Transforming e-services evaluation data into business analytics using value models

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1. Introduction

As Internet penetration and use grows rapidly worldwide, and many new information and communication technologies (ICT) are continuously developed based on it, organizations in the private and public sectors are trying to exploit this trend by making large investments for the design, development, delivery and support of various types of e-services, such as e-business, e-banking, e-government and e-learning. These e-services aim to offer to their users various electronic resources and capabilities to execute electronically various tasks and transactions. These include search for products and services, transactions with banks and government agencies, and acquisition of new knowledge and skills. They can do these on a 24-h basis from their homes or offices.

Despite the high investments that have been made for setting up and running these e-services, for most of them, usage is below expectations and users are not satisfied with their quality. The websites providing these e-services collect large amounts of users’ activity and evaluation data. It is necessary to transform these data into useful business analytics that allow a better understanding of the strengths and weaknesses of the e-service, the various types of value it generates, and its whole value generation mechanism, and at the same time provide guidance for its improvement and optimization. We propose and validate a methodology for transforming user evaluation data into useful business analytics, founded on the technology acceptance model, the IS success model and e-services. We define a three-layer value model for e-services, including concerning its efficiency, effectiveness and impact on users’ future behavior respectively. This value model is used for collecting and processing service evaluation data from users. We calculated two classes of business analytics: average users’ ratings to identify strengths and weaknesses of e-services; and the impacts of first-layer value measures on the second and third layer value ones. The latter allows a better understanding of the value generation mechanism for e-services and identification of improvement priorities. Our methodology has been applied and validated for an e-learning service provided by a university to technology professionals.

The rapidly increasing penetration and use of the Internet, in conjunction with the explosion of various technologies based on it, gave rise to the development of numerous e-services, such as e-business, e-banking, e-government and e-learning ones. The websites providing these e-services collect large amounts of users’ activity and evaluation data. It is necessary to transform these data into useful business analytics that allow a better understanding of the strengths and weaknesses of the e-service, the various types of value it generates, and its whole value generation mechanism, and at the same time provide guidance for its improvement and optimization. We propose and validate a methodology for transforming user evaluation data into useful business analytics, founded on the technology acceptance model, the IS success model and e-services. We define a three-layer value model for e-services, including concerning its efficiency, effectiveness and impact on users’ future behavior respectively. This value model is used for collecting and processing service evaluation data from users.

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and interpretation of them. They also offer directions for the necessary improvement interventions. The development of methodologies for more sophisticated analysis of various types of user activities and evaluation data, so more knowledge can be generated from them, will be useful for the WAS and their client organizations.

We propose and validate a methodology for transforming e-service user evaluation data into useful business analytics, to support the development of valuable insights and conclusions. Our approach is based on the definition of a three-layer value model of a particular e-service. This includes the main dimensions and measures of the value it generates, associated with the resources and capabilities it provides to its users. The first layer focuses on efficiency dimensions and measures. It also considers the support it provides to users for performing various tasks and achieving various objectives. This is the second layer of effectiveness dimensions and measures. In addition, our approach considers the impact on the future behavior of users. This is the third layer involving dimensions and measures for future behavior.

We use this value model for collecting e-service evaluation data from users through an online questionnaire on the e-service website, and then for processing the data. Based on these data, we calculate the average user ratings for all value measures, dimensions and layers. This first class of business analytics allows us to identify the strengths and the weaknesses of the e-service at various levels of detail. Next, the impact of each first-layer value dimension and measure, which are independent variables under the control of the e-service provider, affects the higher-level dependent variables that are not under the control of the e-service provider. Instead, they depend on and are shaped by the independent variables. They offer an objective indicator of its importance for the users, by quantifying its impact on higher-layer value generation.

A second class of impact-related business analytics can be calculated in combination with the ones of the first class. This allows a better understanding of the value generation mechanism of the e-service, and also the rational definition of improvement priorities. They further allow us to identify the resources and capabilities of the e-service rated by users as being of low quality. They also have a high impact on the generation of higher-layer value, and we can assign to them the highest improvement priority.

These classes of business analytics provide a sound basis for rational continuous monitoring, improvement and optimization of the e-service. This is necessary due to the frequent enhancements and changes usually made throughout its operational life for meeting the evolving user needs and responding to competitors' new offerings, making optimal use of the scarce human and financial resources.

The proposed methodology offers significant advantages over the existing e-services evaluation frameworks. For comprehensive reviews of the literature, see Rowley (2006) and Sumak et al. (2009), which we will discuss later in greater depth. The authors propose sets of evaluation dimensions and measures, but only limited processing of them. They mainly exploit their average values over a number of users who evaluate the e-service, as a means to draw conclusions about it. The relations among these evaluation dimensions and measures are neglected and are not exploited for drawing further conclusions. In general, the existing e-services evaluation frameworks do not use more advanced multi-variable statistical techniques to draw deeper insights and extract more knowledge from user evaluation data.

In contrast, our proposed methodology exploits the average values of the evaluation dimensions and measures, and also their relations. It combines them to provide deeper insights than the ones provided by existing e-services evaluation frameworks, such as a better understanding of the value-generation mechanism of the e-service and a rational identification of improvement priorities.

It uses a wider range of statistical techniques (calculations of averages, correlations and Cronbach alpha values, regressions) to intensify knowledge extraction from e-service user evaluation data. Furthermore, the proposed methodology provides a framework for combining, synthesizing and structuring evaluation dimensions and measures from multiple e-service evaluation frameworks.

This paper is structured in five sections. Section 2 outlines the theoretical foundations of the proposed methodology. A description of the methodology is provided in Section 3, while in Section 4 a first application-validation of it is presented for an e-learning service offered by the National Technical University of Athens to ICT professionals. Finally, in Section 5 outlines our conclusions and future research directions.

2. Theoretical foundations

To develop our methodology, we reviewed previous research in the area of e-services evaluation, and also in the wider area of information systems (IS) evaluation literature. Also, we reviewed previous research in the adjacent areas of IS acceptance and success, focusing on the family of technology acceptance models and the IS success models. We next discuss some fundamental conclusions and frameworks from the above areas that have been used as theoretical foundations for building our methodology.

2.1. Information systems evaluation

There is an extensive research literature on the evaluation of IS. This includes Hirschheim and Smithson (1988), Willcocks (1994, 1996), Willcocks and Graeser (2001), Smithson and Hirschheim (1998), Farbey et al. (1999), Irani (2002), Irani et al. (2006), Gunasekaran et al. (2006), Stockdale and Standing (2006), and Irani and Love (2008). The main conclusion is that evaluation is a highly complex task. This is because the benefits and the value created by most categories of IS are multidimensional and complex. They are also financial and non-financial, and tangible and intangible. So the usual financial investment appraisal methods are inadequate, 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 figuring out how to do it is just as hard. Smithson and Hirschheim (1998) classify the existing IS evaluation methods into two basic categories. The first category are efficiency-oriented, which have been influenced mainly by engineering sciences. They evaluate IS performance with respect to some predefined technical and functional specifications, and focus on answering the question of whether the system is doing things right.

The second category consists of effectiveness-oriented methods. They 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, to assess whether the system is doing the right things. Farbey et al. (1999) provide a framework on the "benefits evaluation ladder." It classifies IS according to the kind of benefits they offer in eight IS categories, and for each of them the authors propose a different evaluation methodology.

Willcocks (1994, 1996) suggests that appropriate evaluation of IS should be performed in all stages of their life cycle. This includes for the initial feasibility study, during and at the end of development, and also during its productive exploitation. However, Willcocks recognizes 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. Stockdale and...
Standing (2006) argue that the increasing complexity of IS, and also the emergence in the last ten years of Internet-based IS used inside and outside the organization that developed it (by its customers, prospects, suppliers, etc.) makes IS evaluation even more difficult than in the past. They also recommend that what is evaluated for IS and how the evaluation process is carried out should be shaped according to the context, inclusive of the objectives of the particular IS and its main stakeholders.

Irani and Love (2008) argue that in both the private and the public sector there is a crisis of understanding of the importance, the role and the relevance of IS evaluation throughout their life cycle. However, a robust and comprehensive IS evaluation can result in valuable organizational learning in this critical area, which can produce useful knowledge that may result in significant improvements. This research stream permits us to conclude that it is not possible to develop a single best IS evaluation method appropriate for all types of IS. Instead, for each type of IS it is necessary to formulate a different evaluation method, taking into account its particular characteristics, objectives and expected benefits. However, all IS evaluation methods should deal with both the efficiency and the effectiveness perspective.

2.2. Technology acceptance models

Also, extensive research has been conducted on IS acceptance by users, regarding it as a major measure of IS value, aiming to identify the characteristics and factors that affect 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 early versions of TAM, the attitude towards using an IS, which finally determines the intention to use it and its actual use, is determined mainly by two characteristics. One is its perceived ease of use. This is the degree to which potential users believe that using it would require minimal effort. A second is its perceived usefulness. This is the degree to which potential users believe that using it will enhance their job performance (Davis 1989).

Each of these factors can be elaborated into a detailed set of variables for each particular type of IS under study. Based on this framework extensive research has been conducted for understanding and predicting user acceptance of various types of IS. Comprehensive reviews of this research stream are available from Legris et al. (2003), Schepers and Wetzel (2007), Turner et al. (2010), Holden and Karsh (2010), and Hsiao and Yang (2010). This research stream implies that the evaluation of a particular IS type should focus on its ease of use, usefulness, actual usage and user intentions to use it in the future.

2.3. Information systems success models

Another research stream that can provide useful elements to be taken into account for the evaluation of IS is the IS success models research. The most widely used of them is the DeLone and McLean (1992, 2003) model of IS success. It proposes seven interrelated IS success measures structured in three layers: information quality, system quality and service quality (at the first layer), which affect user satisfaction and also the actual use of the IS (at the second level). Finally these two variables determine the individual impact and the organizational impact of the IS. Seddon (1997) proposed a re-specification and extension of this model, which includes 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 assume the relationships that system quality and information quality cause system use and user satisfaction (Igbaria and Tan 1997, Garrity and Sanders 1998, Rai et al. 2002, Avlonitis and Panagopoulos 2005, Wu and Wang 2006, Bernroider 2008, Park et al. 2010). From this research stream, it has been 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.

2.4. E-services evaluation


Comprehensive reviews of e-service evaluation frameworks are provided in Rowley (2006) and Sumak et al. (2009). These frameworks suggest useful e-services evaluation dimensions and measures, with most of them assessing the quality of the resources and capabilities that the e-service provides to its users, oriented towards the abovementioned efficiency-oriented IS evaluation. Some others are assessing the support it provides to users for performing various tasks and achieving various objectives, or users’ overall satisfaction, oriented towards the abovementioned effectiveness-oriented IS evaluation. However, the above frameworks are weak in the processing they propose for the evaluation data to be collected from the users. They propose mainly average values calculations for all evaluation measures and dimensions over all the users who evaluate the e-service for drawing conclusions about it. They do not use more advanced multi-variable statistical techniques to extract more knowledge from the user evaluation data. These data remain underexploited, and the relations among the proposed evaluation dimensions are not much used either. Thus, we conclude that, to evaluate an e-service, it is necessary to combine efficiency and effectiveness evaluation dimensions and measures from several existing frameworks, and adapt them to the particular objectives, characteristics, resources and capabilities of the particular e-service.

3. Methodology description

Based on the above conclusions of previous research in the areas of IS evaluation, TAM, IS success models and e-services evaluation a methodology has been developed for transforming e-service users’ evaluation data into useful business analytics that lead to valuable insights and conclusions. The basic characteristics of the methodology have been defined so that they exploit the above fundamental conclusions of previous research in order to generate more insight and knowledge on the e-service. In particular our methodology:
The proposed methodology is based on the estimation of a value model of the e-service, which includes the main dimensions and measures of the value it generates structured in three layers, and the relations among them. In particular, as we can see in Fig. 1, the above three layers of the value model of an e-service include:

- Efficiency measures, which assess the quality of the basic 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, as recommended by the IS success models research;
- Usage and effectiveness measures, which assess the extent of use of the e-service and also its outcomes, including to what extent the e-service assists users in completing their tasks, achieving their objectives, offering them fun and enjoyment, and satisfying them;
- Users’ future behavior measures, which assess to what extent the e-service influences the future behavior of its users, for example, the extent they intend to use the e-service again in the future, or recommend it to friends and colleagues.

These measures are in the first layer, and represent efficiency measures. They are independent variables that are under the direct control of the e-service provider, which can take direct actions for improving the resources and capabilities offered by the e-service. In contrast, the measures of the other two layers (usage, effectiveness and future behavior measures) are dependent variables. They are not under the direct control of the service provider. The independent variables concern the means and the dependent variables concern the results and outcomes achieved through them.

In particular, our methodology consists of the following nine stages, as shown in Fig. 2:

- **Step 1.** We begin by defining the value model for the e-service. The main dimensions of the value created by the e-service are identified for each layer. They are associated with the quality of the main resources and capabilities offered by the e-service to its users (first layer). They also are related to the level of usage of it and assistance it offers to the users for completing their tasks or achieving their objectives, with the fun and enjoyment it offers them and with their overall satisfaction (second layer). This also influences users’ future behavior (third layer). Then for each of these value dimensions a number of individual measures are determined. The value dimensions and measures should be selected based on previous relevant literature, and also based on the objectives, characteristics, resources and capabilities of the particular e-service.

- **Step 2.** Based on the value dimensions and measures, an online evaluation questionnaire can be formulated, with one section for each value dimension, including one question for each measure. Then it can be uploaded to the e-service website, to be filled by its users. In this way, user evaluation data are collected.

- **Step 3.** From these data for each value dimension, the Cronbach alpha coefficient of the individual variables corresponding to its measures can be calculated to assess internal consistency. Cronbach’s alpha measures the internal consistency of a set of variables, to quantify to what extent they measure different aspects of single construct (Cronbach 1951, Boudreau et al. 2001, Allen and Yen 2002, Straub et al. 2004). It is defined as:

\[
\alpha = \frac{(k/(k - 1)) + [1 - \sum(s_i^2)/s_{sum}^2]}{k - 1}
\]

In this formula, \(s_i^2\) (\(i = 1, 2, \ldots, k\)) denotes the variances of the \(k\) individual variables, while the \(s_{sum}^2\) denotes the variance of the sum of all items. If the individual variables are not influenced by the construct, then they will be uncorrelated. So the variance of their sum will be the same as the sum of variances of the individual variables, and Cronbach’s alpha will equal 0. If all of the variables are measured perfectly without any error, then Cronbach’s alpha will equal 1. A rule of thumb is that values of Cronbach’s alpha exceeding 0.7 indicate acceptable levels of internal consistency of the variables, while values exceeding 0.8 indicate good levels of internal consistency (Boudreau et al. 2001, Allen and Yen 2002, Straub et al. 2004, Kline 2005). If Cronbach’s alpha exceeds 0.7 for our data, then we can conclude that all the measures have acceptable internal consistency, and we can calculate an aggregate variable for it. This will be equal to the average of the variables corresponding to its measures. If this isn’t the case, then some of the measures are not sufficiently related to this value dimension, so they must be...
removed, or the dimension should be split into two or more sub-dimensions.

- **Step 4.** Average user ratings next can be calculated for all of the value measures, dimensions and layers. This provides the first class of business analytics, which allows us to identify strengths and weaknesses of the e-service at various levels.

- **Step 5.** For each aggregate variable of the second and third layer that assesses one of the dependent variable e-service value dimensions, we next estimate a regression. The independent variables are all of the aggregate variables of the prior layers. We use them to estimate to what extent the 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 (with $R^2 > 0.50$), 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 several 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.

- **Step 6.** For each value dimension of the first layer, we estimate its impact on all value dimensions of the second and third layers. For this purpose, we can use the corresponding standardised coefficients of the above regressions of Stage 5. However, if we have high levels of correlation between the independent variables, or multicollinearity in the regression, then the regression coefficients will not be reliable measures of the impact of the independent variables on the dependent variable. Thus, it is better to use the correlation coefficient between them as a measure of the impact for a first-layer value dimension on a higher-layer value dimension. In this way, a second class of business analytics can be calculated. They constitute objective indicators of the importance of first-layer value dimensions for the users. They quantify their impact on higher-level value generation. This avoids the double evaluation of each measure, so the users don’t rate both the measure and its importance. Other e-service evaluation frameworks have adopted this approach also. An example is the Extended Web Assessment Method proposed by Schubert (2003). This approach supports shorter questionnaires and more reliable measures of the importance of variables.

- **Step 7.** By combining the two classes of analytics calculated in Stages 4 and 6, we can construct a high-level value model for the e-service. This is a way to assess the types of value generated by the e-service and the relations among them. It also enables a better understanding of its value generation mechanism.

- **Step 8.** The value dimensions of the first layer, which are the only independent variables under the control of the e-service provider, are classified. Classification into four groups is made based on the average ratings they receive from the users, as well as their impacts on the value dimensions of the second and the third layers. See Fig. 3. The highest priority should be assigned to the improvement of the value dimensions of the first group, which received low ratings by the users and had a high impact on the generation of higher-level value. In contrast, the lowest priority should be assigned to the improvement of the value dimensions of the fourth group, which received high ratings by the users and yet had a low impact on the generation of higher-level value. It is worthwhile, for this group, to examine whether some of the human and financial resources allocated can be reassigned to improve the value dimensions of the first group. Finally, medium priority should be assigned to improve the value dimensions of the second and third group.

- **Step 9.** Finally, we repeat Stages 5, 6, 7 and 8, but this time for the individual value measures and variables instead of the aggregate variables. This allows us to produce a similar classification of first-layer-value measures, which correspond to particular characteristics of the e-service resources and capabilities. We do this based on average ratings by classifying the users and their impacts on the value measures of the second and the third layer into four groups. See Fig. 2. In this way, we can identify individual first-layer value measures that receive low ratings by the users. We also can see which measures have high impact on second and third-layer value measures, and give to them the highest improvement priority. This methodology provides a basis for continuous monitoring, improvement and optimization of an e-service throughout its lifecycle, and effectively utilizing scarce human and financial resources.

4. Application

A first application and validation of the proposed methodology has been made for an e-learning service offered by the National Technical University of Athens (http://www.ntua.gr) for ICT professionals all over Greece, who need to enhance their skills due to the continuous emergence of new technologies in this domain. 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” and “Introduction to PC Networks and Web Technologies.” E-learners access new educational content via the Internet every week, and download it to their computers. They also read it, ask the responsible instructor

![Fig. 3. Classification of independent first-layer measures of resources/capabilities quality.](image-url)
any questions they have on it. Their questions are accessible to all, together with instructor’s answers, in the e-course space. They also participate in relevant e-discussions with the other e-learners and the instructor in an e-forum tool, and do quizzes and assignments for self-assessment. These are graded by the instructor and 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 model definition

Initially the value model of this e-service was defined, based on previous literature on e-learning evaluation (Jackson 1998; Wang 2003; Selim 2002. Douglas and Van Der Vyver 2004, Ngai et al. 2005; Shee and Wang 2008; Ozkan and Koseler 2009; Paechter et al. 2010), and traditional learning evaluation (Bloom 1956, Marsh 1982, 1983; Kirkpatrick 1983, Cashin and Downey 1992, Hoyt and Cashin 1977), and also on its particular objectives, characteristics, resources and capabilities. It included its main value dimensions per layer (shown in Fig. 4), and for each of them a number of value measures.

We formulated an online evaluation questionnaire for this e-service consisting of ten sections corresponding to the value dimensions, and 38 questions corresponding to the selected value measures. See the Appendix. Each question asked the respondent to what extent he or she agreed with a statement concerning one characteristic of the e-service. We used a seven-point Likert scale, with 1 meaning ‘totally disagree’ and 7 meaning ‘totally agree’. For all of the value dimensions we used the subjective perceptions of the users as value measures. We also examined the possibility of using objective value measures as well, at least for some of the value dimensions, for which they would be meaningful and practical. However, this necessitated non-anonymous filling of the questionnaire by the e-learners. They would have to enter their names in the questionnaires they filled out, to link them to the grades and the time they spent on the platform, for example. This might make the students less willing to reveal their true perceptions and evaluations.

The questionnaire was uploaded on the website of the e-service, and an e-mail with a link to it was sent to 210 e-learners. They participated in the prior six months in an e-course, so not too much time passed, and they could still make reliable evaluations. All of them had a degree in ICT and some professional experience, and most were between 30 and 40 years old. The first page of the questionnaire contained some general information for the respondents, such as the purpose of this questionnaire and instructions for filling it in. The following pages contained other sections of the questionnaire. Altogether, 98 persons responded and filled the questionnaire in for a response rate of 46.6%. We analyzed the data using the SPSS 15 statistical package. The results are presented below.

4.2. Cronbach’s alpha calculations

The Cronbach’s alpha coefficients of the variables for each dimension were calculated, and the results are shown in Table 1. For all value dimensions, the Cronbach’s alpha values exceed the acceptable internal consistency level of 0.7. Furthermore, nearly for all of them, with the exception of Technical Quality, have Cronbach’s alpha value that exceed the good level of internal consistency level at 0.8. We thus conclude that for all of the value dimensions and their selected value measures are sufficiently relevant and measure different aspects of the same uni-dimensional construct. This allowed us to proceed to the calculation for each value dimension of an aggregate variable, which is equal to the average of the individual variables corresponding to its measures.

4.3. Calculations of average ratings for value measures and dimensions

Then we calculated the average ratings for all value measures and dimensions, which are shown in Table 2 together with the corresponding standard deviations. With respect to the value dimensions of the first layer, we can see that the users regard them in general as good. This is because the average of their average ratings is 5.99. This takes into account that 7 corresponds to ‘totally agree’ with the statements of the questions, and 6 corresponds to ‘agree’, so an average of 5.99 for a value dimension means that the users find it good but not very good. Among them, Instructor support, the self-assessment/quiz and the perceived ease of use are perceived to be between very good and good, with ratings of 6.14, 6.13 and 6.13. Technical quality is rated as good (6.02), while educational content, the learning community and the personalization are perceived to be between good and moderately good, with ratings of 5.71, 5.73 and 5.86).

![Fig. 4. The value model definition of the e-learning service.](image-url)
With respect to the value dimensions of the second layer, we can see that the users regard them 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, based on an average rating of 6.05. We can draw similar conclusions about the individual value measures. In some value dimensions, the individual value measures had similar average ratings (e.g., for learning community), while in others there are differences (e.g., for learning outcomes). Users put higher importance on the concepts and principles they have learned (6.35) than on the knowledge synthesis abilities they have acquired (5.28).

### 4.4. 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, we estimated two regression models: the two value dimensions of the second layer as their dependent variables (aggregate variables LOUT_av – Model 1 and USE_av – Model 2). The independent variables are 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 one regression model the value dimension of the third layer as the dependent variable (aggregate variable INT_av). The independent variables include the two value measures of the second layer (aggregate variables PEOU_av, TQ_av, EDCONT_av, ISUPP_av, QUIZ_av, COMMUN_av and PERSON_av). This model has nine independent variables in total (Model 4). Table 3 shown the R² coefficients of these four regression models.

We can see that the R² coefficients of Model 1 and Model 2 are 0.617 and 0.640, indicating that both second-layer value dimensions (use and learning outcomes) are affected to a large extent by the ones of the first layer. In contrast, the R² coefficient of Model 3 is 0.347, which is much lower. This indicates that the third-layer value dimension associated with future behavior is affected to a smaller extent by the variables in the second layer. However, the Model 4 has a much higher R² coefficient of 0.787, which indicates that both first-layer and second-layer value dimensions affect the third layer. So the first-layer value dimensions affect the users' future behavior directly and indirectly through the second-layer value dimensions. From the above results, we conclude that this value model is characterized by high coherence across its layers.

### 4.5. Correlation analysis of value dimensions

After having confirmed the consistency of our value model, the next step was to investigate the impact of the first-layer value
dimensions on the second-layer and the third-layer measures. 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 averages. The results are shown in Table 4, with all correlations statistically significant. 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). This indicates that the four elements of the e-service have the strongest impact on higher-level value generation. Furthermore, Table 4 shows 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).

4.6. High-level value model

By combining the results of Sections 4.3 and 4.5, we were able to construct the high-level value flow model for this e-service. See Fig. 5. It provides a compact visualization of the main dimensions and types of value generated by this e-service, which are quantified through the corresponding average users’ ratings. It also shows the relationships among them, which are quantified through the corresponding correlation coefficients. This enables a better understanding of the value generation mechanism of this e-service. It shows how value of one layer is transformed to value of higher layers, and also the origins of higher layers’ value.

4.7. Correlation analysis of value measures

After gaining an understanding of the extent of influence of the first-layer value dimensions on the ones in the second and third layers, we constructed a more detailed model using the individual value measures by quantifying specific e-service characteristics. For every one of the 28 variables in the first layer, we calculated its correlations with the eight variables in the second layer, and the two variables in the third layer. We also computed their averages, as shown in Table 5. For calculating this average, we only took into account the statistically significant correlations. The insignificant ones were regarded as zero.

From the above results, we conclude that the first-layer value measures 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). This makes sense, 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 their particular needs. Other correlated measures are the instructor’s response to questions about the assignments (0.544), self-assessment and 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. Note that all of them belong to the first-layer value dimensions that have been found previously in Section 4.5 to be strongly correlated to the higher layers’ ones (instructor support, self-assessment/quiz and educational content). Also, by combining the results of Sections 4.3 and 4.7, we can construct a low-level value model for this e-service, which enables us to provide a more detailed visualization of the value generation mechanism of this e-service than the high-level value model shown in Fig. 5.

4.8. Definition of Improvement Priorities

We defined improvement priorities for this e-service, at the higher level of value dimensions and at the lower level of value measures. For this purpose, and based on the results of Section 4.3, we classified the seven first-layer value dimensions into two groups according to their average ratings by the users. In the first group, we have classified the ones below the average of the lowest rated (educational content: 5.71) and the highest rated (self-assessment/quiz: 6.14) ones. Their average is \((5.71 + 6.14)/2 = 5.92\). In the second group, we have the ones that are above this average. See Table 6. Based on the results of Section 4.5, we classified them into two groups according to their average correlations with the second and third-layer value dimensions, see Table 7.

From these two classifications, we conclude that our highest priority should be assigned to the improvement of the Educational Content and the Personalization Capabilities. They received low ratings from the users, yet they have a high impact on higher layers’ value generation.

In a similar manner, we defined improvement priorities at the level of individual value measures. Based on the results in Section 4.3, we classified the 28 first-layer value measures into two groups according to their average ratings by the users. In the first group, we have the ones with the lowest average (interaction initiation by the instructor: 4.2) and team learning (6.2). These do not belong to the above two value dimensions of top improvement priority. This will occur at 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 the second and third layers. See Table 8. The reader should note 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 the 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. They are interaction initiation by the instructor (4.2), instructor response to e-learners assignments (5.2) and team learning (6.2). These do not belong to the above two value dimensions of top improvement priority.

5. Conclusions

Many e-services have been developed and are currently used by individuals and organizations, however their usage and quality typically are below users’ expectations. Since this is a new area, a lot of learning and improvement is required achieve higher levels of maturity. Toward this end, many organizations have started analyzing the enormous amounts of data in their web log files to find new information that will assist them in identifying and implementing technical and business improvements. We also have seen the development of the web analytics industry. An increasing number of firms offer software and services for the analysis of weblog data about the online activities of websites visitors. They produce useful reports that offer guidance for firm-level improvements. This prompts the development of new and advanced method...
odologies. Developments in this area will be very useful both for the web analytics industry and for the organizations offering various types of e-services, and will contribute to achieving maturity and quality in e-services.

We contributed a methodology for transforming the large amounts of evaluation data collected in e-services websites into business analytics. The proposed methodology is based on a value model of the e-service. It includes its main value dimensions, and for each of them its main value measures, structured in three layers focusing on e-service efficiency, effectiveness and the users' future behavior respectively. This value model guides the collection of e-service evaluation data and their processing. Our methodology applies elements from established theoretical frameworks on IS evaluation. We presented an application of our approach for an e-learning service provided by the National Technical University of Athens to ICT professionals. This enabled us to provide evidence that it applicable with a reasonable effort and that it provides interesting insights, conclusions and improvement directions.

The proposed methodology offers significant advantages over the existing e-services evaluation frameworks. The proposed methodology exploits the average values of the evaluation dimensions and measures and the relations among them. By combining these two classes of business analytics, our approach can provide deeper insights than existing e-services evaluation frameworks. It allows identification of the strengths and weaknesses of an e-service, and its value generation mechanism, as well as information about improvement priorities. Our approach uses a wider range of statistical techniques (calculations of averages, correlations and Cronbach alpha values, regression) to support knowledge extraction from e-service user evaluation data.

This research has implications for research and practice. With respect to research, it proposes a widely-applicable approach for defining structured multi-layer e-services value models. It does this by synthesizing views and elements from various frameworks developed in previous research. It also supports estimating them based on user evaluation data, which can be useful in future e-services research. This approach allows highly useful business analytics, which combine information from several e-service value measures. It also supports a detailed assessment of the various types of value they generate and the relationships among them.

With respect to practice, our approach provides a sound basis for continuous monitoring, improvement and optimization of an e-service, by making optimal use of scarce human and financial resources. It allows the identification of its strengths, weaknesses and improvement priorities. The proposed methodology is characterized by wide applicability to any type of e-services with different kinds of objectives and characteristics. It also offers different kinds of resources and capabilities to its users, and supports the achievement of different kinds of tasks and objectives.

For each kind of e-service, it still is necessary to define the value dimensions and measures in the three layers of the value model, which reflect its specific instantiation. In the efficiency layer, it is necessary to define value dimensions and measures that focus on the quality of the particular resources and capabilities it offers to the users. In the effectiveness layer, it is necessary to define value dimensions and measures that focus on the particular tasks or objectives it aims to support.

The proposed methodology can also be used for e-services for which evaluation data have already been collected, without being based on a systematically developed value model of the e-service. In such cases, we can divide the evaluation questions into two categories. One can assess the means that are used, for example, the resources and capabilities offered to users. Another can assess the outcomes that occur. These include the extent of assistance offered to users for executing some tasks or achieving some objectives.

A limitation of this study is that the proposed methodology has been applied, elaborated and validated only for one type of e-services: e-learning. We collected evaluation data for a group of ICT professionals with a high level of education and computer skills. Further research is required for elaborating and validating the proposed methodology for other types of e-services as well. Another limitation is related to the value dimensions we used as value measures for the subjective perceptions of the users. It would be interesting if we could use objective value measures as well. We could measure the learning outcomes based on the grade that each learner achieved in the final exam, for example. Also, use could be measured through the amount of time e-learner spends on the e-learning platform. Finally, it would be interesting to investigate the use of other sophisticated statistical methods for analyzing e-service users’ evaluation data and calculating new types of business analytics providing additional useful insights and conclusions.

Appendix A. Questionnaire for the e-learning service evaluation and conceptualization literature resources

<table>
<thead>
<tr>
<th>Factors</th>
<th>Conceptualization resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ease of use</td>
<td></td>
</tr>
<tr>
<td>1.1 It was easy to learn the basic functionalities of the e-learning system</td>
<td>Shee and Wang (2008), Selim (2005, 2007)</td>
</tr>
<tr>
<td>1.2 It was easy to access the educational content and navigate in it</td>
<td>Ozkan and Koseler (2009), Soong et al. (2001), Selim (2005)</td>
</tr>
<tr>
<td>1.3 It was easy to contact the instructor and other colleagues of mine, by using e-mail, forum, etc.</td>
<td>Shee and Wang (2008), Selim (2005)</td>
</tr>
<tr>
<td>1.4 It was easy to perform the necessary actions in a direct way and a small number of steps</td>
<td>Davis (1989), Volery and Lord (2000), Soong et al. (2001), Selim (2005)</td>
</tr>
<tr>
<td>1.5 The interfaces of the e-learning system were clear, comprehensive and well-organized</td>
<td>Volery and Lord (2000), Soong et al. (2001), Selim (2005)</td>
</tr>
<tr>
<td>2. Technical quality</td>
<td></td>
</tr>
<tr>
<td>2.1 The e-learning system and course were fully available without any interruption problems</td>
<td>ISO 9126 (2001), Fresen and Boyd (2005), Ozkan and Koseler (2009)</td>
</tr>
<tr>
<td>2.2 I did not face any response problems</td>
<td>ISO 9126 (2001), Fresen and Boyd (2005)</td>
</tr>
<tr>
<td>2.3 I did not realize any bugs while using the e-learning system</td>
<td>Bouras and Konidaris (2003), Fresen and Boyd (2005), Ozkan and Koseler (2009)</td>
</tr>
<tr>
<td>2.4 I had a very good technical support while using the e-learning system whenever necessary</td>
<td>Bouras and Konidaris (2003), Fresen and Boyd (2005)</td>
</tr>
<tr>
<td>3. Educational content</td>
<td></td>
</tr>
<tr>
<td>3.1 The electronic educational content was clear and comprehensive</td>
<td>Govindasamy (2002), Turban and Gehrke (2000), Janda et al. (2002), Shee</td>
</tr>
<tr>
<td>Factors</td>
<td>Conceptualization literature resources</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>3.2 The electronic educational content was well organized and structured</td>
<td>Govindasamy (2002); Shee and Wang (2008)</td>
</tr>
<tr>
<td>3.3 The quantity of the content (basic texts, articles, links, multimedia) was sufficient and satisfactory</td>
<td>Govindasamy 2002; Turban and Gehrke (2000); Shee and Wang (2008); Holsapple and Lee-Post (2006)</td>
</tr>
<tr>
<td>3.4 The electronic educational content was useful and according to my personal educational needs</td>
<td>Selim (2005); Shee and Wang (2008)</td>
</tr>
<tr>
<td>3.5 The electronic educational content was complete and up-to-date</td>
<td>Govindasamy 2002; Turban and Gehrke (2000); Janda et al. (2002); Shee and Wang; 2008; Holsapple and Lee-Post (2006)</td>
</tr>
<tr>
<td>4.1 The instructor responded to my questions about the course content in a timely and understandable manner.</td>
<td>Soong et al. (2001), Selim (2005), Paechter et al. (2010)</td>
</tr>
<tr>
<td>4.2 The instructor stimulated interaction among students through e-mail, forum, chat, etc.</td>
<td>Hoyt and Cashin (1977), Cashin and Downey (1992), Soong et al. (2001), Selim (2005), Paechter et al. (2010)</td>
</tr>
<tr>
<td>4.3 The instructor had a good knowledge and background of the course subject</td>
<td>Hoyt and Cashin (1977), Cashin and Downey (1992), Selim (2005), Paechter et al. (2010)</td>
</tr>
<tr>
<td>4.4 The instructor provided me with additional information according to my particular interests</td>
<td>Hoyt and Cashin (1977), Cashin and Downey (1992), Soong et al. (2001), Selim (2005), Paechter et al. (2010)</td>
</tr>
<tr>
<td>5.1 The assignments during the e-course helped me to better comprehend its content</td>
<td>Frezen and Boyd (2005), Paechter et al. (2010)</td>
</tr>
<tr>
<td>5.2 Instructor’s response in questions regarding assignments helped me to understand my mistakes and weaknesses</td>
<td>Shee and Wang (2008), Frezen and Boyd (2005), Paechter et al. (2010)</td>
</tr>
<tr>
<td>5.3 The quiz enabled me to realize the level of my progress and to identify my weaknesses</td>
<td>Shee and Wang (2008), Frezen and Boyd (2005), Paechter et al. (2010)</td>
</tr>
<tr>
<td>6.1 The e-learning system made it easy for me to interact with my colleagues (e.g. through e-mail, forums, chats, etc.)</td>
<td>(2008), Frezen and Boyd (2005)</td>
</tr>
<tr>
<td>6.2 Overall, the e-learning system made me feel a part of a community, sharing common goals with other people</td>
<td>Selim (2005); Shee and Wang (2008), Frezen and Boyd (2005)</td>
</tr>
<tr>
<td>6.3 I had communication and exchanged ideas and opinions with my colleagues and the instructor during the e-course</td>
<td>Volery and Lord (2000), Soong et al. (2001), Selim (2005), Shee and Wang (2008), Piccoli et al. (2001), Frezen and Boyd (2005)</td>
</tr>
<tr>
<td>7.1 The system enabled me to choose the pace of the e-learning process according to my own style and needs</td>
<td>Paechter et al. (2010), Hamid (2001), Shee and Wang (2008)</td>
</tr>
<tr>
<td>7.2 The system enabled me to choose the manner of learning according to my own style and needs</td>
<td>Wang (2003), Paechter et al. (2010), Shee and Wang (2008)</td>
</tr>
<tr>
<td>7.3 The system enabled me to focus on the issues I am really interested in and gain a deeper knowledge of the subject</td>
<td>Ozkan and Koseler (2009), Shee and Wang (2008), Wang (2003)</td>
</tr>
<tr>
<td>7.4 The system allowed me to personalize and set up the e-learning process according to my needs and abilities</td>
<td>Hoyt and Cashin (1977), Cashin and Downey (1992), Bloom (1956), Kirkpatrick (1983)</td>
</tr>
<tr>
<td>8.1 I have learned important concepts and principles regarding this e-course</td>
<td>Hoyt and Cashin (1977), Cashin and Downey (1992), Bloom (1956), Kirkpatrick (1983)</td>
</tr>
<tr>
<td>8.2 I have learned important methods and technologies related to the subject of this e-course</td>
<td>Hoyt and Cashin (1977), Cashin and Downey (1992), Bloom (1956), Kirkpatrick (1983)</td>
</tr>
<tr>
<td>8.3 In this e-course I have gained the ability of practically applying my knowledge</td>
<td>Hoyt and Cashin (1977), Cashin and Downey (1992), Bloom (1956), Kirkpatrick (1983)</td>
</tr>
<tr>
<td>8.4 In this e-course I have gained the ability of analyzing complex problems into smaller parts</td>
<td>Hoyt and Cashin (1977), Cashin and Downey (1992), Bloom (1956), Kirkpatrick (1983)</td>
</tr>
<tr>
<td>8.5 In this e-course I have gained the ability of synthesizing knowledge from facts, ideas and data</td>
<td>Hoyt and Cashin (1977), Cashin and Downey (1992), Bloom (1956), Kirkpatrick (1983), Jackson (1998)</td>
</tr>
<tr>
<td>9.1 I have dedicated a lot of time studying the content</td>
<td>(continued on next page)</td>
</tr>
</tbody>
</table>
Questionnaire for the e-learning service evaluation and conceptualization literature resources (continued)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Conceptualization resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>of the e-course</td>
<td></td>
</tr>
<tr>
<td>9.2 I have extensively used the tools provided to communicate and interact with the Instructor and colleagues</td>
<td>Davis 1989, Selim (2002), Delone and McLean (2003)</td>
</tr>
<tr>
<td>9.3 I have dedicated a lot of time doing the assignment and participating in the quiz</td>
<td>Davis 1989, Selim (2002), Delone and McLean (2003)</td>
</tr>
</tbody>
</table>

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), Nogai 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), Bhattacherjee (2001), Saade and Bahli (2005), Nogai et al. (2005), Chiu et al. (2005)

References


