Evaluation of E-Learning Web Sites Using Fuzzy Axiomatic Design Based Approach

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Abstract

High quality web site has been generally recognized as a critical enabler to conduct online business. Numerous studies exist in the literature to measure the business performance in relation to web site quality. In this paper, an axiomatic design based approach for fuzzy group decision making is adopted to evaluate the quality of e-learning web sites. Another multi-criteria decision making technique, namely fuzzy TOPSIS, is applied in order to validate the outcome. The methodology proposed in this paper has the advantage of incorporating requirements and enabling reductions in the problem size, as compared to fuzzy TOPSIS. A case study focusing on Turkish e-learning websites is presented, and based on the empirical findings, managerial implications and recommendations for future research are offered.

Keywords: Fuzzy axiomatic design, Group decision making, Web site quality, E-Learning web sites, Fuzzy TOPSIS.

1. Introduction

E-Learning, one of the e-service applications, is a wide set of applications and processes that manage diverse types of electronic media to deliver vocational education and training (Aladwani and Palvia, 2002). For e-learning service providers, the Internet serves as the primary interface with the e-learners, since the e-learning web site has a much more extended function, compared to conventional web sites, which only disseminate information about services and products. Consequently, the web site quality should be considered as a critical success factor for e-learning service providers. Especially, in the case of vital education or training services, the web site quality and its evaluation should be studied in a more detailed manner from e-learners' perspective (Colette, 2001).

In a number of publications, quantitative methods are adopted for the evaluation of web site quality, with statistical methods ranking as the most widely used assessment tools (Chao, 2002; Cox and Dale, 2002; Jeong et al., 2003; Kim et al., 2003; Kim and Stoel, 2004; Toms and Taves, 2004). Additionally, other methods such as multidimensional scaling and correspondence analysis (Van der Merwe and Bekker, 2003), weighted scores (Barnes and Vidgen, 2003), index method (González and Palacios, 2004), soft computing technologies (Hwang et al., 2004) and multi criteria decision making (MCDM) (Bilsel et al., 2006) are also used in assessing and improving the web site quality. Nonetheless, there exist few studies comparing customer needs to web sites performance. Axiomatic Design (AD) principles (Suh, 2001) provide a powerful tool to measure how well system capabilities respond to functional requirements. The ultimate goal of AD is to establish a scientific basis for design and to improve design activities. This is achieved through providing the designer with a theoretical foundation based on logical and rational thought process and tools. AD applications include a multitude of areas such as software design (Kim et al., 1991), quality system design (Suh, 1995a), general system design (Suh, 1995b; Suh, 1997), manufacturing system design (Suh et al., 1998; Cochran et al., 2001), ergonomics (Helander and Lin 2002), engineering systems (Guenov and Barker, 2005; Thielman and Ge, 2006), office cell design (Durmusoglu and Kulak, 2008). Even though AD is traditionally applied to the design of physical entities, there exist studies that employ AD in designing intangible systems, such as e-commerce strategies (Martin and Kar, 2002) and e-commercial web sites (Yenisey, 2007).

Conventional information content approach cannot be used in the case of incomplete information, since, the expression of system and design ranges by crisp numbers would be ill defined (Kahraman and Kulak, 2005). For this reason, under incomplete information, the subjectivity and vagueness in the assessment process is dealt with fuzzy logic (Zadeh, 1975). The information axiom of AD is utilized as a fuzzy MCDM technique by Kulak and Kahraman (2005a). However, while there exist many applications of AD methodology (Suh, 2001) in literature, there are relatively few studies on fuzzy AD applications for MCDM. Studies in this domain can be summarized as follows:

In two pioneering studies, Kahraman and Kulak (2005a, 2005b) apply fuzzy AD approach to the comparison of advanced manufacturing systems and then to the multi-attribute selection among transportation companies. Kulak (2005) develops a decision support system for the selection of material handling systems, based on fuzzy AD. Kahraman and Cebi (2009) propose a hierarchical fuzzy AD model, which they apply to teaching assistant selection problem. Celik et al. (2009a) employ the method for shipyard selection. They also utilize fuzzy AD and Fuzzy TOPSIS to manage strategies on Turkish container ports in maritime transportation and then apply SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis to the outcome of the two techniques (Celik et al., 2009b). In another study, the authors integrate fuzzy AD and fuzzy AHP into QFD (Quality Function Deployment) principles for routing of shipping investment decisions in crude oil tanker market (Celik et al., 2009c). Celik (2009) applies fuzzy AD methodology along with AHP in order to combine management standards for ship management companies and Celik et al. (2009) employ the method for shipyard selection. Recently, Yücel and Aktas (2008) propose an evaluation methodology for ergonomic design of electronic consumer products based on fuzzy AD approach while Cevikcan et al. (2009) utilize fuzzy AD technique for an application of candidate assessment.

The aim of this paper is to attain a group consensus on functional requirements of an ideal e-learning web site. A case study is then conducted in order to evaluate several e-learning web sites according to these functional requirements with group fuzzy AD. Fuzzy AD methodology is based on the conventional AD; however, crisp ranges are replaced by fuzzy numbers that represent linguistic terms. For measuring intangible criteria such as reliability, responsiveness, etc., fuzzy AD is applied to translate linguistic terms into performance measures. Also, group consensus is sought throughout the study and therefore, fuzzy AD model is enhanced with a group decision making tool.

The paper is organized as follows. In next section, e-learning web site evaluation criteria are defined. Section

3 briefly describes the proposed fuzzy AD based evaluation methodology. A case study is conducted in e-learning web sites evaluation and the outcomes are explained in Section 4. The concluding remarks are given in the last section.

2. Evaluation criteria for e-learning web sites

Internet-oriented applications aim at satisfying current educational needs by closing the gap between traditional educational techniques and future trends in technology-blended education (Tzouveli et al., 2008), enabling a new type of education on online platforms. E-Learning refers to Internet technologies used to deliver a broad array of solutions that support the instructional process in a networked environment through the establishment of an interactive virtual classroom (Poon et al., 2004). The expected outcomes of online teaching and learning are largely dependent on the quality of the teaching processes and the effectiveness of online access. To this end, e-learning systems must be designed and constructed cautiously, especially while applying a scientific approach with well-designed procedures and techniques. The ultimate goal is to accomplish an effective and high quality learning system, comparable with the traditional educational systems (Colette, 2001). Web sites appear as the primary interface to the end user (e-learner) and user satisfaction vis-à-vis human-computer interaction determines the quality of the e-learning provider. An organization with a poor web site or ineffective services may project weaken the organization's image and position. Hence, determining evaluation criteria for e-learning web sites is important in order to determine user needs (Ahn et al., 2007). In this context, an e-learning web site quality has to be analyzed in a more detailed manner.

Literature offers numerous studies investigating e-service and e-learning web site evaluation criteria. Webb and Webb (2004) states that a business to customer (e-learning provider to e-learner, in our context) web site quality is directly affected by service quality and information quality. According to Ahn et al. (2007), even though web site evaluation criteria may vary, the main categories include system, information, and service quality. System quality (such as interface design and functionality), is an engineering oriented performance characteristic while information quality (such as completeness and timeliness) has both engineering and operational characteristicsService quality refers to availability of communication, mechanisms for accepting consumer complaints and their timely resolution with responsiveness, assurance, and follow-up services. According to the survey conducted by Poon et al. (2004), five main factors influence the effectiveness of e-learning process: students' behavior, characteristics of lecturers, interactive application, technology or system, and the institutions. On the other hand, Mahdavi et al. (2008) state that e-learner satisfaction can be classified into four dimensions: content, personalization, learning community, and learner interface. Kim and Lee (2008) detect two principle factors for learning management systems. Factor I consists of instruction management, screen design, and technology; whereas Factor II consists of interaction and evolution. McPherson and Nunest (2008) investigate the critical success factors required to deliver e-learning within higher education programs and they cite five fundamental aspects of e-learning: organizational, technological, curriculum design, instructional design and e-learning course delivery.

Based on an in-depth literature analysis [such as (Smith, 2001; Aladwani and Palvia, 2002; Chao, 2002; Cox and Dale, 2002; Dragulanescu, 2002; Jeong et al., 2003; Kim et al., 2003; van der Merwe and Bekker, 2003; Wang, 2003; Hwang et al., 2004; Kim and Stoel, 2004; van Iwaarden et al., 2004; Webb and Webb, 2004; Barnes and Vidgen, 2006; Büyüközkan et al., 2007; Gonzalez et al., 2007; Grigoroudis et al., 2008; van den Haak et al., 2009)], results of industrial surveys and in the light of the expert suggestions, seven main criteria were determined as the e-learning web site quality dimensions in this study. Ahn et al. (2007) state that technology-focused approach considers the web site as an information system, while service-focused approach sees a web site as a service provider. Following criteria were determined with a point of view combining the two approaches:

- **Right and Understandable Content (C1):** This criterion includes credibility, clearness and succinctness. While using educational web sites, authority is a particular concern, as high quality content must be assured. Instructional objectives should also be assured. In addition, the content should be easily understood, unambiguous and succinct.

- **Complete Content (C2):** This criterion includes accuracy and coverage. The purpose of this assessment is to guarantee that the content is actually correct: up to date, factual, detailed, exact and comprehensive. This criterion also assesses the existence of tests, quizzes and exams for adequate evaluation procedures.
- **Personalization (C3):** This dimension states a level of individualization. This can make the web site more attractive for the e-learners.
- **Security (C4):** This dimension comprises criteria that may be used for evaluating the security of a web site. A confident web site should assure the secrecy of its users' personal and private data. The scope of the privacy should be stated in the web site. In order to place such information in the web site, having a digital certificate is desirable.
- **Navigation (C5):** This criterion describes the ability of web-based service systems to perform the online service consistently and accurately. It controls the organization and technical capabilities of the navigation through the pages.
- **Interactivity (C6):** This dimension measures the availability of complementary functions of the traditional communication media to digital media. Availability of Frequently Asked Questions (FAQs), help and feedback systems constitute the content of this dimension. Adequate responsiveness is an important source of motivation for the e-learners.
- **User Interface (C7):** This criterion includes the design appearance, consistency, the information structure and the organization of the web site. Applications of the right design principles are essential. A consistent interface allows the e-learners to follow the required tasks easily. The information structure and organization of the web site should also be easy to follow and to be understood by the e-learners.

3. Fuzzy Axiomatic Design based Group Decision-Making

In line with the multi-dimensional characteristics of web site quality, MCDM methodology is a powerful tool widely used for evaluating and ranking problems containing multiple, usually conflicting criteria. Over the years, several behavioral scientists, operational researchers and decision theorists have proposed a variety of methods describing how an evaluator might arrive at a preference judgment while choosing among the multiple alternatives. Hence, this work attempts to model the e-learning web site evaluation in an MCDM framework. In addition, the subjectivity and vagueness in the assessment process is dealt with fuzzy logic (Zadeh, 1975). Multiple decision makers (DMs) are often preferred rather than a single DM to avoid the bias and to minimize the partiality in the decision process (Herrera et al., 2001). Therefore, fuzzy MCDM with group decision is increasingly employed in literature, as evaluation criteria become more intangible and the decision making becomes more complex to make for single DM. For example, Chen and Cheng (2005) apply fuzzy MCDM with group decision to information systems personnel selection. Wang and Parkan (2008) consider fuzzy preference aggregation problem in group decision and they apply it to the broadband internet service selection. Recently, Yeh and Chang (2009) develop a hierarchical weighting method in order to assess the weights of a large number of evaluation criteria by pairwise comparisons.

This paper proposes a set of evaluation criteria for e-learning web sites, as well as a methodology to evaluate these web sites. Main steps of the proposed methodology are recapitulated in Figure 1. The first step in the methodology is determining e-learning web site evaluation criteria. In this study, criteria described in Section 2 are employed. These criteria undergo pairwise comparison by a group of DMs. Fuzzy Analytic Hierarchy Process (AHP) is then applied to compute the criteria weights. E-learning web site alternatives are identified and several sites are considered in order to cover all available services on the net. Then, alternatives and functional requirements are evaluated by DMs. These evaluations are translated into fuzzy numbers and then are aggregated. Information contents are calculated accordingly and alternatives that cannot meet the functional requirements are eliminated. The last step of fuzzy AD methodology is ranking the alternatives in respect to weighted information contents and selecting the best web site according to a decreasing order of information content. Finally, fuzzy TOPSIS technique is applied in order to compare the outcome of two methodologies.

Techniques employed in the study, namely Fuzzy AD, fuzzy AHP, Chen's aggregation methodology and fuzzy TOPSIS are now described.

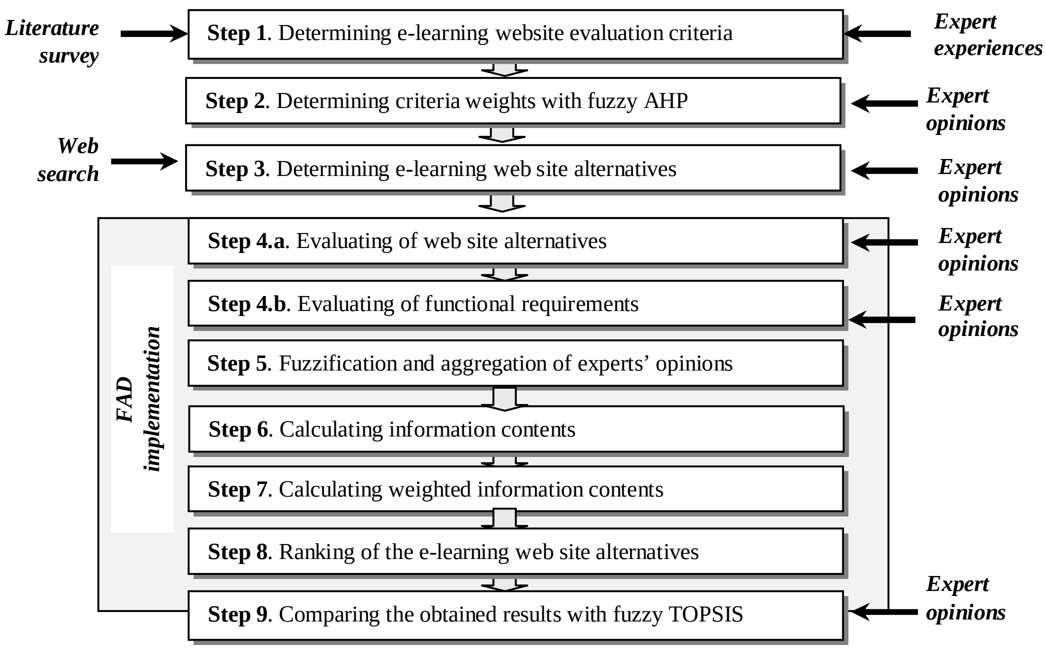

Fig. 1. This is the caption for the figure. If the caption is less than one line then it is centered. Long captions are justified manually.

3.1. *Fuzzy Axiomatic Design*

AD, a systematic method offering a scientific base for design, was introduced by Suh (1990) and its application areas include software design, quality system design, general system design, manufacturing system design, ergonomics, engineering systems, office cell design, and e-commerce strategies. AD is based on two axioms. The independence axiom states that the independence of functional requirements should be maintained and information axiom states that among the designs that satisfy the functional requirements, the design with the minimum information content is the best design. Information content, on which MCDM technique is based, represents a function of probability of satisfying a functional requirement FR. Therefore, the design with the highest probability to meet these requirements is the best design. Information content I_i of a design with probability of success p_i for a given FR_i is defined as follows:

$$I_i = \log_2\left(\frac{1}{p_i}\right) \quad (1)$$

According to Suh (2001), logarithm is employed in calculating the information contents, so as to attain additivity.

On the other hand, the probability of success is given by the design range (the requirements for the design) and the system range (the system capacity). Figure 2 illustrates the design and system ranges as well as the common area. The intersection of the ranges offers the feasible solution. Therefore, the probability of success can be expressed as:

$$p_i = \int_l^u p(FR_i)dFR_i \quad (2)$$

where l and u represent the lower and upper limits of the design range and where p represents the probability distribution function of the system for a given FR_i.

The probability of success p_i is equal to the common area A_c. Consequently, the information content can be expressed as follows:

$$I_i = \log_2\left(\frac{1}{A_c}\right) \quad (3)$$

Also, if the probability distribution function is uniform, the probability of success becomes:

$$p_i = \frac{common\ range}{system\ range} \quad (4)$$

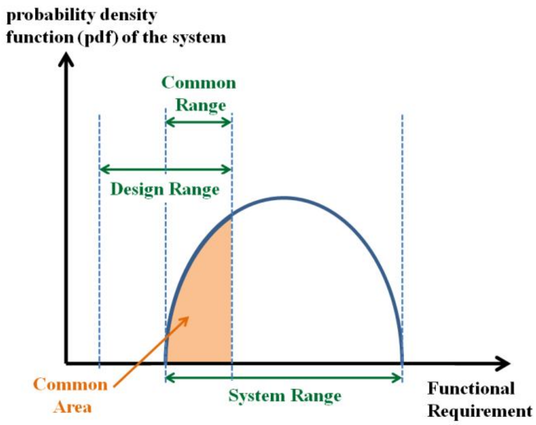

Fig. 2. System-Design ranges and common area.

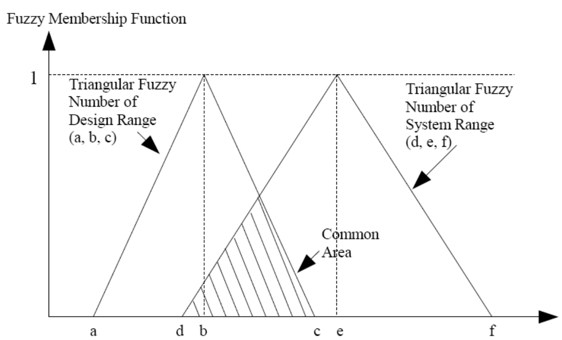

Fig. 3. System-design ranges and common area in fuzzy environment

Therefore, the information content can also be written as:

$$I_i = \log_2\left(\frac{system\ range}{common\ range}\right) \quad (5)$$

Fuzzy AD methodology is based on the conventional AD. However, crisp ranges are replaced by fuzzy numbers that represent linguistic terms (Figure 3). In this study, triangular fuzzy numbers (TFNs) are employed. Intersection of TFNs representing design and system ranges presents the common area (Kulak and Kahraman, 2005a). Firstly, the information content is calculated as in a non-fuzzy environment. Then information content in a fuzzy environment is calculated as follows:

$$I_i = \begin{cases} \infty & , \quad no\ intersection \\ \log_2\left(\frac{Area\ of\ system\ range}{Common\ area}\right) & , \quad otherwise \end{cases} \quad (6)$$

In this study, the calculation of the weighted information content is adapted from Kahraman and Cebi (2008). This model requires determination of weights of criteria and sub-criteria. Total weighted information content for first level criteria is calculated as follows:

$$I = \sum_{i=1}^{n} w_i I_i \quad (7)$$

where n is the number of first level criteria and $\sum_{=1}^{n} w_i = 1$.

Likewise, information content for second level criteria (sub-criteria for criterion i) is calculated as follows:

$$I_i = \sum_{j=1}^{m} w_{ij} I_{ij} \quad (8)$$

where m is the number of sub-criteria for criterion i and $\sum_{j=1}^{m} w_{ij} = 1$ for $i = 1, \ldots n$.

Finally, according to information axiom, alternatives are ranked with increasing order of information content.

3.2. *Fuzzy AHP*

It is not possible to assume that e-learning website evaluation criteria are of equal importance. There are many methods that can be employed to determine weights, such as eigenvector, weighted least square, entropy methods and diverse MCDM methods. In this study, the fuzzy extension of the one of the most outstanding MCDM approaches, AHP (Saaty, 1980) is used to determine the decision criteria weights. Despite its wide range of applications, the conventional AHP approach may not fully reflect a style of human thinking. One reason is that decision makers usually feel more confident to give interval judgments rather than expressing single numeric values. Furthermore, knowledge concepts and models contain tacit values and uncertainty, causing assessment and evaluation to be more difficult. This difficulty is handled by applying AHP in fuzzy environment to solve prioritisation and evaluation problems.

Firstly advocated by Zadeh (1965), fuzzy set theory has become important to deal with the ambiguity in a system. In this study, firstly linguistic terms are used to represent the expert assessments, then triangular fuzzy numbers, $\tilde{1}$ to $\tilde{9}$ as given in Table 1, are used to represent subjective pair-wise comparisons of evaluation processes in order to capture the vagueness.

The four step computational procedure is given as follows:

Table 1. Definition and membership function of fuzzy number (Saaty, 1989)

Intensity of Importance	Fuzzy Number	Definition	Membership Function
9	$\tilde{9}$	Extremely more importance (EMI)	(8,9,10)
7	$\tilde{7}$	Very strong importance (VSI)	(6,7,8)
5	$\tilde{5}$	Strong importance (SI)	(4,5,6)
3	$\tilde{3}$	Moderate importance (MI)	(2,3,4)
1	$\tilde{1}$	Equal importance (EI)	(1,1,2)

1. Compare the performance score. Triangular fuzzy numbers $(\tilde{1}, \tilde{3}, \tilde{5}, \tilde{7}, \tilde{9})$ are used to indicate the relative strength of each pair of elements in the same hierarchy.

2. Construct the fuzzy comparison matrix. By using triangular fuzzy numbers, via pair-wise comparison, the fuzzy judgment matrix $\tilde{A}(a_{ij})$ is constructed as given below:

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{bmatrix} \quad (9)$$

where $\tilde{a}^{\alpha}{}_{ij} = 1$, if I *is equal to* j, and $\tilde{a}^{\alpha}{}_{ij} = \tilde{1}, \tilde{3}, \tilde{5}, \tilde{7}, \tilde{9}$ or $\tilde{1}^{-1}, \tilde{3}^{-1}, \tilde{5}^{-1}, \tilde{7}^{-1}, \tilde{9}^{-1}$, if I *is not equal to* j.

3. Solve the fuzzy eigenvalue. A fuzzy eigenvalue, $\tilde{\lambda}$, is a fuzzy number solution to:

$$\tilde{\boldsymbol{A}}\tilde{\boldsymbol{x}} = \tilde{\lambda}\tilde{\boldsymbol{x}} \quad (10)$$

where $\boldsymbol{A}$ is a $n \times n$ fuzzy matrix containing fuzzy numbers $\tilde{a}_{ij}$ and $\tilde{\boldsymbol{x}}$ is a non-zero $n \times 1$ fuzzy vector containing fuzzy number $\tilde{x}_i$. To perform fuzzy multiplications and additions by using the interval arithmetic and *α-cut*, the equation $\tilde{\boldsymbol{A}}\tilde{\boldsymbol{x}} = \tilde{\lambda}\tilde{\boldsymbol{x}}$ is equivalent to:

$$[a^{\alpha}_{i1l}x^{\alpha}_{1l}, a^{\alpha}_{i1u}x^{\alpha}_{1u}] \oplus \cdots \oplus [a^{\alpha}_{inl}x^{\alpha}_{nl}, a^{\alpha}_{inu}x^{\alpha}_{1u}] = [\lambda x^{\alpha}_{il}, \lambda x^{\alpha}_{iu}] \quad (11)$$

where:

$$\tilde{\boldsymbol{A}} = [\tilde{a}^{\alpha}_{ij}],\ \tilde{\boldsymbol{x}}^{t} = (\tilde{x}_1, \dots, \tilde{x}_n),\ \tilde{a}^{\alpha}_{ij} = [\tilde{a}^{\alpha}_{ijl}, \tilde{a}^{\alpha}_{iju}],$$

$$x^{\alpha}_{i} = [x^{\alpha}_{il}, x^{\alpha}_{iu}], \tilde{\lambda}^{\alpha} = [\lambda^{\alpha}_{l}, \lambda^{\alpha}_{u}] \quad (12)$$

for $0 < \alpha \le 1$ and all I, j, with $I = 1, 2, \dots, n$, $j = 1, 2, \dots, n$.

The *α-cut* is known to incorporate the experts or decision-maker(s) confidence over his/her preference or the judgments. The degree of satisfaction for the judgment matrix $\tilde{A}$ is estimated by the index of optimism μ. A larger value of the index μ indicates a higher degree of optimism. The index of optimism is a linear convex combination (Lee, 1999) defined as:

$$\tilde{a}^{\alpha}_{ij} = \mu\tilde{a}^{\alpha}_{iju} + (1 - \mu)\tilde{a}^{\alpha}_{ijl}, \forall\alpha \in [0,1] \quad (13)$$

When α is fixed, the following matrix can be obtained after setting the index of optimism, μ, in order to estimate the degree of satisfaction:

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}^{\alpha}_{12} & \cdots & \tilde{a}^{\alpha}_{1n} \\ \tilde{a}^{\alpha}_{21} & 1 & \cdots & \tilde{a}^{\alpha}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}^{\alpha}_{n1} & \tilde{a}^{\alpha}_{n2} & \cdots & 1 \end{bmatrix} \quad (14)$$

The eigenvector is calculated by fixing the μ value and identifying the maximal eigenvalue. After defuzzification of each pair wise matrix, the consistency ratio (CR) for each matrix is calculated. The deviations from consistency are expressed by the following equation consistency index, and the measure of inconsistency is called the consistency index (CI):

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (15)$$

The consistency ratio (CR) is used to estimate directly the consistency of pair wise comparisons. The CR is computed by dividing the CI by a value obtained from a table of Random Consistency Index (RI) to:

$$CR = \frac{CI}{RI} \quad (16)$$

If CR is less than 0.10, the comparisons are acceptable, otherwise not. RI is the average index for randomly generated weights (Saaty, 1980).

4. The priority weight of each criterion can be obtained by multiplying the matrix of evaluation ratings by the vector of attribute weights and summing over all attributes.

3.3. *Aggregation methodology*

In this study, the fuzzy group decision-making method presented by Chen (1998) is employed in order to aggregate fuzzy opinions of the DMs. This method is recently employed by Celik et al. (2009).

The steps of the aggregation method are as follows:

1. Calculate the degree of agreement $S_{u,v}(W_u, W_v)$of the opinions between each pair of experts E_u and E_v where $S_{u,v}(W_u, W_v) \in [0,1]$, $1 \leq u \leq M, 1 \leq v \leq M$ and $u \neq v$.

Let A and B be two standardized triangular fuzzy numbers $A = (a_1, a_2, a_3), B = (b_1, b_2, b_3)$ where $0 \leq a_1 \leq a_2 \leq a_3 \leq 1$ and $0 \leq b_1 \leq b_2 \leq b_3 \leq 1$.

Then the degree of similarity between the standardized triangular fuzzy numbers and can be measured by the similarity function:

$$S(A, B) = 1 - \frac{|a_1-b_1|+|a_2-b_2|+|3-b_3|}{4} \qquad (17)$$

where $S(A, B) \in [0,1]$. The larger the value of $S(A, B)$, the greater is similarity between the standardized triangular fuzzy numbers A and B. The equation $S(A, B) = S(B, A)$ is valid for the degree of similarity.

2. Calculate the *average* degree of agreement $AA(E_u)$ of expert $E_u, u = 1,2, \dots, M$, where:

$$AA(E_u) = \frac{1}{M-1} \sum_{v=1, v\neq u}^{M} S_{u,v}(W_u, W_v) \qquad (18)$$

3. Calculate the *relative* degree of agreement $RA(E_u)$ of expert $E_u, u = 1,2, \dots, M$, where:

$$RA(E_u) = \frac{AA(E_u)}{\sum_{u=1}^{M} AA(E_u)} \qquad (19)$$

4. Calculate the consensus degree coefficient $CC(E_u)$ of expert $E_u, u = 1,2, \dots, M$ where:

$$CC(E_u) = \beta w_{eu} + (1-\beta) RA(E_u) \qquad (20)$$

β $(0 \leq \beta \leq 1)$ is a relaxation factor of the method and w_{eu} is degree of importance of expert. It shows the importance of w_{eu} over $RA(E_u)$.

5. The aggregation result of the fuzzy opinions is

$$W_{AG} = CC(E_1) \otimes R_1 \oplus \dots CC(E_M) \otimes R_M \qquad (21)$$

where operators $\otimes$ and $\oplus$ are the fuzzy multiplication operator and the fuzzy addition operator, respectively. The method is independent of the type of membership functions being used (Chen, 1998; Celik et al., 2009).

3.4. *Fuzzy TOPSIS*

In our methodology, another MCDM method, namely TOPSIS is applied in order to compare with fuzzy AD outcome. TOPSIS is proposed by Chen and Hwang (1992) and the basic principle is that the optimal solution should have the shortest distance from the positive ideal solution and the farthest from the negative ideal solution.

In classical MCDM methods, including classical TOPSIS, all data are assumed to be known precisely. However, under many conditions, crisp data are inadequate to model real-life situations since human judgments including preferences are often vague and cannot be estimated with an exact numerical value (Saghafian and Hejazi, 2005). Linguistic terms present a more realistic assessment of subjective judgments and hence, fuzzy set theory aids to deal with biased or imprecise evaluations.

There are many examples of applications of fuzzy TOPSIS in literature (Saghafian and Hejazi, 2005) such as evaluation of service quality (Tsuar et al., 2002), inter company comparison (Deng et al., 2000), aggregate production planning (Wang et al., 2004), facility location selection (Chu, 2002) and large scale nonlinear programming (Abo-Sina and Amer, 2005).

Fuzzy TOPSIS is applied in this study due to its basic concept and wide applications such as Qureshi et al. (2008) and Shih (2008). Moreover, TOPSIS is based on geometrical principles, similar to AD which also operates on a geometrical level. The technique is adapted from Chen (2000) and the steps of the methodology are as follows:

1. With m alternatives, n criteria and k DMs, fuzzy MCDM problem can be expressed as:

$$\widetilde{D} = \begin{matrix} & c_1 & c_2 & & c_n \\ A_1 & \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ A_2 & \vdots & & & \vdots \\ A_3 & \vdots & & & \vdots \\ A_4 & \tilde{x}_{m1} & \dots & \dots & \tilde{x}_{mn} \end{matrix}$$

$\widetilde{D}$ represents the fuzzy decision matrix with alternatives A and criteria C.

2. Aggregated judgments $\tilde{x}_{ij}$ are calculated as follows is

$$\tilde{x}_{ij} = \frac{1}{k}(\tilde{x}_{ij}^1 + \tilde{x}_{ij}^2 + \cdots + \tilde{x}_{ij}^k) \qquad (22)$$

where $\tilde{x}_{ij}^k = (\tilde{a}_{ij}^k, \tilde{b}_{ij}^k, \tilde{c}_{ij}^k)$ represents fuzzy judment of expert k.

3. The next step is the normalization. Normalized fuzzy decision matrix $\tilde{R}$ is calculated as

$$\tilde{R} = [\tilde{r}_{ij}]_{m*n}, i = 1,2, \dots, m;\ j = 1,2, \dots, n$$

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^+}, \frac{b_{ij}}{c_j^+}, \frac{c_{ij}}{c_j^+}\right), C_j^+ = \max_i C_{ij} \qquad (23)$$

Table 5. Membership functions for system and design ranges.

Term	Abbr.	Membership	Term	Abbr.	Membership
Poor	P	0, 0, 0.3	At least poor	LP	0, 1, 1
Fair	F	0.2, 0.35, 0.5	At least fair	LF	0.1, 1 1
Good	G	0.4, 0.55, 0.7	At least good	LG	0.4, 1, 1
Very good	VG	0.6, 0.75, 0.9	At least very good	LVG	0.6, 1, 1
Excellent	E	0.8, 1, 1	At least excellent	LE	0.8, 1, 1

To avoid the complicated normalization formula used in classical TOPSIS, the linear scale transformation is used to transform the various criteria scales into a comparable scale (Chen, 2000). Linear scale transformation for normalization is also employed by Kuo et al. (2007) and Celik et al. (2009).

4. Then, weighted normalized fuzzy decision matrix is computed, where w_j is weight for criteria j:

$$\tilde{v}_{ij} = \tilde{r}_{ij} \otimes \tilde{w}_j$$

$$\tilde{v} = \left[\tilde{v}_{ij}\right]_{m*n}, i = 1,2,\ldots,m; j = 1,2,\ldots,n \quad (24)$$

5. Since the TFNs are included in $[0,1]$ range, positive and negative ideal reference points (FPIRP, FNIRP) are as follows:

$A^+ = \{\tilde{v}_1^+, \tilde{v}_2^+, \ldots, \tilde{v}_n^+\}, A^- = \{\tilde{v}_1^-, \tilde{v}_2^-, \ldots, \tilde{v}_n^-\}$

where $\tilde{v}_j^+ = (1,1,1), \tilde{v}_j^- = (0,0,0)$.

6. The next step is calculating the distance of alternatives from FPIRP and FNIRP:

$$d(\tilde{A}, \tilde{B}) = \sqrt{\frac{1}{3}\left[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2\right]} \quad (25)$$

$$d_i^+ = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^+), i = 1,2,\ldots,m; j = 1,2,\ldots,n \quad (26)$$

$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-), i = 1,2,\ldots,m; j = 1,2,\ldots,n \quad (27)$$

7. The performance indices are computed in order to rank the alternatives. Performance indices are sorted in decreasing order

$$CC_i = \frac{d_i^-}{d_i^- + d_i^+}, i = 1,2,\ldots,m \quad (28)$$

4. Case study: Evaluation of e-learning web sites

E-Learning became an instructional delivery method for the growing number of working adults who sought to earn degrees from universities that provide external programs (Poon et al., 2004). Finance, time or access constraints are minimized with e-learning and an equal-opportunity education environment is generated, since e-learning offers cost-effectiveness, timely content and access flexibility to e-learners (Mahdavi et al., 2008). Turkey, a country of 783,562 km^2 facing the challenge of providing the same quality education nationwide, benefits from this equal-opportunity environment. E-Learning is classically considered to be a new way to empower the workforce with the necessary skills and knowledge (Tzouveli et al., 2008); However, considering the special case of Turkey, where the universities are concentrated on major cities, e-learning stands out as the new era's education provider for not only the workforce, but also for the disadvantaged youth. The current demographics of Turkey where 30.64% of the population (20,778,277 citizens) is made up of 10 to 24-year-olds (Statistics Institute of the Government of Turkey, 2000) engender a very high number of candidates for university education. The annual quota is 500,000 whereas the number of university applicants exceeds 1,600,000 (Student Placement Center, 2008). The severe negative impacts of the capacity constratint, as reflected by the quotas, can be overcome through e-learning, which proposes a great potential to face this educational challenge. Today, nearly all Turkish universities have their own web sites

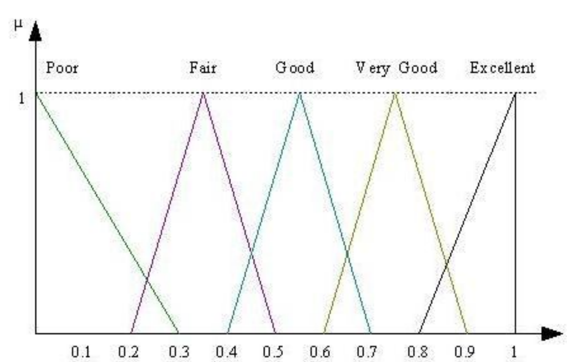

Fig. 4. Membership Functions for System Range.

and hence, they seize an incredible opportunity to catch up to developed countries (Kızılsu, 2006). E-Learning activities are broadening within the universities, as well. Many e-programs are executed at the graduate level, and young professionals with time limit and individuals with no access to major cities can profit from the educational added-value of online access.

However, as the number of available online programs increases, the decision process becomes complex. Therefore, the need arises to evaluate the quality of e-learning providers as a pre-requisite of achieving high quality of e-learning in Turkey. In this study web sites of e-learning providers are considered given that the interface greatly influences the e-learner satisfaction with the e-learning system.

The methodology described in Figure 1 is applied to a case study. The goal of this case study is to evaluate and rank the quality performances of e-learning web sites, with the proposed methodology. The web sites are selected from among successful actors operating globally and locally in Turkey. To identify the functional requirements and evaluate the alternatives, three DMs of equal importance, DM1, DM2 and DM3, have been selected amongst e-learning industry experts. These experts are gathered from knowledgeable e-learning instructors involved in educational design and implementation of online interfaces. They possess an extended experience in e-learning systems given that they have been the pioneers of the industry.

The e-learning web site evaluation process is performed by applying the following steps:

Step 1. *Determination of e-learning web site evaluation criteria*

Right and understandable content (C1), Complete content (C2), Personalization (C3), Security (C4), Navigation (C5), Interactivity (C6) and User interface (C7) are the e-learning web site evaluation criteria as discussed in Section 2.

Step 2. *Determination of criteria weights for e-learning web site evaluation*

DMs apply pairwise comparison to evaluate criteria as given in Table 2 and fuzzy AHP given in Section 3.2 is employed with the index of optimism value $\mu = 0.5$ in order to determine e-learning web site criteria weights. The obtained results are shown in Table 3.

Step 3. *Determination of alternatives*

Table 2. The consensus linguistic comparison matrix for e-learning web site evaluation criteria.

	C1	C2	C3	C4	C5	C6	C7
C1	1	P					
C2		1					
C3	F	P	1				VG
C4	G	F	E	1			E
C5	G	P	E	F	1	E	G
C6	G	F	E	F		1	G
C7	E	G					1

Table 3. E-Learning web site evaluation criteria weights.

C1	C2	C3	C4	C5	C6	C7
0.15	0.33	0.08	0.14	0.07	0.08	0.15

Table 4. E-Learning web site alternatives.

Label	Web address
W1	www.online-degree-enlightenment.com
W2	www.youachieve.com
W3	www.online-education-resources.com
W4	www.universalclass.com
W5	www.sp.edu.sg
W6	www.geolearning.com
W7	www.kidsplus.com.tr
W8	www.ideaelearning.com
W9	www.sanal-kampus.com
W10	www.netron.com.tr
W11	www.enocta.com
W12	www.buelc.boun.edu.tr

To assess the quality of e-learning web sites, 12 web sites given in Table 4 were designated, taking into account experts' opinions in the sector and research conducted through the search engines in January 2008. The first six of these web sites operate worldwide and the remaining six are active only in Turkey. Since the sites all offer mostly common services, the comparison is coherent.

Step 4. *DMs' evaluation of web site alternatives and functional requirements*

Linguistic terms employed in evaluating e-learning web sites needs to be translated into fuzzy numbers in order to operate on the judgments. In this study, 5-level fuzzy scale is used to assess the alternatives and another 5-level fuzzy scale is used to assess the functional requirements, as a bare minimum for functional requirements. Table 5, Figure 4 and Figure 5 describe the linguistic terms, their abbreviations and fuzzy membership functions.

As given in Table 5, in the evaluation process, 5-level scale was employed to translate linguistic terms into fuzzy numbers. The judgments of the experts on alternatives are illustrated in Tables 6,7 and 8.

The functional requirements of e-learning web sites are defined by three experts and illustrated in Table 9.

Step 5. *Fuzzification and aggregation of DMs' opinions*

DMs' judgments on functional requirements and alternatives given in Step 4 are first translated into fuzzy numbers and then aggregated using the methodology described in Section 3.3. Table 10 displays aggregated evaluations on functional requirements and alternatives.

Table 6. Evaluation of alternatives by DM1.

	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12
C1	VG	VG	VG	F	VG	VG	VG	VG	VG	G	VG	G
C2	E	VG	E	F	VG	F	G	VG	E	G	E	F
C3	F	G	G	VG	G	F	F	G	VG	G	E	VG
C4	P	VG	E	G	VG	G	VG	F	E	VG	E	VG
C5	F	VG	VG	G	F	F	VG	VG	VG	F	VG	G
C6	F	E	VG	G	G	G	G	G	F	F	E	G
C7	F	VG	G	G	VG	VG	VG	G	VG	F	E	G

Table 7. Evaluation of alternatives by DM2.

	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12
C1	G	E	VG	G	E	E	E	E	VG	F	E	F
C2	VG	E	VG	F	E	F	VG	VG	VG	G	VG	F
C3	P	G	VG	E	G	F	F	VG	VG	F	VG	VG
C4	F	VG	E	VG	VG	G	VG	F	VG	G	E	G
C5	F	VG	E	VG	F	F	E	G	VG	F	E	VG
C6	G	VG	E	G	VG	F	F	VG	F	G	E	G
C7	P	E	VG	G	VG	G	G	G	VG	F	VG	G

Table 8. Evaluation of alternatives by DM3.

	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12
C1	VG	E	VG	G	E	VG	E	E	G	G	E	G
C2	VG	E	E	G	E	F	VG	G	VG	G	E	F
C3	P	G	G	E	G	F	G	VG	VG	G	E	VG
C4	F	G	VG	VG	G	G	G	F	E	VG	VG	VG
C5	G	E	E	VG	G	F	E	VG	G	F	E	VG
C6	G	VG	E	G	G	F	F	VG	G	F	VG	VG
C7	P	E	VG	VG	G	VG	VG	G	G	G	VG	G

Step 6. *Computation of common area and information contents*

Once fuzzified evaluations of DMs' judgments are aggregated, fuzzy AD methodology described in section 3.1 is applied to compute the common areas, which are shown in Table 11. The greater the common area, better is the response of the alternative to the functional requirements.

Table 9. E-Learning web site functional requirements.

	C1	C2	C3	C4	C5	C6	C7
DM1	LG	LG	LP	LG	LP	LP	LF
DM2	LG	LVG	LP	LF	LP	LF	LF
DM3	LG	LVG	LF	LG	LP	LF	LG

Computed common areas result in information contents. Table 12 displays information contents for each alternative in response to each criteria and total information content for each alternative. Alternatives that cannot meet functional requirements are eliminated as there are no information content.

Step 7. *Calculation of the weighted information contents*

Weighted information contents, given in Table 13, are calculated as described in section 3.1.

Step 8. *Ranking the e-learning website alternatives*

The final ranking is also given in Table 13. Final results demonstrate that two web sites (W6 and W12) are eliminated, meaning that they do not meet the necessary functional requirements. The evaluation results point out that web site W11 web site has the best

Table 10. Aggregated evaluations of DMs.

	C1			**C2**			**C3**			**C4**			**C5**			**C6**			**C7**		
FR	0.40	1.00	1.00	0.53	1.00	1.00	0.03	1.00	1.00	0.30	1.00	1.00	0.00	1.00	1.00	0.07	1.00	1.00	0.20	1.00	1.00
W1	0.53	0.68	0.83	0.67	0.83	0.93	0.06	0.11	0.36	0.14	0.24	0.44	0.26	0.41	0.56	0.34	0.49	0.64	0.06	0.11	0.36
W2	0.74	0.92	0.97	0.73	0.92	0.97	0.40	0.55	0.70	0.54	0.69	0.84	0.67	0.83	0.93	0.67	0.83	0.93	0.74	0.92	0.97
W3	0.60	0.75	0.90	0.73	0.91	0.96	0.47	0.62	0.77	0.74	0.92	0.97	0.74	0.92	0.97	0.74	0.92	0.97	0.54	0.69	0.84
W4	0.34	0.49	0.64	0.27	0.42	0.57	0.73	0.92	0.97	0.53	0.68	0.83	0.53	0.68	0.83	0.40	0.55	0.70	0.46	0.61	0.76
W5	0.74	0.92	0.97	0.73	0.92	0.97	0.40	0.55	0.70	0.53	0.68	0.83	0.27	0.42	0.57	0.46	0.61	0.76	0.54	0.69	0.84
W6	0.67	0.83	0.93	0.20	0.35	0.50	0.20	0.35	0.50	0.40	0.55	0.70	0.20	0.35	0.50	0.26	0.41	0.56	0.54	0.69	0.84
W7	0.74	0.92	0.97	0.53	0.68	0.83	0.27	0.42	0.57	0.53	0.68	0.83	0.73	0.92	0.97	0.26	0.41	0.56	0.54	0.69	0.84
W8	0.74	0.92	0.97	0.53	0.68	0.83	0.53	0.68	0.83	0.20	0.35	0.50	0.53	0.68	0.83	0.54	0.69	0.84	0.40	0.55	0.70
W9	0.53	0.68	0.83	0.67	0.83	0.93	0.60	0.75	0.90	0.73	0.91	0.97	0.53	0.68	0.83	0.27	0.42	0.57	0.54	0.69	0.84
W10	0.34	0.49	0.64	0.40	0.55	0.70	0.33	0.48	0.63	0.54	0.69	0.84	0.20	0.35	0.50	0.27	0.42	0.57	0.26	0.41	0.56
W11	0.73	0.92	0.97	0.73	0.91	0.97	0.73	0.91	0.96	0.73	0.92	0.97	0.73	0.92	0.97	0.73	0.92	0.97	0.66	0.83	0.93
W12	0.33	0.48	0.63	0.20	0.35	0.50	0.60	0.75	0.90	0.53	0.68	0.83	0.53	0.68	0.83	0.46	0.61	0.76	0.40	0.55	0.70

Table 11. Common areas (A_c)

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
W1	0.11	0.11	0.04	0.01	0.10	0.10	0.01
W2	0.11	0.11	0.12	0.12	0.13	0.13	0.11
W3	0.12	0.11	0.13	0.11	0.12	0.11	0.13
W4	0.04	0.00	0.12	0.12	0.13	0.11	0.11
W5	0.11	0.11	0.12	0.12	0.10	0.12	0.13
W6	0.12	0.00	0.08	0.09	0.09	0.09	0.13
W7	0.11	0.07	0.09	0.12	0.12	0.09	0.13
W8	0.11	0.07	0.13	0.02	0.13	0.13	0.10
W9	0.11	0.11	0.14	0.11	0.13	0.09	0.13
W10	0.04	0.02	0.11	0.12	0.09	0.09	0.07
W11	0.11	0.11	0.12	0.11	0.12	0.12	0.13
W12	0.04	0.00	0.14	0.12	0.13	0.12	0.10

Table 12. Information contents

	I_{C1}	I_{C2}	I_{C3}	I_{C4}	I_{C5}	I_{C6}	I_{C7}	I_{TOT}
W1	0.51	0.26	1.74	3.83	0.62	0.53	3.51	11.01
W2	0.03	0.07	0.36	0.34	0.04	0.05	0.02	0.92
W3	0.30	0.08	0.24	0.02	0.01	0.01	0.25	0.91
W4	2.02	7.49	0.01	0.34	0.16	0.39	0.39	10.81
W5	0.03	0.07	0.36	0.35	0.61	0.28	0.25	1.95
W6	0.14	∞	0.89	0.81	0.82	0.74	0.24	∞
W7	0.03	1.02	0.66	0.34	0.01	0.74	0.24	3.06
W8	0.03	1.04	0.17	2.63	0.16	0.18	0.57	4.78
W9	0.51	0.25	0.10	0.03	0.16	0.73	0.25	2.03
W10	2.01	2.73	0.49	0.34	0.82	0.74	1.15	8.28
W11	0.04	0.08	0.01	0.03	0.01	0.01	0.07	0.25
W12	2.03	∞	0.10	0.34	0.16	0.28	0.57	∞

performance overall, followed by web site W2.

Step 9. *Comparison with Fuzzy TOPSIS*

As described in Section 3.4, fuzzy TOPSIS is applied to the aggregated decision matrix in order to compare and justify the outcome of fuzzy AD. Tables 14 and 15 demonstrate distances from FPIRP and FNIRP and total distances.

E-Learning web sites were ranked in increasing order of performance index. As seen in Table 16, the outcome of the fuzzy AD methodology is justified with fuzzy TOPSIS. W11 is ranked as the best alternative with both methodologies. Alternatives W6 and W12 are eliminated with fuzzy AD methodology given that these two alternatives cannot meet FR for C2, complete content. However, as fuzzy TOPSIS evaluate the alternatives with respect to FPIRP and FNIRP instead of a set of requirements determined by DMs, alternatives W6 and W12 are considered as well. This comparison of the outcome proves fuzzy AD to be a more suitable methodology to evaluate a large number of alternatives, since a bare minimum for the alternatives can be defined and unsuitable alternatives can easily be eliminated.

5. Concluding remarks

Current developments of information systems facilitate greatly the diffusion of knowledge. Knowledge and education form the source of more than 50% of the personal national incomes of especially developed western countries and a well educated manpower working at the jobs related with information (Kızılsu, 2006). On the other hand, the advances in information systems and internet change the nature of education (Poon et al., 2004). Therefore, education activities transfer to electronic platforms for higher speed and less effort. Consequently, the web sites hosting the e-learning system become an important interface for the end-user and web site quality directly affects e-learning provider's performance. Therefore, a performance analysis based on MDCM techniques is applied to measure the quality of e-learning web sites. More precisely, in this paper, a group decision based fuzzy AD methodology was applied to the problem of ranking e-learning web sites. The proposed methodology is expected to provide additional contribution and decision support to the managers working in the learning and e-business industries, due to

Table 13. Weighted information contents.

	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12
WI	1.45	0.11	0.13	2.93	0.21	∞	0.54	0.84	0.28	1.58	0.05	∞
Ranking	**8**	**2**	**3**	**10**	**4**	**Eliminated**	**6**	**7**	**5**	**9**	**1**	**Eliminated**

Table 14. Distances from FPIRP.

	d^+_1	d^+_2	d^+_3	d^+_4	d^+_5	d^+_6	d^+_7	Tot d^+_1
W1	0.89	0.72	0.99	0.96	0.97	0.96	0.97	6.47
W2	0.86	0.70	0.95	0.90	0.94	0.93	0.86	6.16
W3	0.88	0.70	0.95	0.87	0.94	0.93	0.89	6.17
W4	0.92	0.86	0.93	0.90	0.95	0.95	0.91	6.42
W5	0.86	0.70	0.95	0.90	0.97	0.95	0.89	6.24
W6	0.87	0.88	0.97	0.92	0.97	0.97	0.89	6.48
W7	0.86	0.77	0.97	0.90	0.94	0.97	0.89	6.29
W8	0.86	0.77	0.94	0.95	0.95	0.94	0.91	6.33
W9	0.89	0.72	0.94	0.87	0.95	0.97	0.89	6.24
W10	0.92	0.81	0.96	0.90	0.97	0.97	0.94	6.48
W11	0.87	0.70	0.93	0.87	0.94	0.93	0.87	6.11
W12	0.93	0.88	0.94	0.90	0.95	0.95	0.91	6.46

Table 15. Distances from FNIRP

	d^-_1	d^-_2	d^-_3	d^-_4	d^-_5	d^-_6	d^-_7	Tot d^-_1
W1	0.11	0.28	0.02	0.04	0.03	0.04	0.03	0.55
W2	0.14	0.30	0.05	0.10	0.06	0.07	0.14	0.85
W3	0.12	0.30	0.05	0.13	0.06	0.07	0.11	0.84
W4	0.08	0.15	0.07	0.10	0.05	0.05	0.10	0.59
W5	0.14	0.30	0.05	0.10	0.03	0.05	0.11	0.77
W6	0.13	0.13	0.03	0.08	0.03	0.04	0.11	0.54
W7	0.14	0.24	0.04	0.10	0.06	0.04	0.11	0.72
W8	0.14	0.24	0.06	0.05	0.05	0.06	0.09	0.68
W9	0.11	0.28	0.06	0.13	0.05	0.04	0.11	0.77
W10	0.08	0.19	0.04	0.10	0.03	0.04	0.07	0.54
W11	0.14	0.30	0.07	0.13	0.06	0.07	0.13	0.90
W12	0.08	0.13	0.06	0.10	0.05	0.05	0.09	0.56

Table 16. Performance indices for alternatives and ranking of the alternatives.

	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	**W11**	W12
PI	0.079	0.121	0.120	0.084	0.110	0.076	0.102	0.097	0.110	0.077	**0.128**	0.079
Ranking	**10**	**2**	**3**	**8**	**4**	**12**	**6**	**7**	**5**	**11**	**1**	**9**

its advantages over already established techniques, such as fuzzy TOPSIS. Specifically, the proposed methodology incorporates functional requirements into the ranking and selection process, and can identify the alternatives that do not comply with the requirements.

For future research, the set of alternatives can be further extended and a two-stage MCDM analysis consisting of pre-assessment and detailed evaluation can be applied in order to thoroughly review e-learning web site alternatives. Given that service web sites are increasing in number, pre-assessment stage will eliminate rapidly the unsuitable candidates with general criteria and minimum assessment of alternatives, preferably with a single expert. A more meticulous evaluation with fewer alternatives will be realized with a hierarchic structure of criteria and a more detailed assessment of a group of expert. Also, criteria set may be altered to evaluate web sites other than e-learning, such as e-commerce, hospital, and bank web sites, based on the proposed methodology, since the general scheme of criteria can be applied to all web sites with only a few changes.

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