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Proposing an approach for evaluating e-learning by integrating critical success factor and fuzzy AHP

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Abstract. By advancing information and communication technology (ICT), e-learning is emerged as a modern educational paradigm. This online learning environment improves the delivery of teaching content, knowledge sharing among trainees, social interaction and so forth. Regarding mass investment for e-learning solutions which don't meet their original objectives, e-learning performance assessment remains crucial. E-learning appraisal assists managers of educational institutes by revealing weak and strength aspects of these initiatives and creates opportunity to improve and make effective e-learning systems. This paper aim is to introduce a new approach to e-learning system assessment by identify and prioritize the preliminary e-learning critical success factors (CSFs) or enablers that need to be concentrated by universities and educational institutes using Fuzzy analytic hierarchy Process (FAHP) method. The result of such performance evaluation subsequently acts as informative tools for developing e-learning systems plan.

Keywords: E-learning, Critical Success Factors (CSF), Fuzzy analytic hierarchy Process (FAHP).

1. Introduction

During recent decade designing and implementing learning methods have increased exponentially[1]. Information technology (IT) is playing important role in recent educational evolution via providing more efficient, effective and modern way of student learning, IT has been viewed as a solution for cost and quality issues of universities [2]. The main reasons of rapid growth of e-learning can be summarized as follows: an opportunity for overcoming the limitations of traditional learning, such as geographical distance, time, budget or busy program; equal opportunities for getting education no matter where you live, how old you are, better quality and a variety of lecture materials; use shared resources and the students can receive knowledge, skills and experience from other universities [3]. These e-learning systems gather a huge deal of information; which is worthy in evaluating students' performance and assisting teachers to detect of possible errors, shortcomings and finally get improvements [4].

Worldwide, the e-learning market has a growth rate of 35.6%, but failures exist [5]. Although some researchers believe e-learning students learn as well as student of traditional methods, e-learning courses have some limitations which must be reveal and amend [6]. For instant, many online courses cannot sufficiently motivate students to participate, in other word, web based education (e-learning) is apt to isolate trainees and this feature lead to high rate of failure. By considering increasing investment on e-learning solutions, it is important to know how evaluate e-learning programs and overcomes their shortcomings [7].

As Strand & Thune [8] notified that evaluation process answers questions such as: Are new technologies producing better learning than traditional classrooms and traditional teachers? Or, are claims of radical

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improvements in learning as a result of ICT only empty words aimed at making people believe in the utility of ICT and buy more technology? One way of facing these challenges is identifying critical success factors of e-learning. Implementing CSFs is vital to achieve success. Critical Success Factors (CSF) entitles something which must be implemented if companies want to be success. These factors should be controllable and measurable and also few in number [2]. The factors affecting e-Learning performance presented by previous studies are basically focused on certain perspectives [5,9]. The paper has two main contributions: first, proposing a comprehensive approach for assessing e-learning initiatives by using CSF methodology and FAHP method and second, prioritizing the important of each CSF from E-learners viewpoints. To get these aims, the paper combines tow well known managerial methodologies, fuzzy AHP and CSF.

The analytic hierarchy process (AHP) is one of the most widely used multiple-criteria decision-making (MCDM) methods. Because of the uncertainty and vagueness as well as imprecision of human decision making in daily life decisions, a fuzzy AHP (FAHP) is used to add with the CSF. The remainder of this paper is organized as follows. Section 2, briefly reviews CSF and fuzzy AHP literature. Section 3, introduces research methodology and data collection. In section 4, the gathered data is analyzed. In section 5, conclusion is argued.

2. Background

2.1. E-learning Critical Success Factor (ECSF)

Keramati et al. [1] considered elarning as a new method of training which complements traditional methods and its final ambition is to build an advanced society for citizens and support creativity.

Issues related to efficiency, effectiveness and cost are as a driver force for organizations and universities to implement e-learning initiatives [10]. E-learning as an application of IT is integrated with many universities programs [2]. By corresponding, considerable e-learning growth, many researchers from psychology and information system fields have identified important variables dealing with e-Learning success [5]. The rationale behind of e-learning initiatives, like any other learning approach, is to realize the learning objectives. The success criteria of e-learning measures can be environmental, technological, student related, and instructor related [8]. In e-learning some of CSFs are related to technological issues like board band width, reliability of hardware, accessibility, network security, and another success factor is the level of trainees participation and other success factor is related to trainee characteristics like student' commitment and motivation and also their learning speed [2]. Table (1) shows briefly some studies about e-learning CSF.

Table (1): some of e-learning CSF studies

Author(s)	Critical Success Factors
Dillon and Guawardena [11]	technology, instructor characteristics, student characteristics
Govindasamy [12]	Institutional support, course development, teaching and learning, course structure, student support, faculty support, and evaluation and assessment
Selim [2]	Instructor, student, information technology, and university support
Shee & Wang [13]	Learner interface, learner community, system content, personalization
Sun et al [5]	Learner dimension, Instructor dimension, Course dimension, Technology dimension, Design dimension, Environmental dimension
Ozkan & Koseler [9]	System quality, service quality, content quality, learner perspective, instructor attitudes, supportive issues
Mosakhani & Jamporazmey [6]	Instructor characteristics, Student characteristics, Content quality, Information technology quality, Participations Interaction, Educational institutes support, Knowledge management

Based on comprehensive study by Mosakhani and Jamporazmey [6], this paper grouped CSF of elearnig in to seven categories. CSFs and their related indicators are mention in the following: Instructor characteristics (Instructor attitude to student, Instructor attitude to e learning, Computer skill), Student characteristics (Computer skill, motivation, commitment, learning speed), Content quality (Updated content, sufficient content, understandable content), Information technology quality (reliability, accessibility, degree of guidance, design of user interface, network security, and timeliness), Participations Interaction (Learning community, ease of interaction with together), Educational institutes support (Providing financial support, proper feedback, diversity evaluation methods) and KM (Degree of applying knowledge management tools).

2.2. Fuzzy Set Theory

Fuzzy Set Theory was first introduced by Bellman and Zadeh in 1965 to deal with the uncertainty and vagueness as well as imprecision of human decision making in daily life decisions [14].

The characteristic function μ_A of a crisp set $A \subseteq X$ assigns a value either 0 or 1 to each member in X. in a fuzzy set we have: $\mu_{\tilde{A}}: X \to [0,1]$ where the assigned value indicates the membership grade of the element in the set A.

A fuzzy number is said to be a triangular fuzzy number if its membership function is given as:

$$\mu_{\tilde{M}}(x) = \begin{cases} \frac{x-l}{m-l} & l \le x \le m \\ \frac{u-x}{u-m} & m \le x \le u \\ 0 & otherwise \end{cases} \quad (1)$$

Consider 2 triangular fuzzy number $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$. Arithmetic operations are:

$$(l_1, m_1, u_1) \oplus (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \quad (2)$$

$$(l_1, m_1, u_1) \otimes (l_2, m_2, u_2) = (l_1 l_2, m_1 m_2, u_1 u_2) \quad (3)$$

$$(l_1, m_1, u_1)^{-1} = (\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1}) \quad (4)$$

2.3. Methodology of FAHP

Let $X = \{x_1, \dots, x_n\}$ be an object set, and $U = \{u_1, \dots, u_n\}$ be a goal set, According to the method of Chang's [15] extent analysis, extent analysis for each goal, gi is performed, respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs: $M_{gi}^1, M_{gi}^2, \dots, M_{gi}^m, i = 1,2, \dots, n$.

Where all $M_{g_i}^j, j = 1, \dots, m$ are fuzzy triangular numbers. The steps of Chang`s are briefly represented bellow:

Step 1: The value of fuzzy synthetic extent with respect to the ith object is defined as

$$s_i = \sum_{j=1}^{m} M_{g_i}^j \otimes [\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j]^{-1} \quad (5)$$

Where: $\sum_{j=1}^{m} M_{g_i}^j = (\sum_{j=1}^{m} l_i, \sum_{j=1}^{m} m_i, \sum_{j=1}^{m} u_i)$, (6)

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j = (\sum_{i=1}^{n} \sum_{j=1}^{m} l_i, \sum_{i=1}^{n} \sum_{j=1}^{m} m_i, \sum_{i=1}^{n} \sum_{j=1}^{m} u_i), \quad (7)$$

And $[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j]^{-1} = (\frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} u_i}, \frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} m_i}, \frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} l_i})$ (8)

Step2: the degree of possibility of $M_1 \ge M_2$ is defined as

$$V(M_1 \ge M_2) = \underbrace{\sup}_{x \ge y} [\min(\mu_{M_1}(x), \mu_{M_2}(y))] \quad (9)$$

Since M_1 and M_2 are convex fuzzy numbers, then $V(M_1 \ge M_2) = 1 \quad if\ m_1 \ge m_2$, (10)

$$V(M_2 \ge M_1) = hgt(M_1 \cap M_2) = \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} \quad (11)$$

To compare M1 and M2, we need both the values of $V(M_1 \ge M_2)$ and $V(M_2 \ge M_1)$.

Step3: The degree possibility for a convex fuzzy number to be greater than k fuzzy numbers can be defined by:

$$V(M \ge M_1, M_2, \dots, M_k) = V[(M \ge M_1) and\ (M \ge M_2) and\ \dots (M \ge M_k) = minV(M \ge M_i)\ , i = 1, \dots, k \quad (12)$$

Assume that $\acute{d}(A_i) = \min(S_i \ge S_k)$. For $k = 1, \dots, n\ ; k \ne i$ the the weight vector is given by

$$\acute{W} = (\acute{d}(A_1), \acute{d}(A_2), \dots, \acute{d}(A_n))^T \quad (13)$$

Where A_i (i = 1, 2 . . . . . n) are n elements. Via normalization, we get the normalized weight vectors

$W = (d(A_1), d(A_2), \dots, d(A_n))^T$ .Where W is a no fuzzy number. (14)

3. Research methodology and data collection

Data gathered via questionnaire survey. The questionnaire contains proposed CSF indicators and their criteria. The questionnaires were distributed among sample e-learner and ask them for compare importance of each CSF indicator to another one and compare importance of each criterion under each indicator to the other one at the same indicator. The scale used in this questionnaire is presented in table 2. Surveys were sent to 235 learners' with in 4 universities which offer e-learning courses via email which 200 of them were received back. So the respond rate is approximately 85%. To calculate the final score of each indicator and criterion, the arithmetic operations between triangular fuzzy numbers is used. Then answers are analyzed by FAHP method. To simplify calculations a FAHP program which is developed by the authors is applied.

Table 2: the FAHP questionnaire scale used for pairwise comparison

(1,1,1)	E	Equal	$(\frac{1}{2},1,\frac{3}{2})$	EI	Equally Important	$(1,\frac{3}{2},2)$	WMI	Weakly More Important
$(\frac{3}{2},2,\frac{5}{2})$	SMI	Strongly More Important	$(2,\frac{5}{2},3)$	VSMI	Very strongly More Important	$(\frac{5}{2},3,\frac{7}{2})$	AMI	Absolutely More Important

4. Findings

The final score of the pair wise comparison among indicators and among criteria are input to the FAHP software developed by the authors. Figure 1 show the pairwise comparison matrix related to the "Student Characteristics". The final weights of each CSFs and their related indicators are summarized in table 3.

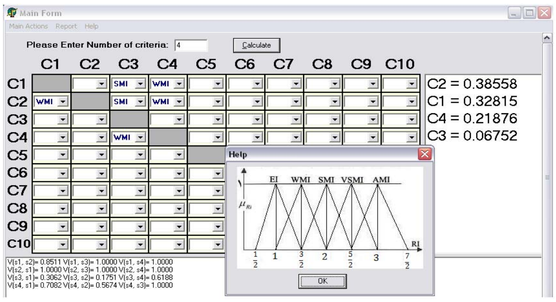

Fig. 1: the software output of FAHP calculation related to Student Characteristics.

Table3: the weights of CSFs and related criteria

CSFs	Criteria	weights
Student Characteristics (weight=0.24456)	Computer skill	0.32815
	Motivation	0.38558
	Commitment	0.06752
	Learning speed	0.21876
Instructor Characteristics (weight=0.19169)	Instructor attitude to students	0.310165
	Instructor attitude to e-learning	0.18552
	Computer skill	0.504315
content quality (weight=0.13361)	Update content	0.36879
	Sufficient content	0.26356
	Understandable content	0.36765
IT quality (weight= 0.21747)	Reliability	0.14132
	Accessibility	0.16798
	Degree of guidance	0.21186
	Design of user interface	0.09665
	Network security	0.12052
	Timeliness	0.26167
participation interaction (weight=0.05612)	Learning community	0.68421
	Ease of interaction with together	0.31579
educational institutes support(weight =0.11283)	Providing financial support	0.68421
	Proper feedback	0.31579
KM(weight =0.04372)	Degree of applying knowledge management tools	1

The final ranking of the CSF of e-learning systems and their criteria are summarized in figure (2).

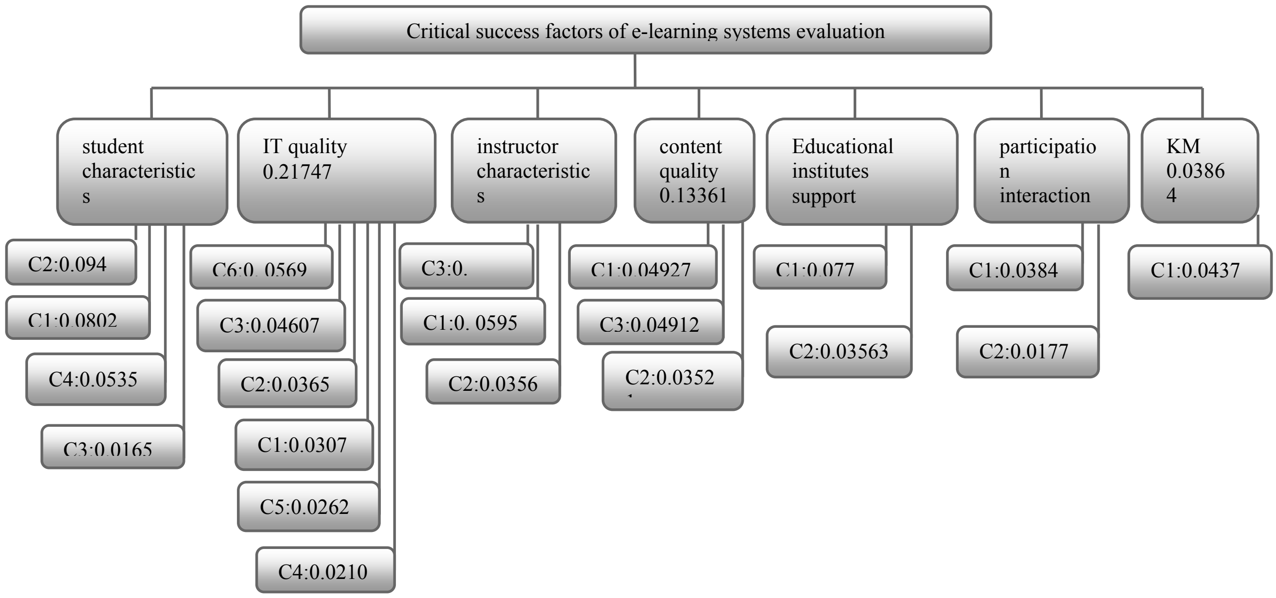

Fig. 2: the final ranking of the critical success factors and their criteria for e-learning systems evaluation

5. Conclusion

The emergence of e-learning has brought vitality to traditional teaching, because it has a great advantage in knowledge transformation, classroom teaching, social interaction. This paper proposes an approach based on the FAHP and CSF for evaluating the performance of e-learning. The analytic hierarchy is structured by the seven major CSFs including Instructor characteristics, Student characteristics, Content quality, Information technology quality, Participations Interaction, Educational institutes support, Knowledge management followed by sub categories of CSFs. The results show that student characteristics and IT quality have higher weightings and instructor characteristics, content quality, educational institutes support, participation interaction and KM are in the next priorities of importance. For sub measures, "computer skills" and "motivation" of students as well as "providing financial support from educational institutes" are the most important factors to be focused on. A prioritized list of CSFs was used to guide vendors to design and develop better systems and also assist managers to improve and justify existing e-learning systems. This approach for evaluation provides opportunity for educational institutes and universities to concentrate on key issues and it also can offer be beneficial information in strategic planning of e-learning initiatives.

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