Community	Communication	0.256
6.2		Team learning	0.428
6.3		Exchange of ideas	0.263
7.1	Personalization	Choice of learning pace	0.338
7.2		Choice of learning manner	0.351
7.3		Focus on personal interests	0.525
7.4		Learning process customization	0.417

Table 4. Average correlations of first layer value measures with the ones of second and third layer

4.7 Definition of Improvement Priorities

Finally, we focused on providing guidance and support of decisions concerning improvements, by defining improvement priorities for this e-service, first at the higher level of value dimensions and then at the lower level of value measures. For this purpose initially based on the results of 4.2 we classified the first layer value dimensions into two groups according to their average ratings by the users: in the first group were classified the ones below the average of the lowest rated (Educational Content: 5.71) and the highest rated (Self-assessment/Quiz: 6.14), and in the second group the ones above the average (Table 5). Then based on the results of 4.4 we classified them into two groups according to their average correlation with the second and third layers' value dimensions (Table 6). From these two classifications we can conclude that our highest priority should be assigned to the improvement of the Educational Content and the Personalization Capabilities, since these two value dimensions received low ratings by the users, and at the same time they have high impact on higher layers' value generation.

5.71	5.92	6.14
Educational Content, Learning Community, Personalization		Technical Quality, Perceived Ease of Use, Instructor Support, Self-assessment/Quiz

Table 5. Classification of first layer value dimensions according to their average ratings by users

0.342	0.497	0.653
Technical Quality, Perceived Ease of Use, Learning Community		Personalization, Educational Content, Self-assessment/Quiz, Instructor Support

Table 6. Classification of first layer value dimensions according to their average correlations with the second and third layers' value dimensions

In a similar manner we defined improvement priorities at the lower level of the individual value measures corresponding to individual characteristics of the e-service. Based on the results of 4.2 we classified the 28 first layer value measures into two groups according to their average ratings by the users (Table 7). Aldo, based on the results of 4.6 we classified them into two groups according to their average correlations with the second and third layers' value measures (Table 8).

5.48	5.99	6.51
2.2, 3.1, 3.2, 3.3, 3.4, 3.5, 4.2, 5.2, 6.1, 6.2, 6.3, 7.1, 7.2, 7.3, 7.4		1.1, 1.2, 1.3, 1.4, 1.5, 2.3, 2.4, 4.1, 4.3, 4.4, 5.1, 5.3

Table 7. Classification of first layer value measures according to their average ratings by users

0	0.276	0.552
1.1, 1.3, 1.4, 1.5, 2.1, 2.2, 2.3, 2.4, 6.1, 6.3		1.2, 3.1, 3.2, 3.3, 3.4, 3.5, 4.1, 4.2, 4.3, 4.4, 5.1, 5.2, 5.3, 6.2, 7.1, 7.2, 7.3, 7.4

Table 8. Classification of first layer value measures according to their average correlations with the second and third layers' value measures

From these two classifications we can identify the value measures (i.e. individual e-service characteristics) to which the highest improvement priority should be assigned, as the intersection of the subset of the measures that received low ratings from the users, and the subset of those having higher average correlations with the ones of the second and third layer; they are shown below in Table 9. We remark that 3.1-3.5 and 7.1-7.4 belong to the value dimensions 'Educational content' and 'Personalization', which have been identified previously as having highest priority for improvement. Also, the analysis at the level of the individual value measures revealed three additional ones that should be assigned the highest priority for improvement (interaction initiation by the instructor (4.2), instructor response to e-learners assignments (5.2) and team learning (6.2)), which do not belong to the above two value top improvement priority dimensions. This shows the usefulness of creating both high and low level value models of the e-service.

3.1	Content Clarity
3.2	Content Structure
3.3	Content Quantity
3.4	Content Usefulness
3.5	Content Completeness
4.2	Interaction initiation by the instructor
5.2	Instructor response to assignments
6.2	Team learning
7.1	Choice of learning pace
7.2	Choice of the way of learning
7.3	Focus on issues of interest
7.4	Learning process customization

Table 9. Value measures (characteristics) to be assigned the highest improvement priority

5 CONCLUSIONS

As mentioned in the introduction high investments have been made for setting up and running various types of e-services (e.g. e-business, e-banking, e-government, e-learning, etc.) based on the Internet/WWW. However their usage and quality have been much lower than expectations. Since this is a new area, a lot of learning and improvement is required in order to progress towards higher levels of maturity. This can be greatly assisted by the development of sophisticated e-services evaluation methods, which have solid foundations on and exploit previous IS research, and can produce more value-related knowledge and insight on these e-services, and also better support for improvement decisions. Advances in e-services evaluation methods will intensify learning and improvement in this economically critical area.

In this direction in the previous sections of this paper has been presented a methodology for a better and more structured evaluation of e-services throughout their lifecycle. It is based on the definition and estimation of a multi-level value flow model of the e-service, initially at a high level and then at a lower more detailed level, which includes its main value dimensions and measures, and the relations among them. This model is structured in three layers focusing on e-service efficiency, effectiveness and future users' behavior respectively. Our methodology adds value to the existing e-services evaluation frameworks, as it enables the exploitation of the relations among the various evaluation dimensions and measures they propose, which increases considerably the value-related information and knowledge that can be produced. Based on these value flow models useful conclusions can be drawn and new knowledge can be created about the main dimensions/types of value the e-service generates and the relations among them, the strengths and weaknesses of it, its value generation mechanism, and its improvement priorities, providing support and guidance for improvement decisions.

A first application/validation of it has been presented for an e-learning service provided by the National Technical University of Athens (NTUA) to ICT professionals, and has provided evidence that it is practically applicable with a reasonable effort and it can provide useful conclusions. In particular, the proposed methodology produced useful information on the level of value this e-learning service generates for its users along several important dimensions, such as educational content, instructor support, learning community development, personalization capabilities, self-assessment, ease of use, technical quality, and also use, accomplishment of educational objectives and future use of it as a continuous education tool. Additionally, it allowed us to go into more detail and get a deeper understanding of the level of value produced for the users at the level of the main sub-dimensions of the above dimensions. In this way a complete and detailed picture has been constructed of the multi-dimensional value that this e-learning service generates for its users. Also, the proposed methodology enabled us to identify which of the above dimensions and sub-dimensions are rated lower by the users, so they can be regarded as weaknesses, and which are rated higher, so they can be regarded as

strengths. Furthermore, it has provided useful insight concerning the impact of the particular e-learning resources and capabilities offered to the users, which are under the direct control of the provider, on the higher level value dimensions: usage of this e-service, accomplishment of users' educational objectives and their future behaviour. The combination of all the above information produced by the proposed methodology allowed the construction of a value flow model of this e-learning service, which provides a comprehensive visualization of the value generation mechanisms of it. Furthermore, it allowed the rational identification of e-learning resources and capabilities offered to the users that should be given the highest priority for improvement with the limited resources usually available for this purpose, providing substantial support for these decisions.

The research presented in this paper has interesting implications for research and management. It proposes an approach for developing structured e-services value flow models with several layers at different levels of detail, by synthesizing conclusions and elements from previous IS research, which can be useful in future e-services research. This approach enables a more structured and comprehensive evaluation of e-services, a detailed assessment the various types of value they generate and the relations among them, and in general a deeper understanding of their value generation mechanisms. It allows an extension of the existing e-services evaluation frameworks (reviewed in section 2) through the estimation and the exploitation of the relations among the various sets of evaluation dimensions and measures each of them proposes, which can widen and enhance the information and insight they provide. With respect to e-services management it provides a sound base for the rational continuous monitoring, improvement and optimization of an e-service throughout its operational lifecycle, making optimal use of the usually scarce human and financial resources; it provides e-services providers' management with a clear picture of the multi-dimensional value generated for users, and assists in identifying strengths and weaknesses, and in prioritizing improvements. It should be emphasized that the proposed methodology is characterized by wide applicability to the research and management of any type of e-services, e.g. to e-business, e-banking, e-government and e-learning services, by appropriately defining the main value layers, dimensions and measures of the particular e-service, taking into account previous relevant literature, and also the objectives, characteristics, resources and capabilities of the e-service.

A limitation of this study is that the proposed methodology has been applied, elaborated and validated only in one type of e-services (an e-learning service). Also, for collecting evaluation data has been used a group of ICT professionals having high educational level and computer skills. Therefore further research is required for elaborating and validating the proposed methodology in other types of e-services as well and collecting data from users of various educational levels and computer skills.

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APPENDIX:
Questionnaire for the e-learning service evaluation and conceptualization literature resources

	Factors	Conceptualization Resources
	1. EASE OF USE	
1.1	It was easy to learn the basic functionalities of the e-learning system.	Shee and Wang (2008), Selim (2005)
1.2	It was easy to access the educational content and navigate in it.	Ozkan and Koseler (2009), Soong et al (2001), Selim (2005)
1.3	It was easy to contact the instructor and other colleagues of mine, by using e-mail, forum, etc.	Shee and Wang (2008), Selim (2005)
1.4	It was easy to perform the necessary actions in a direct way and a small nymber of steps.	Davis (1989), Volery and Lord (2000), Soong et al (2001), Selim (2005)
1.5	The interfaces of the e-learning system were clear, comprehensive and well-organized.	Volery and Lord (2000), Soong et al (2001), Selim (2005)
	2. TECHNICAL QUALITY	
2.1	The e-learning system and course were fully available without any interruption problems.	ISO 9126, Fresen and Boyd (2005), Ozkan and Koseler (2009)
2.2	I didn't face any response problems.	ISO 9126, Fresen and Boyd (2005)
2.3	I didn't realize any bugs while using the e-learning system.	Bouras and Konidaris (2003), Fresen and Boyd (2005), Ozkan and Koseler (2009)
2.4	I had a very good technical support while using the e-learning system whenever neccessary.	Bouras and Konidaris (2003), Fresen and Boyd (2005)
	3. EDUCATIONAL CONTENT	
3.1	The electronic educational content was clear and comprehensive.	Govindasamy (2002), Turban and Gehrke (2000), Janda et al (2002), Shee and Wang (2008), Fresen and Boyd (2005)
3.2	The electronic educational content was well organized and structured.	Selim (2005), Govindasamy (2002), Shee and Wang(2008)
3.3	The quantity of the content (basic texts, articles, links, multimedia material) was sufficient and satisfactory.	Govindasamy, 2002, Turban and Gehrke (2000),Shee and Wang (2008), Holsapple and Lee-Post (2006)
3.4	The electronic educational content was useful and according to my personal educational needs.	Selim (2005), Shee and Wang (2008)
3.5	The electronic educational content was complete and up-to-date.	Govindasamy, 2002,Turban and Gehrke (2000),Janda et al (2002),Shee and Wang, 2008,Holsapple and Lee-Post (2006)
	4. INSTRUCTOR SUPPORT	
4.1	The instructor responded to my questions about the course content in a timely and understandable manner.	Hoyt and Cashin (1977), Selim (2005), Ozkan and Koseler (2009)
4.2	The instructor stimulated interaction among students through e-mail forum, chat, etc.	Soong et al (2001), Selim (2005), Paechter et al (2010)
4.3	The instructor had a good knowledge and background of the course subject.	
4.4	The instructor provided me with additional information according to my particular interests.	Hoyt and Cashin (1977), Cashin and Downey (1992), Soong et al (2001), Selim (2005), Paechter et al. (2010)
	5. QUIZ/SELF-ASSESMENT	
5.1	The assignments during the e-course helped me to better comprehend its content.	Paechter et al. (2010), Marsh (1982), Marsh (1987)
5.2	Instructor's response in questions regarding assignments helped me to understand my mistakes and weaknesses.	Fresen and Boyd (2005), Paechter et al. (2010)
5.3	The quiz enabled me to realize the level of my progress and to identify my weaknesses.	Shee and Wang (2008), Fresen and Boyd (2005), Paechter et al. (2010)
	6. ELECTRONIC LEARNING COMMUNITY	
6.1	The e-learning system made it easy for me to interact with my colleagues (e.g. through e-mail, forums, chats, etc.)	Volery and Lord (2000), Soong et al. (2001), Selim (2005), Shee and Wang (2008), Fresen and Boyd (2005)
6.2	Overall, the e-learning system made me feel a part of a community, sharing common goals with other people.	Selim (2005), Shee and Wang (2008), Fresen and Boyd (2005)
6.3	I had communication and exchanged ideas and opinions with my colleagues and the instructor during the e-course.	Volery and Lord (2000), Soong et al (2001), Selim (2005), Shee and Wang (2008), Piccoli et al (2001), Fresen and Boyd (2005)
	7. CUSTOMIZATION	
7.1	The system enabled me to choose the pace of the e-learning process according to my own style and needs.	Paechter et al (2010), Hamid (2001), Shee and Wang (2008)
7.2	The system enabled me to choose the manner of learning according to my own style and needs.	Paechter et al (2010), Hamid (2001), Shee and Wang (2008)
7.3	The system enabled me to focus on the issues I am really interested in and gain a deeper knowledge.	Wang (2003), Paechter et al (2010), Shee and Wang (2008)
7.4	The system allowed me to personalize and set up the e-learning process according to my needs and abilities.	Ozkan and Koseler (2009), Shee and Wang (2008), Wang (2003)
	8. ACEO	
8.1	I have learned important concepts and principles regarding this e-course.	Hoyt and Cashin (1977), Cashin and Downey (1992), Bloom (1956), Kirkpatrick (1983)
8.2	I have learned important methods and technologies related to the subject of this e-course	Hoyt and Cashin (1977), Cashin and Downey (1992), Bloom (1956), Kirkpatrick (1983)
8.3	In this e-course I have gained the ability of practically applying my knowledge.	Hoyt and Cashin (1977), Cashin and Downey (1992), Bloom (1956), Kirkpatrick (1983)
8.4	In this e-course I have gained the ability of analyzing complex problems into smaller parts.	Hoyt and Cashin (1977), Cashin and Downey (1992), Bloom (1956), Kirkpatrick (1983)
8.5	In this e-course I have gained the ability of synthesizing knowledge from facts, ideas and data.	Hoyt and Cashin (1977), Cashin and Downey (1992), Bloom (1956), Kirkpatrick (1983), Jackson (1998)
	9. USE	
9.1	I have dedicated a lot of time studying the content of the e-course	Davis, (1989), Selim (2002), Delone and McLean (2003)
9.2	I have extensively used the tools provided to communicate and interact with the Instructor and colleagues.	Davis, (1989), Selim (2002), Delone and McLean (2003)
9.3	I have dedicated a lot of time doing the assignment and participating in the quiz.	Davis, (1989), Selim (2002), Delone and McLean (2003)
	10. FUTURE USAGE BEHAVIOR	
10.1	I would recommend this e-learning course to someone I know and would be interested in the same subject.	Winer (2001), Saade and Bahli (2005), Ngai et al (2005), Chiu et. al (2005)
10.2	I would be interested in participating in another e-learning course offered by the same institution.	Winer (2001), Bhatarchejee (2001), Saade and Bahli (2005), Ngai et al (2005,) Chiu et al (2005)