



Assessing the Critical Factors for E-Learning Systems Using Fuzzy TOPSIS and Fuzzy Logic

Karamollah Bagheri Fard, Fakhte Soltani Tafreshi, Mehrbakhsh Nilashi, Mansooreh Jalalyazdi

Dept. of Computer Engineering, Faculty of Engineering, Arak University, Arak, Iran,
Dept. of Computer Engineering Islamic Azad University, Yasooj branch, Yasooj, Iran

Karam_bagheri@yahoo.com

Dept. of Computer Engineering, Faculty of Engineering, Arak University, Arak, Iran,
f-soltani@araku.ac.ir

Faculty of Computing, Universiti Teknologi Malaysia, Skudai, Johor, Malaysia
nilashidotnet@yahoo.com

Dept. of Computer Engineering, Technical and Vocational University, Qom, Iran,
Mansooreh.jalalyazdi@gmail.com

ABSTRACT

Assessing the success of Information Systems (ISs) has been identified as one of the most critical issues in IS field. Offering more services and the ease of access is considered as a significant factor for today's academic environments. E-learning systems are having an exquisite impact over the success of academic environments by reducing the costs and time of training students, by providing an integrated place where students can have access to it for finding their desired materials and to share the knowledge properly among the students and the lecturers. To implement effective e-learning systems, assessment of the quality of these systems has become an important issue. This study identifies the significant factors that influence on successes in e-learning systems. Hence, we use two powerful techniques from Multiple Criteria Decision Making (MCDM) and Artificial Intelligence fields. Using fuzzy TOPSIS, we rank the factors using a pair-wise questionnaire. Then, to get the real level of factors, we perform the fuzzy logics using a 5-likert questionnaire. Results of assessing show that the system quality is very important factor in relation to the service quality, information quality and learning community.

Indexing terms/Keywords

Fuzzy Logic, Fuzzy TOPSIS, E-Learning, Assessment

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INTRODUCTION

E-Learning is defined as all kinds of electronic-based learning and teaching that intend to affect the building of knowledge according to individual experience, practice and knowledge of the person who is learning. Information systems, whether connected or not, play the role of media to deploy the learning process. E-learning is actually the network and computer based transfer of knowledge. E-learning is equivalent with using electronic processes and applications to learn. Such processes and applications include computer-based learning, web-based learning, digital collaboration and, virtual classrooms. Content is delivered via the intranet or extranet, internet, audio or video tape, CD-ROM and, satellite TV. It can be self-paced or teacher-led and includes media in the form of text, animation, image, streaming video and audio. An online e-learning system eliminates major limitations in traditional learning approaches because E-learning does not depend on location, time, and age. Lifelong learning is easily accomplished through an e-learning system. Compared with the traditional learning approaches, e-learning systems are superior in terms of convenience, independence, adaptation, and interaction. Servage in [1] has expressed concern with these variations in terms stating that there is an "utter lack of consistency" in terminology surrounding eLearning. Although there are differences in terminology and some definitions are broader than others, Servage's concerns are undue as most definitions contain similar elements. Moore [2] shared the concerns of Servage [1] that there is a lack of consistency in terminology. As a result, Moore [2] performed a study to assess how researchers defined the learning environment and what they identify as the differences between distance learning, e-learning, and online learning. The study concluded that participants perceive a difference between the terms and that different characteristics are attributed to each of the learning environments; in short, the participants struggled to find consensus as to what term should be used in what situation.

There are a lot of benefits about the implementation of e-learning. Firstly, it is the networkability that enables synchronous and asynchronous learning activities possible [3, 4]. Secondly, it is cost-effective for once the infrastructure and developmental costs have been established, little amount of extra cost will only be needed for additional learners. It is scalable and flexible; classes may be enormous or just as small as an individual. Thirdly, because it is web-enabled, the reach of a number of people simultaneously is possible [2, 4]. The content and information can be updated instantly and retrieved without the constraints of time and place [5, 6]. Fourthly, perhaps the most important feature; it enhances the building of an online community to contribute, to share knowledge in addition to the collaboration through group interaction. The community comes in the form of open and focused group discussion, private mentoring, project work or even general Q&A sessions [6]. Finally, it allows learners to arrange the content for their own needs and learning styles with the services provided 24 hours a day [4, 6]. These benefits make e-learning a tempting and potential solution for future education. According to the definition of information systems, "An information system (IS) is any combination of information technology and people's activities using that technology to support operations, management, and decision-making. In a very broad sense, the term information system is frequently used to refer to the interaction between people, algorithmic processes, data and technology. In this sense, the term is used to refer not only to the information and communication technology (ICT) an organization uses, but also to the way in which people interact with this technology in support of business processes", e-learning system is the technology and the students and the lecturers are the people who interact with this system, so it can be concluded that e-learning is a type of information system.

Overall, most authors seem to agree that the main benefit of e-learning for the learners is increased accessibility: the ability to use the technology anytime and anywhere which allows users to proceed at their own pace and engage in autonomous work [7-9].

2. QUALITY FACTORS IN E-LEARNING SYSTEMS

The DeLone and McLean Model is one of the mostly used models suggesting six different dimensions that are in fact a combination of individual measures from IS success categories can create a comprehensive measurement instrument. The model includes six IS success dimensions, that are as follows: system quality, information quality, system's use, users satisfaction, individual impact and finally organizational impact. As can be seen in their model, these six dimensions are interrelated rather than independent. Information quality and system quality separately and together have influence over both user satisfaction and, use. Besides, the amount of use can also have an impact on the level of user satisfaction. Use and user satisfaction are also having direct impacts over individual impact. And eventually, the effect on individual performance will impact organizational impact.

The main goal of the original DeLone and McLean paper was to combine previous researches including IS success into a more coherent body of knowledge and to provide guidance to future researchers. Based on the communications research of Shannon and Weaver and the information "influence" theory of Mason, as well as empirical management information systems (MIS) research studies from 1981–87, a comprehensive, multidimensional model of IS success was proposed. Shannon and Weaver defined the technical level of communications as "the accuracy and efficiency of the communication system that produces information. The semantic level is the success of the information in conveying the intended meaning. The effectiveness level is the effect of the information on the receiver". In the D&M IS Success Model, "systems quality" measures technical success; "information quality" measures semantic success; and "use, user satisfaction, individual impacts," and "organizational impacts" measure success. This has important implications for the analysis, measurement, and reporting of information systems success in empirical studies. A temporal, process model suggests that an IS is first created, containing various features, which can be characterized as exhibiting various degrees of system and information quality. Next, users and managers experience these features by using the system and are either satisfied or dissatisfied with the system or its information products. The use of the system and its information products then impacts or influences the individual user in the conduct of his or her work, and these individual impacts finally result in organizational impacts.



There are many factors have been recognized by researchers to have an influence on the e-learning systems and e-learning systems. Some perceived factors are related to the technical, human, system, instructor, student, and cultural factors. Papp in [10] determined number of critical success factors for the e-learning development in supporting the faculty and university. Among these factors are the suitability of the course for e-learning environment, e-learning course-content and maintenance and intellectual property. A considerable number of studies have been done accentuating the factors to be considered for effectiveness assessing. Several assessing models are considered with specific aspects. The criteria used for e-learning effectiveness evaluation are numerous and influence one another. The evaluation models however, are deficient and do not have an evaluation guideline. Effectiveness evaluation criteria must integrate learning theories, relative system design, course design, and learning satisfaction theories to form an integrated evaluation model. One of the good samples of using an information system success model in an academic environment was done in ChungChou institute of technology. In that study, the researchers after reviewing few IS success models came up with using the Delone and Mclean's success model since it covers a broad range of items. Then, by reviewing various items such as web satisfaction, e-learner satisfaction, web quality, system quality, and other related items, and also experts' comments, they came up with 34 items as their measurement tool.

Table 1. Success Dimensions and Related Statements

Variables	Statements
System Quality	The e-learning system provides high availability The e-learning system is easy to use The e-learning system is user-friendly The e-learning system provides interactive features between users and system The e-learning system provides a personalized information presentation The e-learning system has attractive features to appeal to the users The e-learning system provides high-speed information access
Information Quality	The e-learning system provides information that is exactly what you need The e-learning system provides information you need at the right time The e-learning system provides information that is relevant to your job The e-learning system provides sufficient information The e-learning system provides information that is easy to understand The e-learning system provides up-to-date information
Service Quality	The e-learning system provides a proper level of on-line assistance and explanation The e-learning system developers interact extensively with users during the development of the e-learning system The IS department staff provides high availability for consultation The IS department responds in a cooperative manner to your suggestion for future enhancements of e-learning system The IS department provides satisfactory support to users using the e-learning system
System Use	The frequency of use with the e-learning system is high The e-learning system usage is voluntary You depend upon the e-learning system
User Satisfaction	Most of the users bring a positive attitude or evaluation towards the e-learning system function You think that the perceived utility about the e-learning system is high You are satisfied with the e-learning system
Net Benefits	The e-learning system helps you improve your job performance The e-learning system helps you think through problems The e-learning system helps the organization enhance competitiveness or create

	<p>strategic advantages</p> <p>The e-learning system enables the organization to respond more quickly to change</p> <p>The e-learning system helps the organization provide better products or services to customers</p> <p>The e-learning system helps the organization provide new products or services to customers</p> <p>The e-learning system helps the organization save cost</p> <p>The e-learning system helps the organization to speed up transactions or shorten product cycles</p> <p>The e-learning system helps the organization increase return on investment</p> <p>The e-learning system helps the organization to achieve its goal</p>
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This model proposed by Hassan Ahmad [11] is actually a hybrid model which consists of six elements i.e. Learner's Attitude, Instructor Quality, System Quality, Information Quality, Service Quality, and Supportive Issues. His model also has been used in an empirical study in Middle East Technical University, by Sevgi Ozkan, Refika Koseler. The Figure 1 shows the model.



Figure 1. HELAM Model by Hassan Ahmad [11]

System quality measures technical success-the desired characteristics of the system itself-which produces the information [12, 13] . A number of studies [14-17] typically measure system quality in terms of "ease-of-use, functionality, reliability, flexibility, data quality, portability, integration, and importance" [13]. The quality of the system has a direct influence on individual impacts (measured as quality of work environment and job performance)[13]. Information quality is the measurement of output from the IS. It stresses characteristics of the information and the way it is presented according to the needs of the users. Information quality was defined as quality of the content, accuracy, precision, currency, reliability, timeliness, completeness, relevance, and format required as perceived by the end user [13, 18].

The service quality dimension was added to the updated model to ensure the effectiveness focus was not only on the product itself but the services function as well [19]. Service quality refers to the level of service received by IS users and the way in which the service is provided by the IS department or providers/maintainers of the system [13, 20]. This is principally measured as user satisfaction with the service provided [13, 20]. Service quality is viewed as the difference between the expected service from the IS department and the perceived service received by the end-user [21].

Net benefits was an improvement to the original model [12] in which individual impacts and organizational impacts were collapsed into one descriptor of the final success variable. Individual impact refers to the influence that information from the IS has on the attitude of the user in regards to the user's job [22]. It includes the personal improvements and also the overall consequences on the performance of the department or business unit in relation to what effect the information from the IS has on management decisions. This impact occurs when the information is received and interpreted by the users

and applied to their jobs [12]. Organizational impact draws from research that investigated the influence of implemented IS on organizational performance [13]. According to [23] organizational impact relates to the benefits of the investment in technological innovation. DeLone and McLean [13, 19] have shown the adaptability of the D&M IS Success Model by applying it to the context of e-commerce success. Measures for each of the factors were adjusted to accurately capture the e-commerce context. For example, measures of information quality were completeness, ease of understanding, personalization, relevance, and security. Elements of service quality unique to an ecommerce setting were assurance, empathy, and responsiveness. Petter, DeLone and McLean [24] state that whilst recent research provides strong support for the D&M IS Success Model, more research is needed-particularly empirical research-to establish the strength of interrelationships across different contextual boundaries. E-learning is one such context which lends itself to the application of the D&M IS Success Model. Although the D&M IS Success Model has been applied in many different domains it has received little attention in the area of e-learning [24, 25]. In recent years, researchers have begun to link the two and a limited number of studies have resulted. Holsapple and Lee-Post [26] interpreted the dimensions of the D&M IS Success Model in the context of educational eLearning and developed an E-learning Success Model. Metrics were also included for each of the model's six dimensions. For example, system quality measures the characteristics of ease of use, user-friendly, stability, security, speed, and responsiveness. Holsapple and Lee-Post [26] validated the model with an action research methodology, which resulted in a slight change to the model in which user satisfaction was moved from being a 'use' dimension to a factor of 'system outcomes'. Lee-Post's application [27] of the model in educational settings has found the model to be valid; however, the authors call for further research to explore the applicability of the success model in other areas of e-learning besides the higher education setting.

3. RESEARCH APPROCACHES

3.1. Fuzzy TOPSIS Method

TOPSIS, one of the known classical MCDM methods, was first developed by Hwang and Yoon [28] that can be used with both normal numbers and fuzzy numbers. In addition, TOPSIS is attractive in that limited subjective input is needed from decision makers. The only subjective input needed is weights. Since the preferred ratings usually refer to the subjective uncertainty, it is natural to extend TOPSIS to consider the situation of fuzzy numbers. Fuzzy TOPSIS can be intuitively extended by using the fuzzy arithmetic operations as follows [29].

Given a set of alternatives, $A = \{A_i | i = 1, \dots, n\}$, and a set of criteria, $C = \{C_j | j = 1, \dots, m\}$, where $\tilde{X} = \{\tilde{x}_{ij} | i = 1, \dots, n; j = 1, \dots, m\}$ denotes the set of fuzzy ratings and $\tilde{W} = \{\tilde{w}_j | j = 1, \dots, m\}$ is the set of fuzzy weights.

The first step of TOPSIS is to calculate normalized ratings by

$$\tilde{r}_{ij}(\mathbf{x}) = \frac{\tilde{x}_{ij}}{\sqrt{\sum_{i=1}^n \tilde{x}_{ij}^2}}, \quad i = 1, \dots, n; \quad j = 1, \dots, m \tag{1}$$

and then to calculate the weighted normalized ratings by

$$\tilde{v}_{ij}(\mathbf{x}) = \tilde{w}_j \tilde{r}_{ij}(\mathbf{x}), \quad i = 1, \dots, n; \quad j = 1, \dots, m. \tag{2}$$

Next the positive ideal point (PIS) and the negative ideal point (NIS) are derived as

$$PIS = \tilde{A}^+ = \{\tilde{v}_1^+(\mathbf{x}), \tilde{v}_2^+(\mathbf{x}), \dots, \tilde{v}_j^+(\mathbf{x}), \dots, \tilde{v}_m^+(\mathbf{x})\} \tag{3}$$

$$= \{(max_i \tilde{v}_{ij}(\mathbf{x}) | j \in J_1), (min_i \tilde{v}_{ij}(\mathbf{x}) | j \in J_2) | i = 1, \dots, n\}$$

$$NIS = \tilde{A}^- = \{\tilde{v}_1^-(\mathbf{x}), \tilde{v}_2^-(\mathbf{x}), \dots, \tilde{v}_j^-(\mathbf{x}), \dots, \tilde{v}_m^-(\mathbf{x})\} \tag{4}$$

$$= \{(min_i \tilde{v}_{ij}(\mathbf{x}) | j \in J_1), (max_i \tilde{v}_{ij}(\mathbf{x}) | j \in J_2) | i = 1, \dots, n\}$$

Similar to the crisp situation, the following step is to calculate the separation from the PIS and the NIS between the alternatives. The separation values can also be measured using the Euclidean distance given as:

$$\tilde{S}_i^+ = \sqrt{\sum_{j=1}^m [\tilde{v}_{ij}(\mathbf{x}) - \tilde{v}_j^+(\mathbf{x})]^2}, \quad i = 1, \dots, n \tag{5}$$

And



$$\tilde{S}_i^- = \sqrt{\sum_{j=1}^m [\tilde{v}_{ij}(\mathbf{x}) - \tilde{v}_j^-(\mathbf{x})]^2}, i = 1, \dots, n \tag{6}$$

Where

$$\max\{\tilde{v}_{ij}(\mathbf{x})\} - \tilde{v}_j^+(\mathbf{x}) = \min\{\tilde{v}_{ij}(\mathbf{x})\} - \tilde{v}_j^-(\mathbf{x}) = 0. \tag{7}$$

Then, the defuzzified separation values should be derived using one of defuzzified methods, such as CoA to calculate the similarities to the PIS.

Next, the similarities to the PIS is given as

$$C_i^* = \frac{D(S_i^-)}{[D(S_i^+) + D(S_i^-)]}, i = 1, \dots, n \tag{8}$$

where $C_i^* \in [0, 1] \quad \forall i = 1, \dots, n$

Finally, the preferred orders are ranked according to C_i^* in descending order to choose the best alternatives. Fuzzy-TOPSIS method is another type of fuzzification for the TOPSIS method in fuzzy environment that is defined and investigated by credibility measure. In this method, trapezoid -fuzzy numbers are used for ranking all sub-criteria of system quality. Therefore, using fuzzy trapezoid numbers enabled us to change normal TOPSIS into fuzzy TOPSIS which is more precisely as the result shows in the next paragraph.

One of the characteristic of fuzzy numbers is fuzzy sets with special consideration for easy calculations. Trapezoid Fuzzy Numbers Let $\tilde{A} = (a, b, c, d)$, $a < b < c < d$, be a fuzzy set on $R = (-\infty, \infty)$. It is called a trapezoid fuzzy number, if its membership function is

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{x-a}{b-a}, & \text{if } a \leq x \leq b \\ 1, & \text{if } b \leq x \leq c \\ \frac{d-x}{d-c}, & \text{if } c \leq x \leq d \\ 0, & \text{otherwise} \end{cases} \tag{9}$$

Figure 2 shows the shape of a fuzzy trapezoid number:

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$$\tilde{v}_{ij}(\mathbf{x}) = \tilde{w}_j \tilde{r}_{ij}(\mathbf{x}), i = 1, \dots, n; j = 1, \dots, m. \tag{11}$$

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$$\begin{aligned}
 PIS &= \tilde{A}^+ = \{\tilde{v}_1^+(\mathbf{x}), \tilde{v}_2^+(\mathbf{x}), \dots, \tilde{v}_j^+(\mathbf{x}), \dots, \tilde{v}_m^+(\mathbf{x})\} \\
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 \end{aligned}
 \tag{12}$$

$$\begin{aligned}
 PIS &= \tilde{A}^- = \{\tilde{v}_1^-(\mathbf{x}), \tilde{v}_2^-(\mathbf{x}), \dots, \tilde{v}_j^-(\mathbf{x}), \dots, \tilde{v}_m^-(\mathbf{x})\} \\
 &= \{(min_i \tilde{v}_{ij}(\mathbf{x}) | j \in J_1), (max_i \tilde{v}_{ij}(\mathbf{x}) | j \in J_2) | i = 1, \dots, n\}
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Similar to the crisp situation, the following step is to calculate the separation from the PIS and the NIS between the alternatives. The separation values can also be measured using the Euclidean distance given as:

$$\tilde{S}_i^+ = \sqrt{\sum_{j=1}^m [\tilde{v}_{ij}(\mathbf{x}) - \tilde{v}_j^+(\mathbf{x})]^2}, i = 1, \dots, n
 \tag{14}$$

And

$$\tilde{S}_i^- = \sqrt{\sum_{j=1}^m [\tilde{v}_{ij}(\mathbf{x}) - \tilde{v}_j^-(\mathbf{x})]^2}, i = 1, \dots, n
 \tag{15}$$

Where

$$\max\{\tilde{v}_{ij}(\mathbf{x})\} - \tilde{v}_j^+(\mathbf{x}) = \min\{\tilde{v}_{ij}(\mathbf{x})\} - \tilde{v}_j^-(\mathbf{x}) = 0.
 \tag{16}$$

Then, the defuzzified separation values should be derived using one of defuzzified methods, such as CoA to calculate the similarities to the PIS.

Next, the similarities to the PIS is given as

$$C_i^* = \frac{D(S_i^-)}{[D(S_i^+) + D(S_i^-)]}, i = 1, \dots, n
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where $C_i^* \in [0, 1] \quad \forall i = 1, \dots, n$

Finally, the preferred orders are ranked according to C_i^* in descending order to choose the best alternatives. Fuzzy-TOPSIS method is another type of fuzzification for the TOPSIS method in fuzzy environment that is defined and investigated by credibility measure. In this method, trapezoid -fuzzy numbers are used for ranking all sub-criteria of system quality. Therefore, using fuzzy trapezoid numbers enabled us to change normal TOPSIS into fuzzy TOPSIS which is more precisely as the result shows in the next paragraph.

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 \tag{18}$$

Figure 2 shows the shape of a fuzzy trapezoid number:

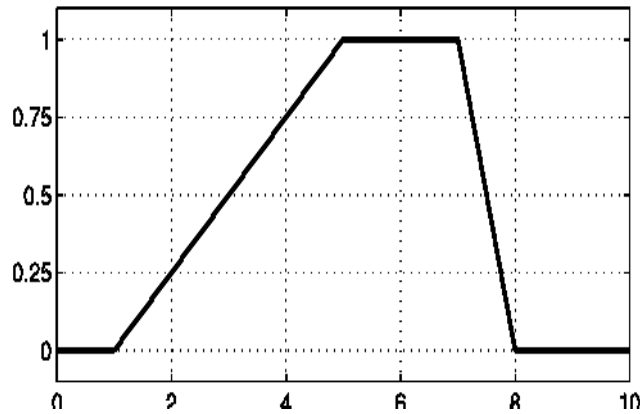


Figure 2. Fuzzy trapezoid number

All process of fuzzy TOPSIS will be calculated upon three of trapezoid numbers that average numbers of experts are shown in Table 2:

Table 2. Fuzzy trapezoid number for fuzzy TOPSIS method

Linguistic Variable	Range of Fuzzy trapezoid number
Non Important	[0.6, 0.8, 1.6, 1.8]
Low Important	[1.4, 1.6, 2.5, 2.7]
Moderate	[2.3, 2.5, 3.8, 4]
Important	[3.6, 3.8, 4.6, 4.8]
Very Important	[4.4, 4.6, 5.2, 5.4]

3.2 Fuzzy Logic

In this study, the fuzzy logic has been used to assess e-learning system quality by developing model based on fuzzy reasoning. Fuzzy inference is the process of formulating the mapping from a given input determinant to an output determinant via fuzzy logic reasoning. Determination can be made on bases of mapping, or patterns perceived.

The fuzzy inference process includes three critical steps: Membership Functions (MF), inference rules, and fuzzy set operation. A membership function is a curve that defines how each point in the input space is mapped to a membership value between 0 and 1.

Fuzzy logic comprises, usually, fuzzification, evaluation of inference rules, and defuzzification of fuzzy output results. Fuzzification is process to define inputs and outputs as well as their respective membership function that change the crisp value into a degree of match to a fuzzy set, which explains a characteristic of the variables. After the inputs are fuzzified, the degree to which each part of the antecedent is satisfied for each rule. If the antecedent of a given rule has more than one part, the fuzzy operator is applied to obtain one number that represents the result of the antecedent for that rule. This number is then applied to the output function. The input to the fuzzy operator is two or more membership values from fuzzified input variables. The output is a single truth value.

The input for the connotation process is a single number given by the preceding, and the output is a fuzzy set. Implication is implemented for each rule. Because in fuzzy logic system decisions are based on the testing of all of the rules in a FIS and the rules must be merged in some manner in order to make a decision. Aggregation is the process by which the fuzzy sets that represent the outputs of each rule are combined into a single fuzzy set. Ultimately, the input for the defuzzification process is a fuzzy set and the output is a single number. As much as fuzziness assists the rule evaluation during the intermediate steps, the final desired output for each variable is generally a single number. However, the aggregate of a fuzzy set encompasses a range of output values, and so must be defuzzified in order to resolve a single output value from the fuzzy set. The basic structure of the fuzzy logic systems considered in this paper is shown in Figure 3.

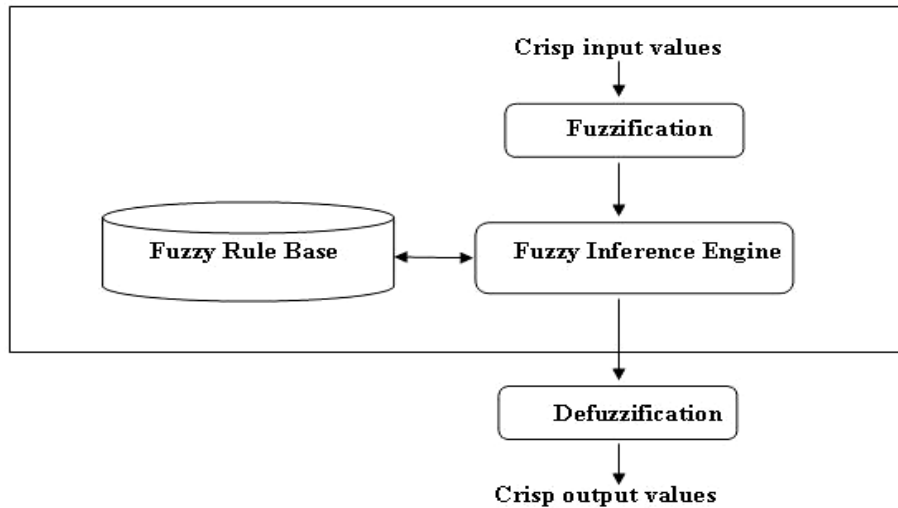


Figure 3. Structure of a Fuzzy Logic model

In the fuzzifier, crisp inputs are fuzzified into linguistic values to be associated to the input linguistic variables. After fuzzification, the inference engine refers to the fuzzy rule base containing fuzzy IF-THEN rules to derive the linguistic values for the intermediate and output linguistic variables [30]. Once the output linguistic values are available, the defuzzifier produces the final crisp values from the output linguistic values. According to Siler [31], fuzzifying process has two definitions. The first is the process refining the fuzzy value of a crisp one. The second is refining the grade of membership of a linguistic value of a linguistic variable corresponding to a fuzzy or scalar input. The most used meaning is the second. Fuzzification is done by membership functions.

In the next step that can be called inference process involves deriving conclusions from existing data[31]. In the inference process an outline from input fuzzy sets into output fuzzy sets is clarified. It causes to having a satisfied outputs based on related rules. One of the interface method is MIN. MIN allot the minimum of antecedent terms to the suitable degree of the rule. Then fuzzy sets that depict the output of each rule are merged to form a single fuzzy set. Also by using MAX that match to applying fuzzy logic OR, or SUM composition methods the combination action is done.

In last step Defuzzification process is applied and it is the process for converting fuzzy output sets to crisp values[31]. In fuzzy logic systems, Centroid, Average Maximum and Weighted Average methods are used for Defuzzification process that Centroid method of Defuzzification is the most commonly used method. Using this method the defuzzified value is defined by:

$$Centroid = \frac{\int x\mu(x)dx}{\mu(x)dx} \tag{19}$$

Where $\mu(x)$ is the aggregated output member function.

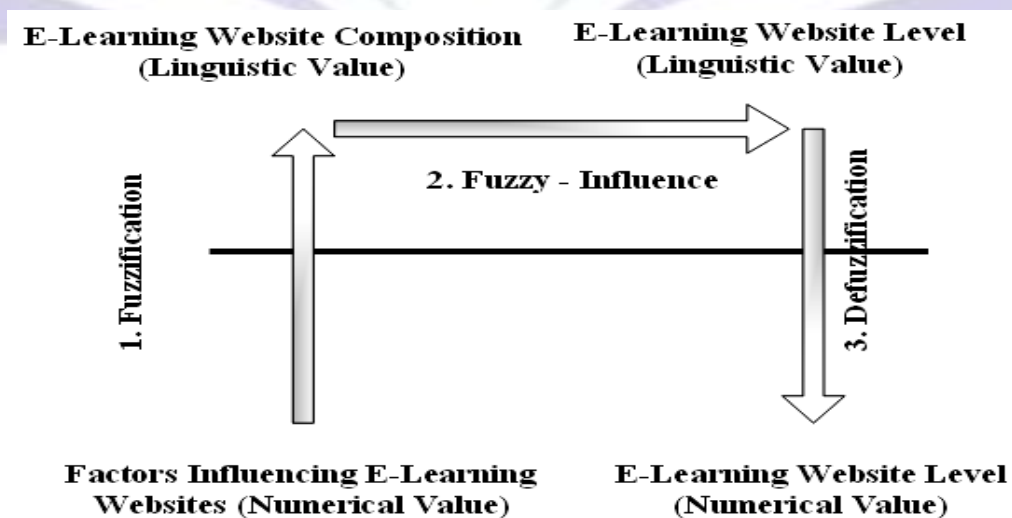


Figure 4. Structure of a Fuzzy Logic System for Proposed model



For getting a complete depiction of fuzzy logic system, an inference diagram can give a detailed operation of the procedure involved. Figure 4 attempts to summaries the steps and operations involved.

As can be seen in figure 4, the process with the crisp inputs to the fuzzy logic system; for example, this might be the crisp input for design, and content or quality of e-learning systems to get a value for the considered e-learning system level. According to the fuzzy logic systems the initial input(s) are a crisp set of numbers then these values converted from a numerical level to a linguistic level. Next that the fuzzy rules are applied and fuzzy inference engine is executed. The last step that is the Defuzzification process, that a numeric value of the e-learning system is extracted.

4. RESEARCH MODEL

The proposed model has been established based on this principle that each real level of E-learning systems includes 4 major factors as System Quality, Information Quality, Service Quality and Learning Community as shown in Figure 5. Therefore, we propose to investigate into the truthfulness of the following relationship:

$$L_{E-Learning} = F(\text{System Quality}, \text{Information Quality}, \text{Service Quality}, \text{Learning Community})$$

The hypothesis is that the factors determining the level of e-learning system $L_{E-Learning}$ are a function of these four parameters.

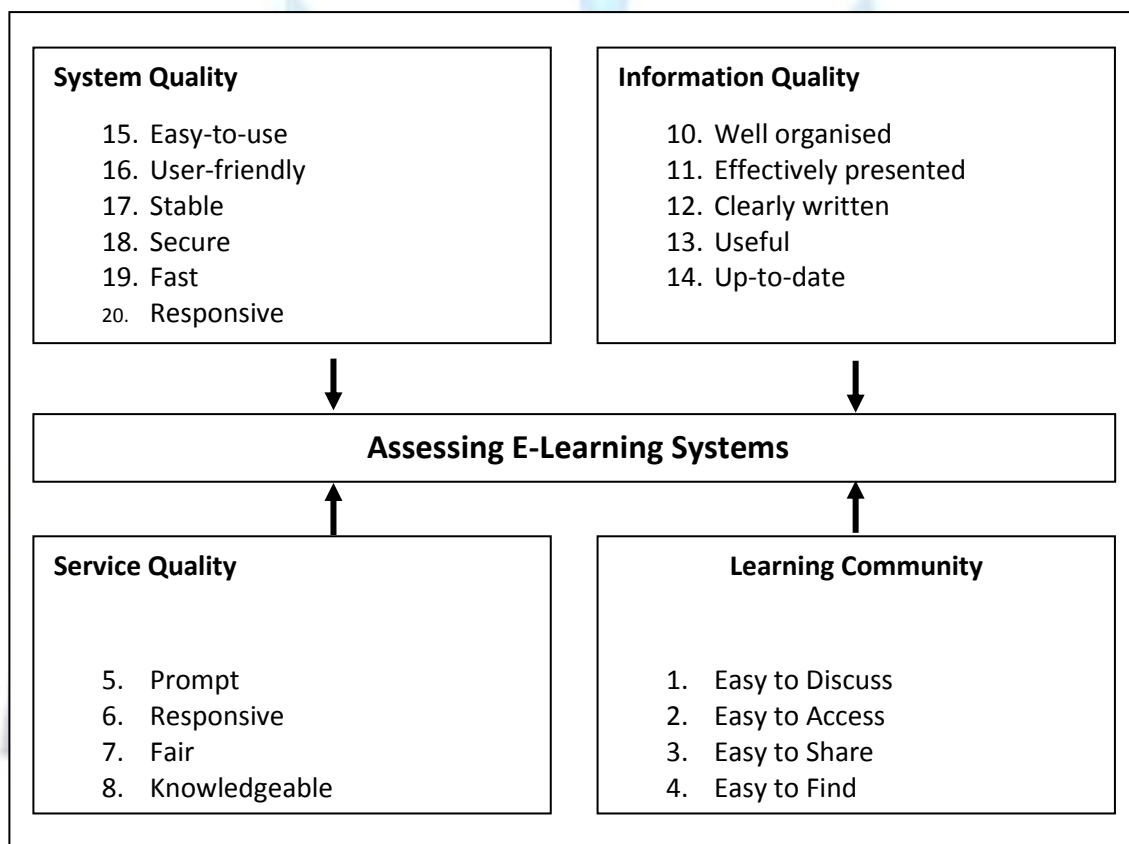


Figure 5: Research Framework

5. DATA ANALYSIS

5.1. Data Collection

In this study two questionnaires was used .Therefore, for first questionnaire the survey instrument was made available to the participants via e-mail, online questionnaire and a printed out papers. Study participants were requested to make interviews about the e-learning systems through three virtual universities environments and the participants were interact with us to discuss e-learning systems, after that they were requested to fill in a given pair wise questionnaire. 15 People (expert lectures in e-learning systems) called up the questionnaires, of which 15 actually completed it. The collected data was analysed using the Expert choice software. For second questionnaire 150 students of IT were used. The statistics for the data collected is shown in Table 2. The most of respondents aged between 30-40 years old, while 70% of the respondents were male. The respondents were expert in e-learning systems that had experience in working with e-learning systems. Table 3 shows the demographic results according to years of experience.



Table 2. Students demographic data for second questionnaire

Demographics	Responses obtained	Percentage %
Gender		
Male	105	70%
Female	45	30%
Total	150	100%
Age		
22-24	46	20%
24-33	67	13.33%
33-40	37	66.66%
Total	150	100%
Degree Program		
Graduate	80	53.33%
Postgraduate	70	46.66%
Total	150	100%

Table 3. Students demographic data for second questionnaire

Experience	Less than 3 years	Between 3 and 6	Between 6 to 9	More than 9 years
Percentage	30%	60%	10%	10%
Prior experience in designing E-learning system				
Yes	No			
79%	21%			

In second questionnaire system assessment is conducted by asking respondents to rate their analysis using a 5 point Likert scale as very low, low, moderate, high and very high. The responses have been recorded on five point likert type scale (0= very low and 4 = very high). The questions related to demographic profiles of the respondents such as gender, age, education and income were also included

5.2. Ranking parameters using fuzzy TOPSIS

Using fuzzy TOPSIS discussed in the sub-section 3.1, the final ranking of parameters shown in the Figure 5 are presented in the Table 4. Thus, based on ranking in this table, we select the factors that their value is greater than 0.5 for fuzzy system modeling. Therefore, totally 15 factors are selected for the second questionnaire.

Table 4. Final ranking of parameters using fuzzy TOPSIS

Parameter Type	Parameter	Rank Value
System Quality	Responsive	0.48
	Fast	0.81
	Secure	0.89
	Stable	0.75
	User-friendly	0.65
	Easy-to-use	0.83
Information Quality	Well organised	0.47
	Effectively presented	0.73

	Clearly written	0.67
	Useful	0.49
	Up-to-date	0.74
Service Quality	Prompt	0.56
	Responsive	0.61
	Fair	0.48
	Knowledgeable	0.44
	Available	0.69
Learning Community	Easy to Discuss	0.79
	Easy to Access	0.56
	Easy to Share	0.47
	Easy to Find	0.56

5.3. Rules indicating for E-learning system level

After ranking affecting factors and finding out weights of these factors, second questionnaire was prepared for customers to collect desired data. Based on respondents' answers, some VBA codes were written for organizing collected data.

5.4. Fuzzy logic System for applying discovered rules and detection real level of factors

After organizing data via excel software and discovering 81 rules, all rules entered in fuzzy logic system for depicting real level of affecting factors. Therefore, there were a total of 81 rules for estimating of e-learning system level deduced from the survey.

5.5. Complete fuzzy logic system

Fuzzy logic system for this research was conducted using MATLAB tools FIS editor, which was created by a fuzzy model to evaluate level of e-learning level systems. Three input variables as quality, content and one output variable (system level). The output variable is a value from 0 to 1; representing very low e-learning system, low level e-learning system, moderate e-learning system, high level e-learning system and very high level e-learning system. This system uses Mamdani inference method and simulation applied in MATLAB R2010b fuzzy logic toolbox. Figure 6 shows a Mamdani fuzzy inference system for proposed framework.

It shows a simple diagram with the names of the System Quality, Information Quality, Service Quality and Learning Community. In each of the input we defined 3 membership functions (MF) because we wanted to classify the all factors into 3 different level low, moderate and high.

Figure 6 shows the complete information of fuzzy inferences of proposed system. In this figure input membership functions, output membership functions and rules of system were identified. In addition, Figure 7 and 8 show the membership functions for output and system quality, respectively. And in the Figure 9, defined fuzzy rules for proposed fuzzy model is shown.

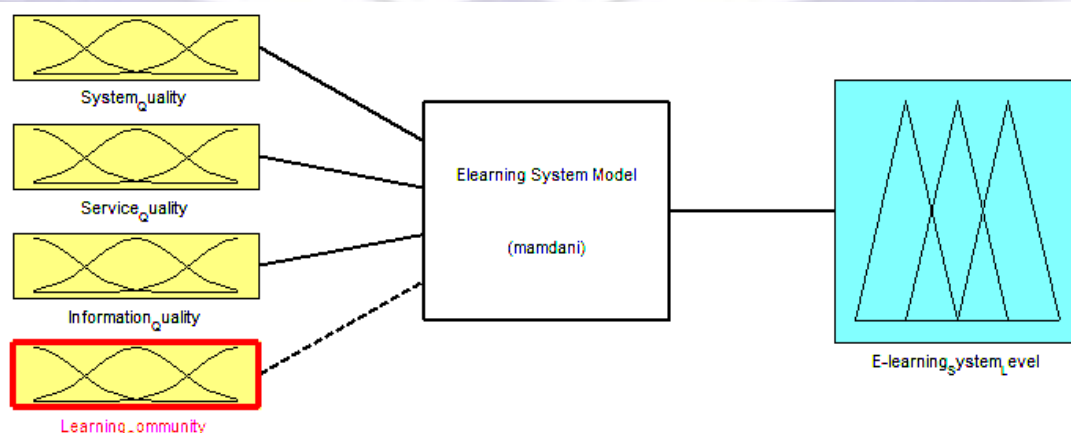


Figure 6. Mamdani FIS for proposed fuzzy model

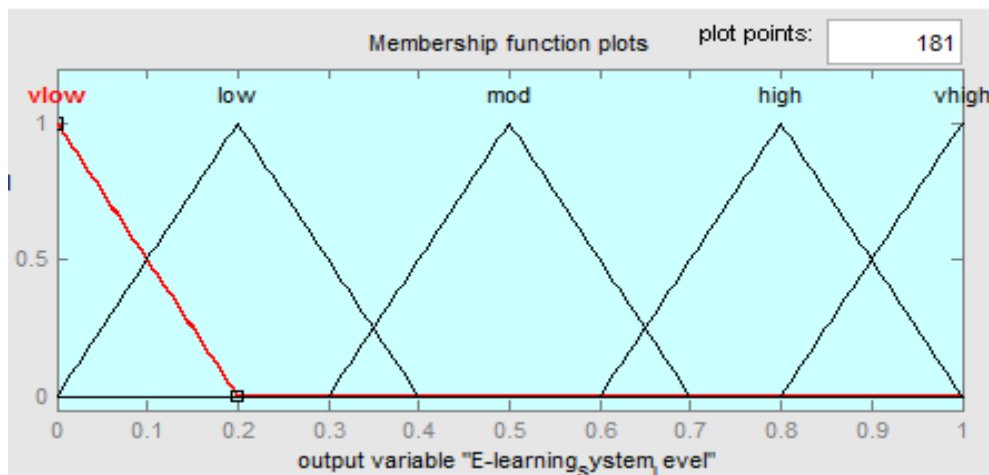


Figure 7. Membership functions for the output (e-learning system level)

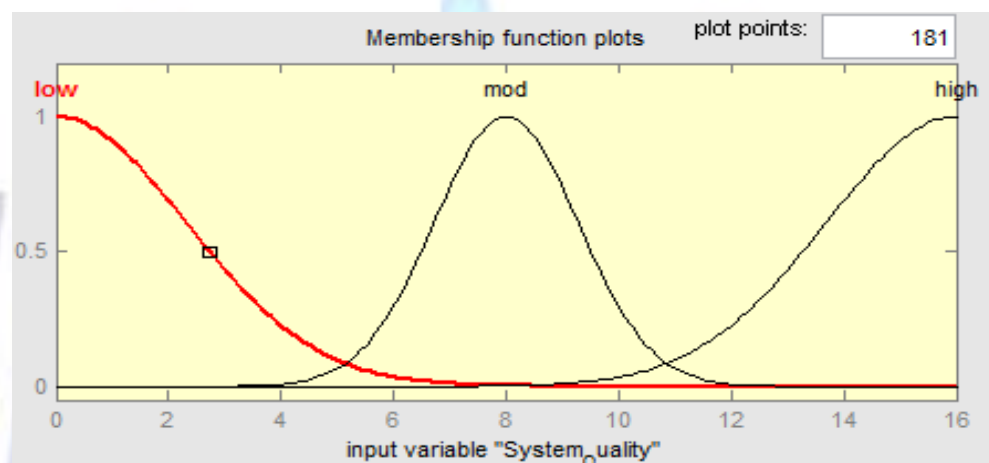


Figure 8. Membership functions for system quality

1. If (System_Quality is low) and (Service_Quality is low) and (Information_Quality is low) and (Learning_Community is low) then (E-learning_System_Level is vlow) (1)
2. If (System_Quality is low) and (Service_Quality is low) and (Information_Quality is mod) and (Learning_Community is low) then (E-learning_System_Level is vlow) (1)
3. If (System_Quality is low) and (Service_Quality is low) and (Information_Quality is high) and (Learning_Community is low) then (E-learning_System_Level is low) (1)
4. If (System_Quality is low) and (Service_Quality is mod) and (Information_Quality is low) and (Learning_Community is low) then (E-learning_System_Level is low) (1)
5. If (System_Quality is low) and (Service_Quality is mod) and (Information_Quality is mod) and (Learning_Community is low) then (E-learning_System_Level is low) (1)
6. If (System_Quality is low) and (Service_Quality is mod) and (Information_Quality is high) and (Learning_Community is low) then (E-learning_System_Level is mod) (1)
7. If (System_Quality is low) and (Service_Quality is high) and (Information_Quality is low) and (Learning_Community is low) then (E-learning_System_Level is mod) (1)
8. If (System_Quality is low) and (Service_Quality is high) and (Information_Quality is mod) and (Learning_Community is low) then (E-learning_System_Level is mod) (1)
9. If (System_Quality is low) and (Service_Quality is high) and (Information_Quality is high) and (Learning_Community is low) then (E-learning_System_Level is high) (1)
10. If (System_Quality is mod) and (Service_Quality is low) and (Information_Quality is low) and (Learning_Community is mod) then (E-learning_System_Level is mod) (1)
11. If (System_Quality is mod) and (Service_Quality is low) and (Information_Quality is mod) and (Learning_Community is mod) then (E-learning_System_Level is mod) (1)
12. If (System_Quality is mod) and (Service_Quality is low) and (Information_Quality is high) and (Learning_Community is mod) then (E-learning_System_Level is high) (1)
13. If (System_Quality is mod) and (Service_Quality is mod) and (Information_Quality is low) and (Learning_Community is mod) then (E-learning_System_Level is mod) (1)
14. If (System_Quality is mod) and (Service_Quality is mod) and (Information_Quality is mod) and (Learning_Community is mod) then (E-learning_System_Level is mod) (1)
15. If (System_Quality is mod) and (Service_Quality is mod) and (Information_Quality is high) and (Learning_Community is mod) then (E-learning_System_Level is vhigh) (1)

Figure 9. Defined fuzzy rules for proposed fuzzy model

5.6. Analysis of e-learning systems level versus service quality, system quality, information quality and learning community

For absolutely comprehend the collaboration from various factors contributing to the e-learning system level it is required that we probe contribution from each factor separately. The Figure 10 shows contribution to e-learning system level originating from the service quality, system quality, information quality and learning community, separately. Figure 10 shows that e-learning system level is monotonically increasing for increasing perceived system quality. However, this value is less for three other factors.

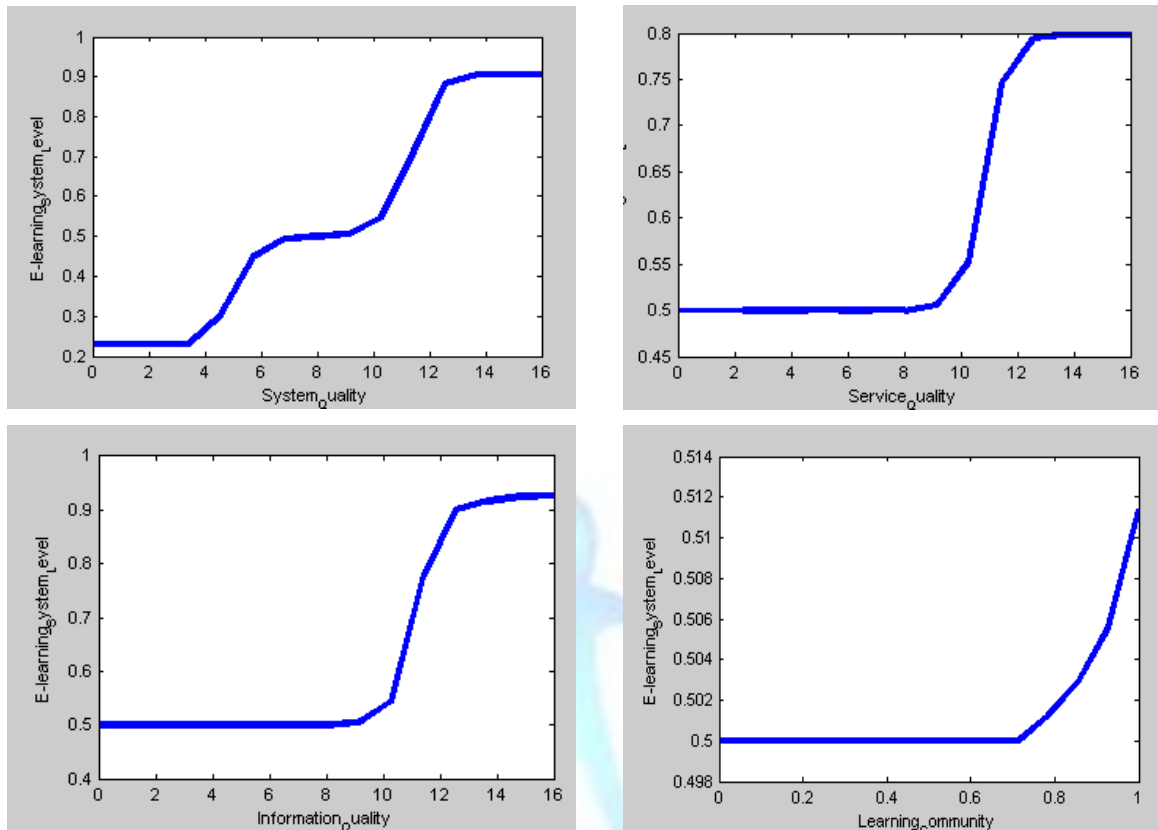


Figure 10: E-learning System Level versus service quality, system quality, information quality and learning community

5.7. Visualization of e-learning systems level as function two factors

We now attempt to visualize the e-learning system level as a continuous function of its input parameters. The surface models with two significant parameters showing two way interactions and relationship towards the desired response, e-learning system level is shown by Figure 11 the interaction of system quality and information quality and Figure 12 the interaction of system quality and service quality.

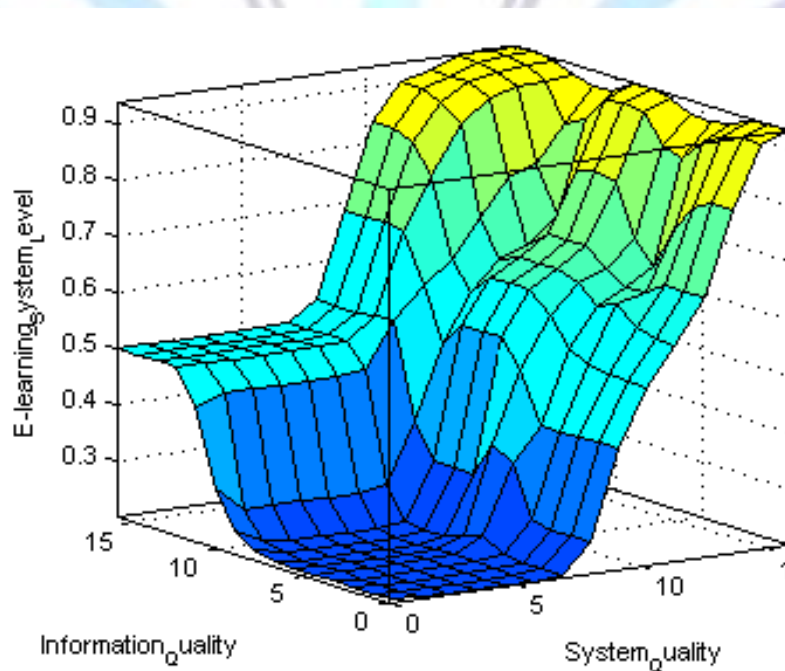


Figure 11: The inference surfaces in 3D as function of system quality and information quality versus e-learning system level

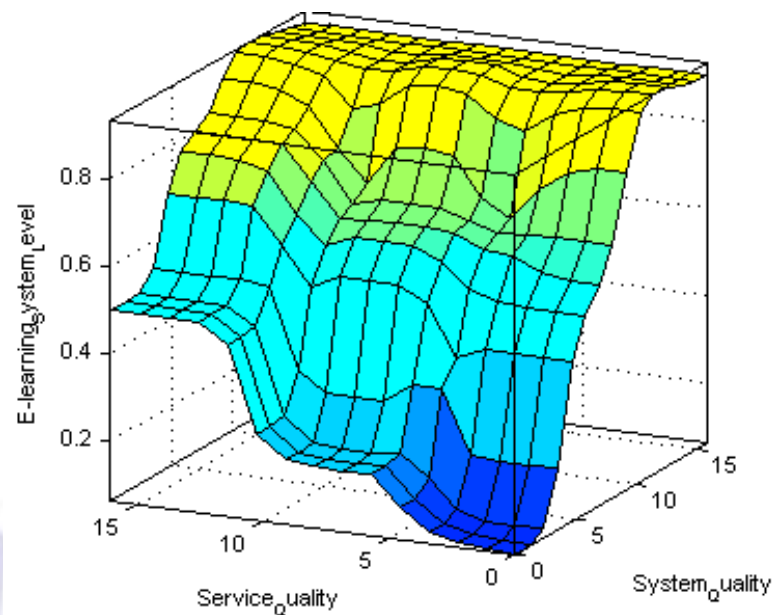


Figure 12. The inference surfaces in 3D as function of system quality and service quality versus e-learning system level

6. CONCLUSION

In this research, a new method of evaluation e-learning system was proposed using fuzzy logic and fuzzy TOPSIS. Using fuzzy TOPSIS, all factors have been ranked. We considered system quality, service quality, information quality and learning community as main factors used in the fuzzy TOPSIS model. Fuzzy logic helps us to reveal real level of factors ranked by fuzzy TOPSIS. The findings of this research showed that System Quality, Information Quality, Service Quality and Learning Community affect on e-learning systems level positively. Also findings in this research showed that system quality has the most positive influence on online learners perceive of e-learning system level.

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