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Assessing and Prioritizing Affecting Factors in E-Learning Websites Using AHP Method and Fuzzy Approach

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Abstract

The evolution of information technologies has caused to the growth in online training as an important education method. Assessment of the quality of e-learning has become a strategic issue; one that is critical to improve e-learning websites .This study identifies the significant factors that influence on successes in e-learning websites. In this study two questionnaires were used. One of questionnaire was AHP questionnaire. From the literature these factors was discovered and then AHP method was applied for prioritizing .Based on literature effective factors was organized in four major groups by experts .After prioritizing by second questionnaire ,data collected from 150 IT students of three virtual universities in Iran. Used factors in second questionnaire were from prioritized factors in first questionnaire. Data was organized by Excel software and 81 rules were obtained .Finally using fuzzy toolbox in Matlab software and applying obtained rules, outputs of factors were calculated and then in some 3D surface plots were depicted.

Keywords: Fuzzy logic, AHP, E-Learning Website, Assessment, Evaluation.

1. Introduction

Electronic learning has grown into a revolutionary way of learning due to the rapid development of information and communication technologies [1].The technological innovations have made training, teaching, and learning over the Internet possible, which is so-called Web-based instruction (WBI) in education and training fields [2].

An online e-learning system eliminates major limitations in traditional learning approaches because E-learning does not depending 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 [3] [4].

Electronic learning is the use of internet technology to deliver and share information for education and training in organizations. With the progress of internet technology and IT facilities, e-Learning is emerging as the model of modern education. The most important utilities of using e-learning are saving time, interactions between learners and instructors, or learners and learners through the asynchronous and synchronous learning network model. The recent advent of e-learning technology has made training, teaching and learning on the Internet more feasible and the new challenge for Internet education providers is attracting potential learners to use an e-learning website. This study develops a model for an e-learning website for acquiring more efficiency based on learner view. For assist and enhance the traditional learning systems, some e-learning systems and adaptive online education systems have been suggested [5] [6].Based on 2 category of E-learning systems ,synchronous systems of E-learning concentrate on online, real-time, interactive courses via multimedia Web pages, such as a virtual laboratory and a virtual classroom [7], [8].

There are many factors have been recognized by researchers to have an influence on the e-learning websites and e-learning systems. Some perceived factors are related to the technical, human, system, instructor, student, and cultural factors. Papp [9] 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 website design, course design, and learning satisfaction theories to form an integrated evaluation model [15] [16] [17].

2. Data Analysis

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 websites through three virtual universities environments and the participants were interact with us to discuss e-learning websites, after that they were requested to fill in a given pair wise questionnaire. 10 People (expert lectures in e-learning systems) called up the questionnaires, of which 10 actually completed it. The collected data was analyzed using the Expert choice software. For second questionnaire 150 students of IT were used. The statistics for the data collected is shown in table1. The most of respondents aged between 30-50 years old, while 78.1% of the respondents were male. The respondents were expert in e-learning systems that had experience in working with e-learning websites .Table 2 and figure 1 show the demographic results according to years of experience.

Demographics	Responses obtained	Percentage %
Gender		
Male	81	65%
Female	68	35%
Total	**150**	**100%**
Age		
22-24	46	25%
24-33	67	69%
33-40	37	6%
Total	**150**	**100%**
Degree Program		
Graduate	88	77%
Postgraduate	62	23%
Total	**150**	**100%**

Table 1: Students demographic data for second questionnaire

Experience	Less than 3 years	Between 3 and 6	Between 6 to 9	More than 9 years
Percentage	15%	50%	30	5%
Prior experience in designing E-learning website				
Yes		No		
65%		35%		

Table 2: Students demographic data for second questionnaire

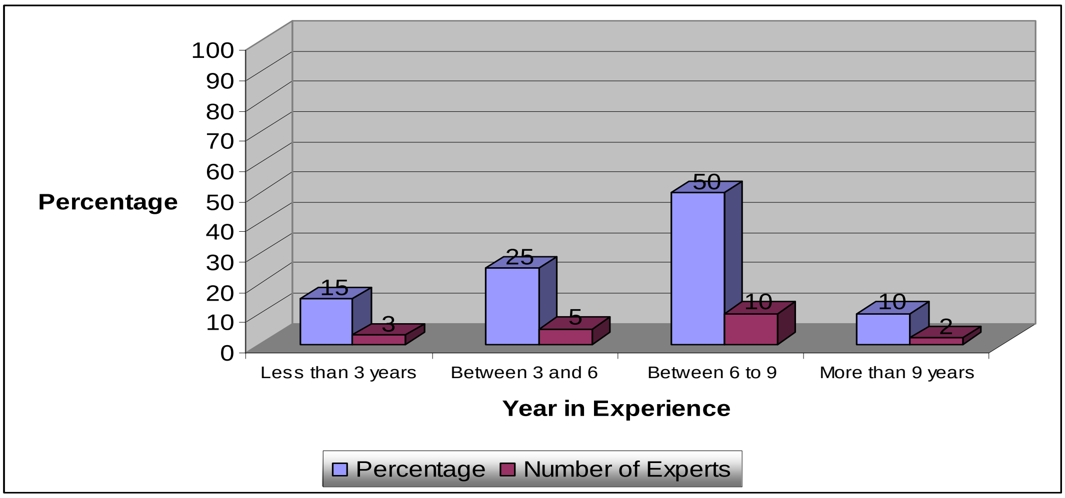

Figure 1 .Chart of demographics results of experts with experience in year

In second questionnaire website 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

3. AHP Method

AHP, developed by Saaty [11], is used to tack MCDM in real applications [12]. MCDM is denoted to screen, prioritize, rank, or select a set of alternatives under usually independent, incommensurate or conflicting attributes [13]. The AHP is based on following steps:

Step1: Compose AHP structure:

MCDM is structured as a hierarchy. The MCDM is decomposed into a hierarchy of interrelated decision elements. With the AHP, the objectives, criteria and alternatives are arranged in a hierarchical structure. Usually, a hierarchy has three levels demonstrated in figure 2: overall goal of the problem at the top, multiple criteria that define alternatives in the middle, and decision alternatives at the bottom [14].

Step2: Compose AHP structure:

Establish a pair-wise comparison decision matrix. The second step is the pair comparison of criteria to determine the relative weight of criteria. The criteria are compared pair-wise according to their influence and based on the specified criteria in the higher level [14].

In AHP, multiple pair-wise comparisons are from a standardized comparison scale of nine levels shown in table3 .Suppose that C = {Cjjj = 1, 2 . . . n} be the set of criteria. Evaluation matrix can be gotten, in which every element aij(i,j = 1, 2 . . . n) represents the relative weights of the criteria illustrated:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ a_{1n} & a_{2n} & \cdots & 1 \end{bmatrix} \qquad (1)$$

Definition	Value
Equal importance	1
Weak importance	3
Essential importance	5
Demonstrated importance	7
Extreme importance	9
Intermediate values	2, 4, 6, 8

Table 3: Standardized comparison scale of nine levels.

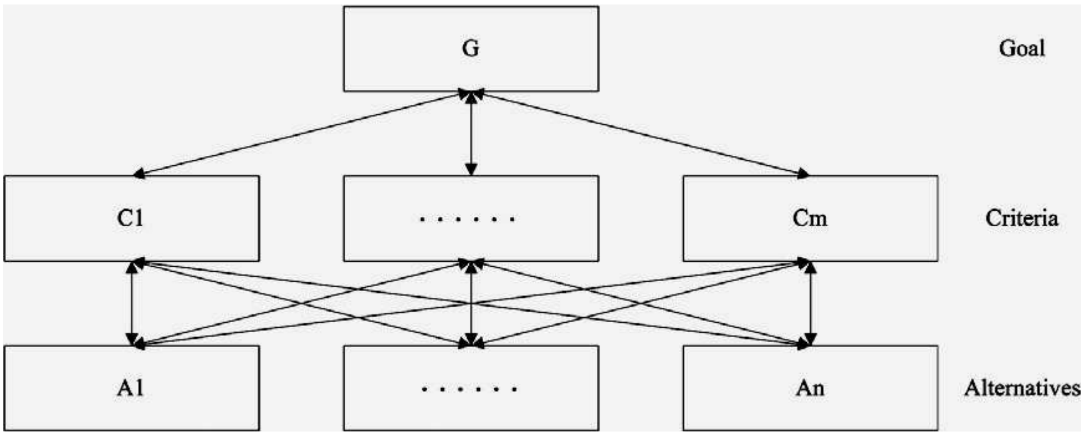

Figure. 2. AHP structure.

Where a_{ij}(i, j = 1, 2 . . . n) has comply with following condition:
$a_{ij} = 1/a_{ij}$; a_{ij}= 1; $a_{ij} > 0$.
(2)

Step 3: Calculate criteria weight:

By the formula:

$$AW = \lambda_{max} W \quad (3)$$

The λ max can be acquired. If the λ max is equal to n and the rank of matrix A is n, A is consistent. In this case, the relative criteria can be discussed. The weight of each criterion will be calculated by normalizing any of the rows or columns of matrix A [14].

Step 4: Test consistency:

AHP must meet the requirement that matrix A is consistent There are two parameters consistency index (CI) and consistency ratio (CR). Both of them are defined as following:

$$CI = \frac{\lambda \max - n}{n-1} \quad (4)$$

$$CR = \frac{CI}{RI} \quad (5)$$

Where RI is random index. For different count of criteria, it has different value demonstrated in Table 2. If CR is less than 0.10, the result can be acceptable and matrix A is sufficient consistency. Otherwise, we have to return to step 1 and repeat again.

4. Fuzzy Logic

In this study, the fuzzy logic has been used to assess e-learning website 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.

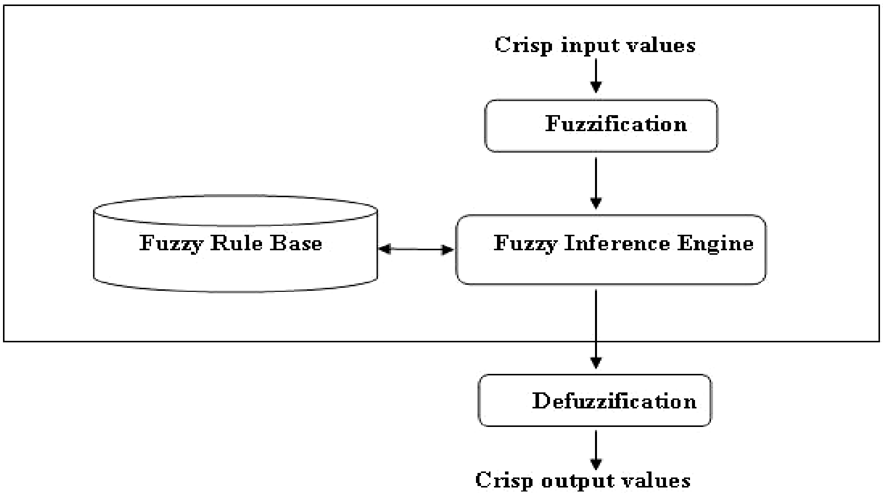

Figure 3. Structure of a Fuzzy Logic Model

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 [10]. Once the output linguistic values are available, the defuzzifier produces the final crisp values from the output linguistic values. According to [18], 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 [18]. 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 [18].

In last step Defuzzification process is applied and it is the process for converting fuzzy output sets to crisp values [18]. 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:

$$Centroid = \frac{\int x\mu(x)dx}{\mu(x)dx} \quad (6)$$

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

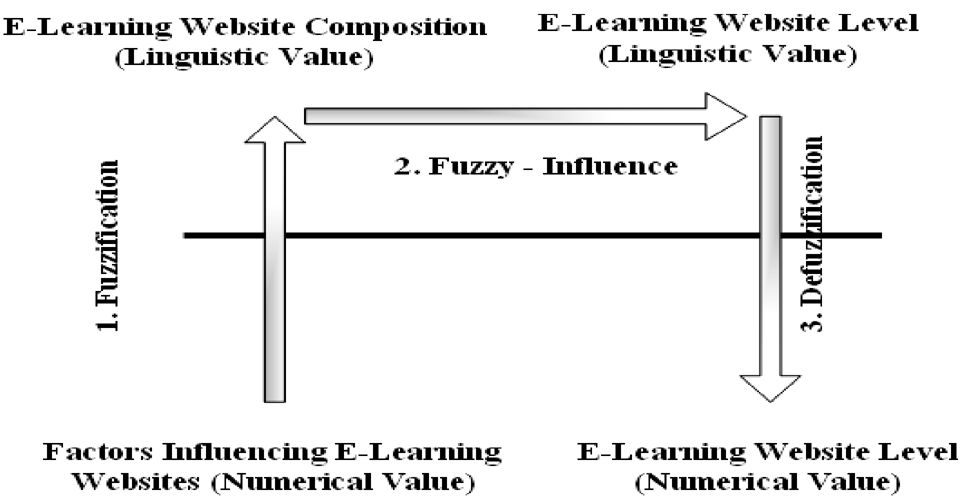

Figure 4. Structure of a Fuzzy Logic System for Proposed model

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 websites to get a value for the considered e-learning website 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 website is extracted.

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5. Research model

The proposed model has been established based on this principle that each real level of E-learning websites includes 3 major factors as Website Design Information, Website Content Quality Information and Website Quality Information. Therefore, we propose to investigate into the truthfulness of the following relationship:

$$L_{E-Learning} = F(D, C, Q) \tag{6}$$

Where D is the level of e-learning website design, C is the level of content, and Q is the level of e-learning website. The hypothesis is that the factors determining the level of e-learning website $L_{E-Learning}$ are a function of these three parameters.

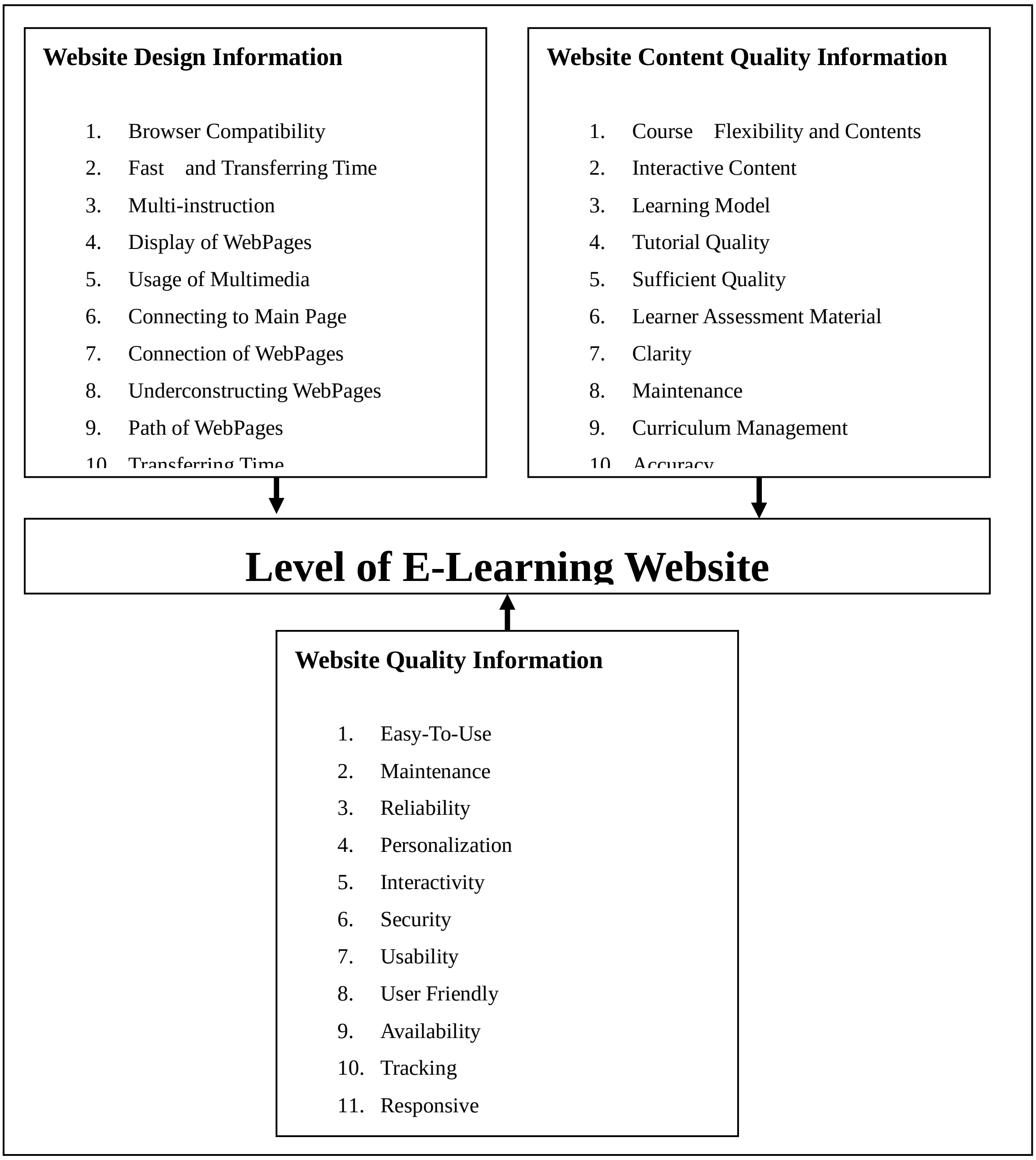

Figure 5: Emerged Frame of work

5. Hierarchy of factors

For applying AHP method, the first step would be building the hierarchy of factors. In previous section, the conceptual frame of work of this research was depicted. Hence, based on the main criteria and sub-factors introduced in section 2, a pairwise questionnaire was created for gathering data. Figure 5 depicts the steps needed to be done in first part of this research.

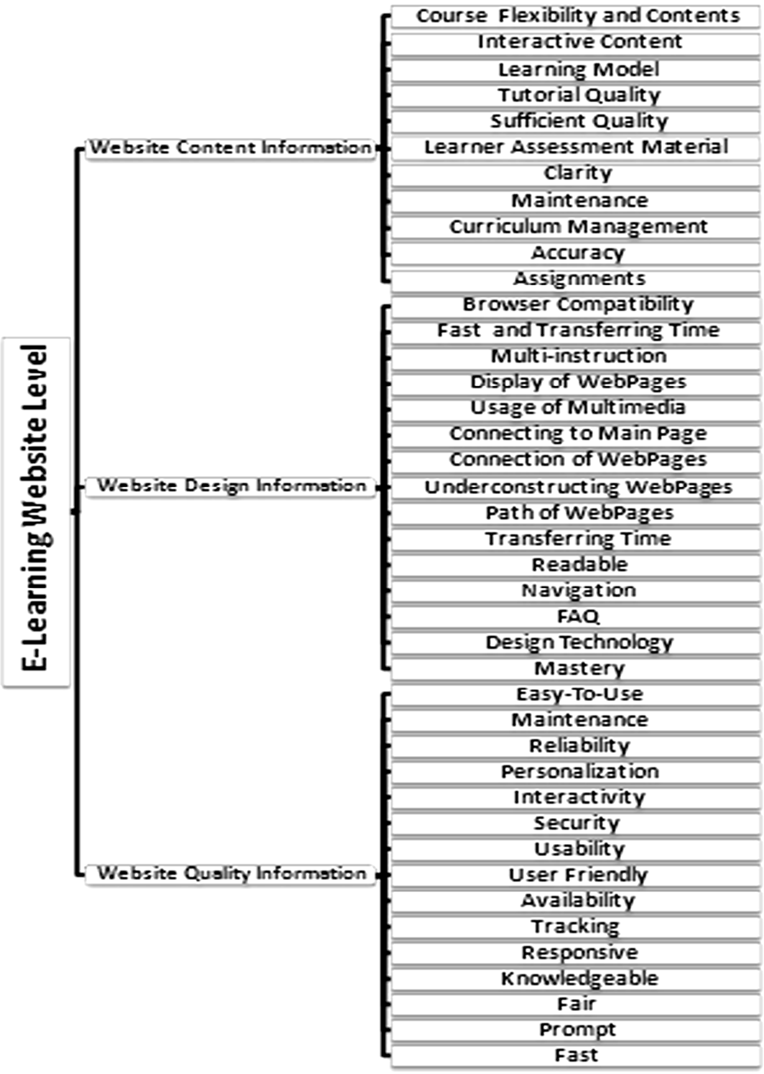

Figure 6: Hierarchy of factors for AHP method

6. Calculating the weights of factors and ranking of factors

In this study for applying AHP method to determine the rank factors, expert choice (EC version 2000) software was used. After using EC on factors, based on threshold decided by experts, the most important of sub factors were selected. Table 4 summarized the weights of the four most important sub factors. For all experts' judgments, geometric mean method was used to aggregate individual judgment to obtain a collective judgment. Equation 7 shows way of calculating geometric mean of x for n elements. Also the threshold was selected more than number 0.150 for all factors after ranking.

$$GM = \left(\prod_{i=1}^{n} x_i \right)^{\frac{1}{n}} = \sqrt[n]{\prod_{i=1}^{n} x_i} \qquad (7)$$

Objective:
Assessing and Prioritizing Affecting Factors in E-Learning Websites

Weighs of Sub-Criteria Counted By Experts.										Priorities of Criteria	I.R.	Criteria	
10	9	8	7	6	5	4	3	2	1				
0.203	0.172	0.154	0.2	0.204	0.201	0.219	0.211	0.206	0.209	0.196	0.04	**Navigation**	**Design (0.2)**
0.2	0.205	0.113	0.241	0.184	0.297	0.2	0.19	0.152	0.23	0.195		**Usage of Multimedia**	
0.148	0.155	0.191	0.261	0.132	0.149	0.12	0.136	0.179	0.254	0.166		**Transferring Time**	
0.17	0.182	0.186	0.119	0.169	0.184	0.126	0.15	0.164	0.103	0.152		**FAQ**	
0.285	0.297	0.22	0.175	0.189	0.236	0.208	0.286	0.191	0.274	0.23	0.03	**Course Flexibility**	**Content (0.3)**
0.261	0.237	0.211	0.207	0.224	0.19	0.201	0.233	0.26	0.232	0.22		**Interactive Content**	
0.245	0.131	0.26	0.252	0.268	0.212	0.141	0.289	0.203	0.241	0.21		**Accuracy**	
0.137	0.245	0.228	0.238	0.15	0.206	0.213	0.227	0.256	0.22	0.20		**Clarity**	
0.24	0.216	0.292	0.224	0.138	0.284	0.257	0.24	0.206	0.13	0.215	0.02	**Easy-To-Use**	**Quality (0.5)**
0.179	0.286	0.27	0.226	0.227	0.166	0.163	0.209	0.243	0.172	0.210		**Reliability**	
0.277	0.189	0.226	0.166	0.145	0.196	0.198	0.251	0.264	0.184	0.205		**Availability**	
0.221	0.179	0.128	0.206	0.211	0.242	0.196	0.209	0.233	0.246	0.204		**Security**	

Table 4: Twelve of most important parameters that affect on level of e-learning websites ranked by their weight via Expert Choice

7. Rules indicating for E-learning website 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 was written for organizing collected data.

Figure 7 shows Pseudo code in Excel software for organizing data for indicating rules.

```
Sub accumulated_Design()
Dim i As Integer
Dim sum As Integer

Worksheets("design").Activate

For i = 4 To 153 Step 1

Cells(i, 3).Select

  sum = Cells(i, 3).Value + Cells(i, 5).Value + Cells(i, 7).Value + Cells(i, 9).Value
  Cells(i, 10).Value = sum
  Cells(i, 11).Value = (sum / 8) * 100

  If (Cells(i, 11).Value >= 67) Then
    Cells(i, 12).Value = "Good"
  End If

  If (Cells(i, 11).Value >= 34) And (Cells(i, 11).Value < 67) Then
    Cells(i, 12).Value = "Moderate"
  End If

  If (Cells(i, 11).Value < 34) Then
    Cells(i, 12).Value = "Poor"
  End If

Next i
End Sub
```

Figure 7: Pseudo code in Excel software for organizing data for indicating rules

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

After organizing data via excel software and discovering 27 rules, all rules entered in fuzzy logic system for depicting real level of affecting factors. Therefore, there were a total of 27 rules for estimating of website level deduced from the survey.

9. 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 websites. Three input variables as quality, content and one output variable (website level). The output variable is a value from 0 to 1; representing very low e-learning website , low level e-learning website ,moderate e-learning website ,high level e-learning website and very high level e-learning website. This system uses Mamdani inference method and simulation applied in MATLAB R2010b fuzzy logic toolbox. Figure 8 shows a Mamdani fuzzy inference system for proposed framework.

It shows a simple diagram with the names of the input quality, content and design. 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.

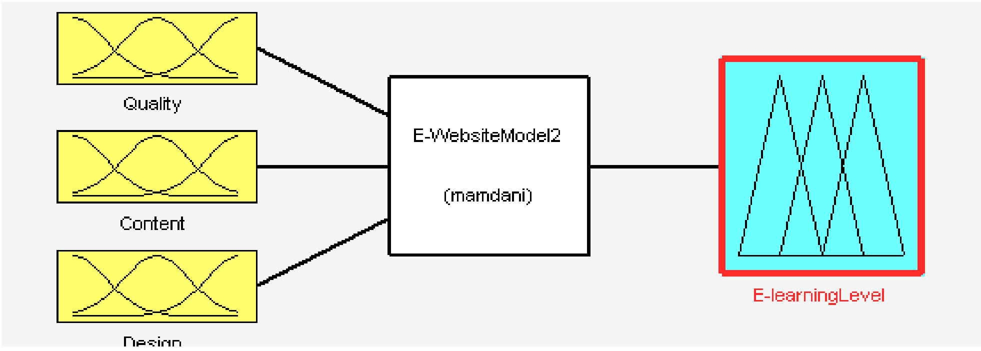

Figure 8. Mamdani FIS for proposed framework

Figure 9 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.

```
[System]
Name='E-WebsiteModel'
Type='mamdani'
Version=2.0
NumInputs=3
NumOutputs=1
NumRules=28
AndMethod='min'
OrMethod='max'
ImpMethod='min'
AggMethod='max'
DefuzzMethod='centroid'


[Input1]
Name='Quality'
Range=[0 16]
NumMFs=3
MF1='low':'gaussmf',[2.32 0]
MF2='mod':'gaussmf',[1.286 8]
MF3='high':'gaussmf',[2.32 16]

[Input2]
Name='Content'
Range=[0 16]
NumMFs=3
MF1='low':'gaussmf',[2.32 -
1.665e-016]
MF2='mod':'gaussmf',[1.287 8]
MF3='high':'gaussmf',[2.319 16]


[Input3]
Name='Design'
Range=[0 16]
NumMFs=3
MF1='poor':'gaussmf',[2.32 0]
MF2='mod':'gaussmf',[1.286 8]
MF3='good':'gaussmf',[2.32 16]

Name='E-learningLevel'
Range=[0 1]
NumMFs=5
MF1='vlow':'trimf',[-0.2 0 0.2]
MF2='low':'trimf',[0 0.2 0.4]
MF3='mod':'trimf',[0.3 0.5 0.7]
MF4='high':'trimf',[0.6 0.8 1]
MF5='vhigh':'trimf',[0.8 1 1.2]


[Rules]
1 1 1, 1 (1) : 1
1 1 2, 1 (1) : 1
1 1 3, 2 (1) : 1
1 2 1, 2 (1) : 1
1 2 2, 2 (1) : 1
1 2 3, 3 (1) : 1
1 3 1, 3 (1) : 1
1 3 2, 3 (1) : 1
1 3 3, 4 (1) : 1
2 1 1, 3 (1) : 1
2 1 2, 3 (1) : 1
2 1 3, 4 (1) : 1
2 2 1, 3 (1) : 1
2 2 2, 4 (1) : 1
2 2 3, 5 (1) : 1
2 2 2, 3 (1) : 1
2 3 1, 3 (1) : 1
2 3 2, 4 (1) : 1
2 3 3, 5 (1) : 1
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3 1 2, 5 (1) : 1
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3 2 1, 5 (1) : 1
3 2 2, 5 (1) : 1
3 2 3, 5 (1) : 1
3 3 1, 5 (1) : 1
3 3 2, 5 (1) : 1
3 3 3, 5 (1) : 1
```

Figure 9. The complete information of fuzzy inferences of proposed system

10. Analysis of e-learning websites level versus Quality, Content and Design for constant factors

For absolutely comprehend the collaboration from various factors contributing to the e-learning website level it is required that we probe contribution from each factor separately. The figure 10 shows contribution to e-learning website level originating from the quality, content and design separately. Therefore, for quality factor the contribution from content and Design has been kept constant in zero level.

Figure 10 shows that e-learning website level is monotonically increasing for increasing perceived quality factor of a website. Also figure 7 shows that e-learning website level is versus quality 0.937, content 0.5 and design 0.2 at its maximum separately.

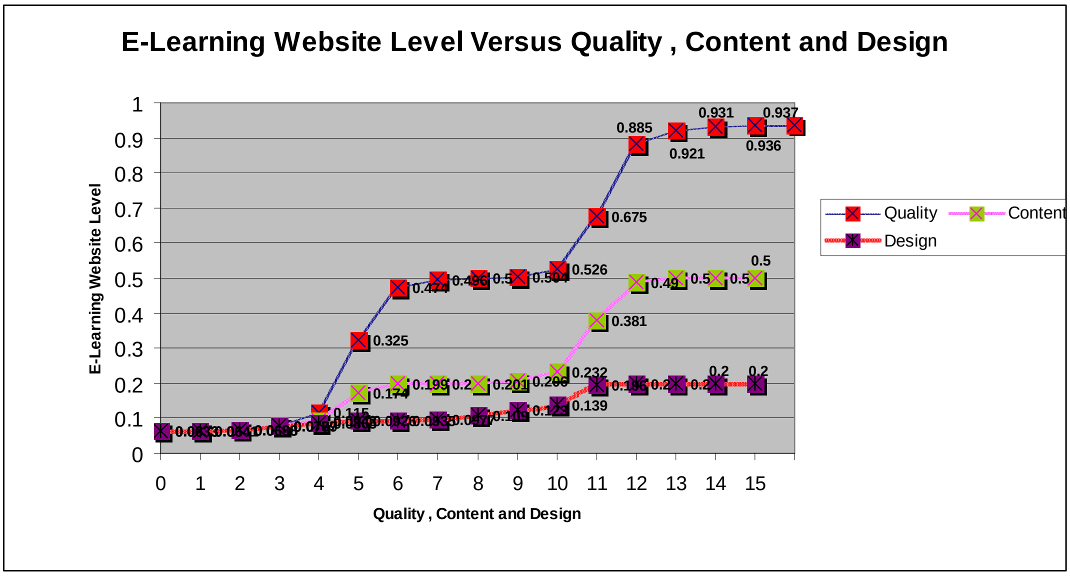

Figure 10: E-learning Website Level versus Quality, Content and Design for constant each other.

11. Visualization of e-learning websites level as function of quality and content

We now attempt to visualize the e-learning website 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 website level is shown by figure 11 the interaction of quality and conten and figure 12 the interaction of content and design.

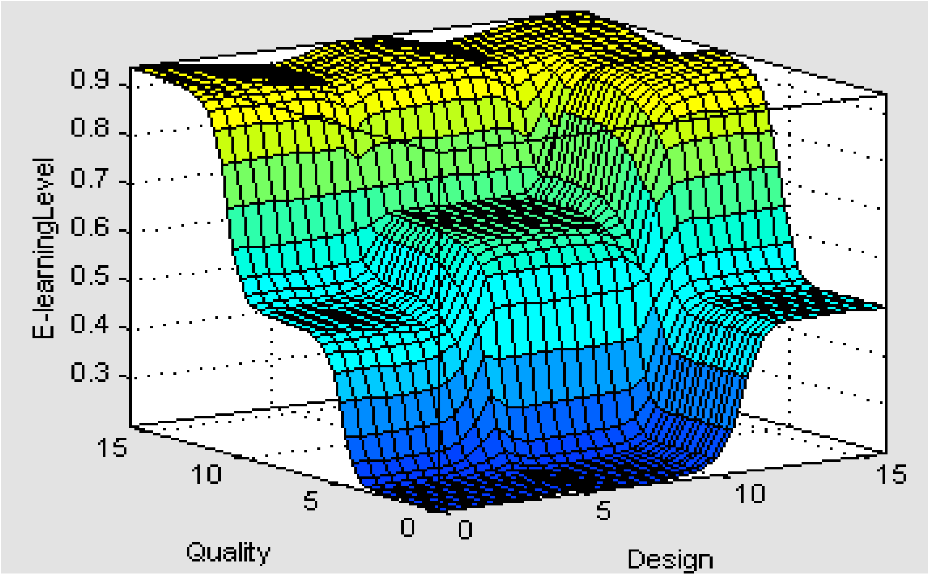

Figure 11 :The inference surfaces in 3D as function of design and quality versus e-learning website level

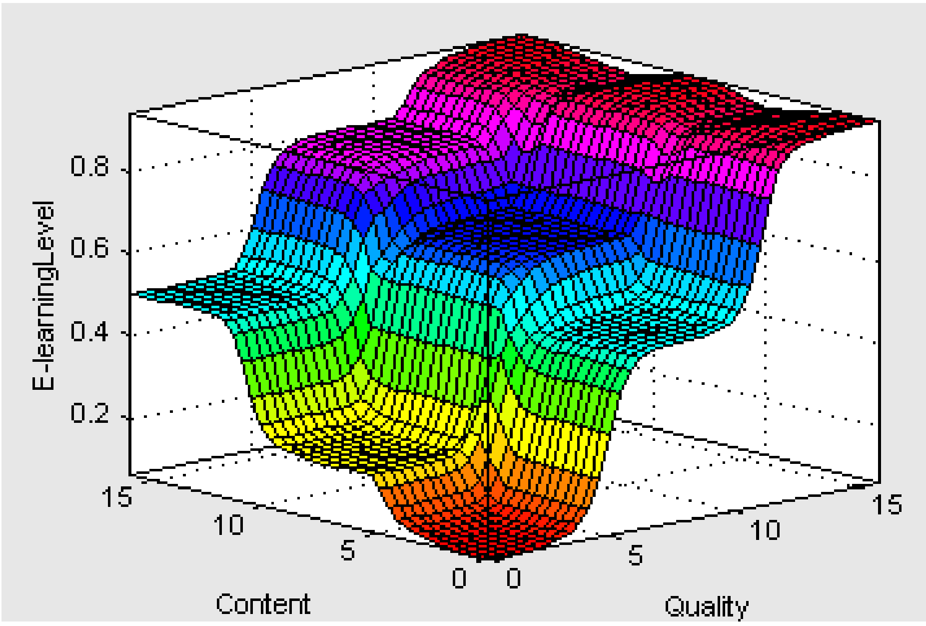

Figure 12 :The inference surfaces in 3D as function of content and quality versus e-learning website level

The fuzzy rule viewer of the established model is shown in figure 13. It indicates the behavirol of the response over the change in values of all the three significant e-learning websites factors.

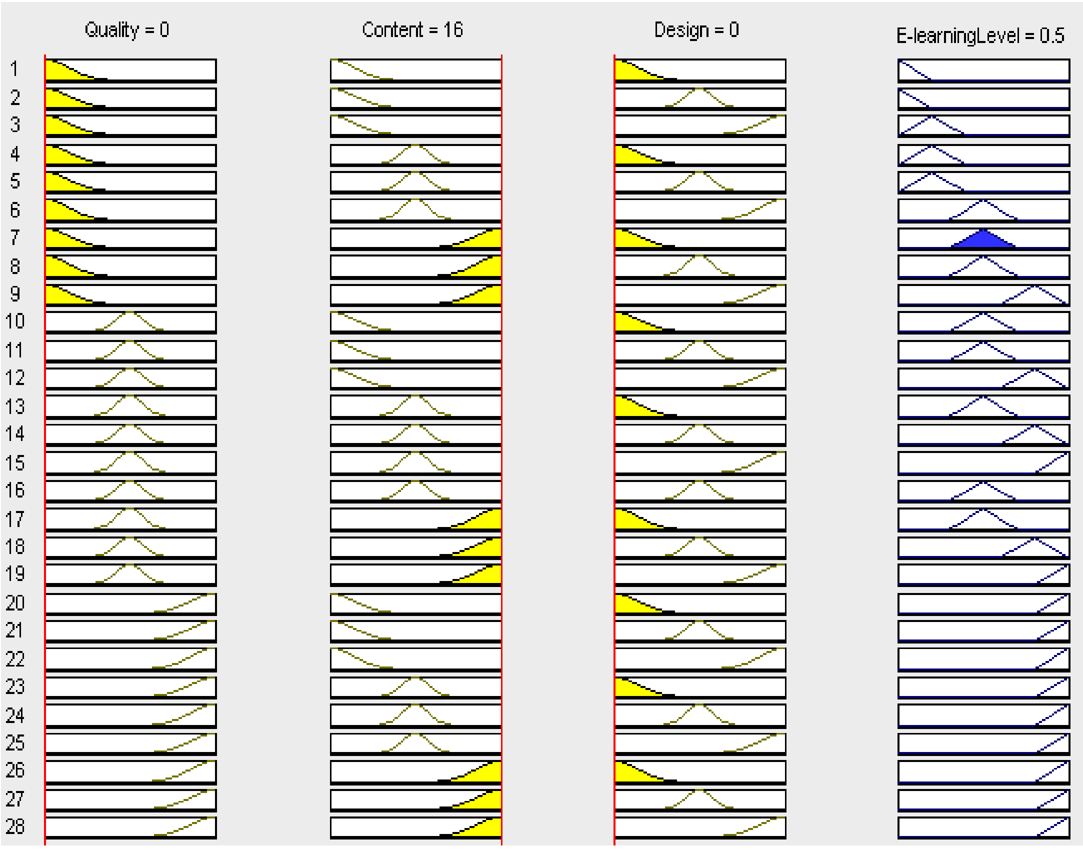

Figure13: Result Of Tested Values

12. Conclusion

In this research a new method of assessment and ranking affecting factors on e-learning websites through the use of fuzzy logic was presented. Fuzzy logic is the flexible tool for developing evaluating model with a simple framework and constructed with natural language.

Also this paper, in line with the literature, three major factors with related sub factors for e-learning websites that can assist universities and instructors and web designer to evaluate e-learning websites were detected. Using AHP method, all factors in three groups was ranked and based on important sub factors second questionnaire was designed.

The findings of the research showed that website quality, website content, and website design affect on e-learning websites positively. Also findings in this research showed that website quality has the most positive influence on online learners perceive of e-learning website level.

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