A Fuzzy AHP Approach to Select Learning Management System

Ali Hakan Işık, Murat İnce, and Tuncay Yiğit

Abstract—**A great deal of learning management system (LMS) are available in e-learning environment. Each LMS has distinguished technical and educational features. Due to the diversity of these systems and increase in demand, choosing the most appropriate one that meets our priorities becomes challenging issue. In addition, determination of suitable LMS can be accepted as a multi-criteria decision making (MCDM) problem. In this context, Fuzzy Analytic Hierarchy Process (FAHP) which is a popular MCDM method is used for selection of the appropriate LMS. It provides objective expert evaluation. Obtained results show that Joomla LMS is the best LMS that meets our criteria.**

***Index Terms*—Fuzzy AHP, learning management system, multi-criteria decision making, triangular fuzzy numbers.**

I. Introduction

Developments in web technologies cause different and excessive usage of computer systems in education. Various organizations such as institutions, schools, universities and even commercial companies use computers for educational purposes. Using of computers systems in education can be enabled by LMSs. Due to the increase in the variety and quantity of LMSs, the problem of the selecting the most suitable and best LMS is arisen.

For instance, there are huge amount of LMS which have a lot of technical and pedagogical properties. Therefore, how can they be selected correctly according to the needs and priorities of the learners and also organizations? How it can be decided? These questions can be answered by the help of the MCDM methods. In this paper, a fuzzy analytic hierarchy process is used for the selection of the learning management system.

This study is organized in four sections. In the first section, the matter of LMS selection with Fuzzy AHP is introduced. In the second section, method of our study is given. In the third section, results about the system are presented. Finally, the conclusion and future works related to the Fuzzy AHP approach to select learning management system issue are given.

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II. LMS Selection with Fuzzy AHP

Selection of the best LMS according to the priorities of needs can be provided by MDCM methods. For this evaluation process, criteria are defined and applied to choose bestLMS among alternatives by using comparison sets. A quantitative approach with spreadsheet might have been a solution to this problem [1]. However, finding the most effective and easy MCDM method is not easy for LMS selection issue. It requires time for the implementation of MCDM methods, evaluation of criteria and alternatives [2].

III. Method

Analytical hierarchy process (AHP) method was developed by Saaty [3]. This method is successfully applied to different types of MCDM problems [4]. Although its popularity, AHP is criticized for its inability to handle uncertain and imprecise decision maker's evaluations [5]. In AHP, human's judgments are presented as crisp (exact) numbers but in many cases human preferences are uncertain to assign exact numbers to comparisons of the alternatives and criteria [6]. In order to cope with uncertain judgments comparisons of alternatives and criteria can be expressed as fuzzy sets or fuzzy numbers which incorporate the vagueness of the human preferences [6]. These fuzzy set can be provided by the most popular MCDM method which is Fuzzy Analytical Hierarchy Process [7]-[10]. FAHP is implemented in different fields as follows:

1) Supplier selection [11]
2) Selection computer integrated manufacturing systems [12]
3) Consideration of global supplier development risk factors [13]
4) Selection of the best catering service firm [7]
5) Evaluation of success factors for e-commerce [14]
6) Selection of convenience store location [15]
7) Job evaluation [16]
8) Evaluation of IT department performance [17]
9) Evaluation of the architectural design services [18]
10) Evaluation of services [6]
11) Selection of optimum underground mining method [19]
12) Selection of ERP software [20]
13) Selection of academic staff [21]
14) Analysis of fuel management [22]
15) Assessment of water management plans [23]

Generally, imprecise judgments are used rather than precise judgments in daily life. In FAHP, crisp values of the decision makers are expressed as fuzzy comparison sets (fuzzy triangular numbers). It uses derivative fuzzy ratios instead of crisp priorities in AHP because decision maker

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preferences in AHP are based on perception but the FAHP is more representative for decisions of humans[24]. Due to these reasons, FAHP is used as a MCDM method in our study.

The decision hierarchy of the criteria and the alternatives of our study are same as the Çetin's and his colleagues work [2], as shown in Fig. 1. Atutor, Black Board, Dokeos, E-nocta, HotChalk, Ilias, JoomLA, Moodle, Sakai Project, Sumtotal systems are the candidate alternatives for selection process of the best LMS. In our study, defined criteria are compared with each other representatively by Triangular Fuzzy Numbers(TFN) in a matrix. TFN are given in Table I [25]. TFN pair-wise comparison matrix of criteria is given in Table II.

TABLE I: TFN PAIR-WISE COMPARISON MATRIX OF CRITERIA

Linguistic Variables	TFNs	Reciprocal of TFNs 2
Equally Preferred	1,1,1	1,1,1
Moderately Preferred	0.66, 1, 1.5	0.66, 1, 1.5
Strongly Preferred	1.5, 2, 2.5	0.4, 0.5, 0.66
Very Strongly Preferred	2.5, 3, 3.5	0.285, 0.333, 0.4
Extremely Preferred	3.5, 4, 4.5	0.222, 0.25, 0.285

The steps of the FAHP are given as follows. It also includes TFNs [11]:

Step 1: The value of fuzzy synthetic extent with respect to the i^{th} object is defined as:

$$S_i = \sum_{j=i}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} \quad (1)$$

To obtain $\sum_{j=i}^{m} M_{gi}^{j}$, and perform the fuzzy addition operation of m extent analysis values for a particular matrix such that:

$$\sum_{j=i}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j , \sum_{j=1}^{m} m_j , \sum_{j=1}^{m} u_j\right) \quad (2)$$

and to obtain $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$, and perform the fuzzy addition operation of $M_{gi}^{j}\,(j = 1, 2, \ldots\ldots, m)$ values such that

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j} = \sum_{i=1}^{n} l_i , \sum_{i=1}^{n} m_i , \sum_{i=1}^{n} u_i \quad (3)$$

and then compute the inverse of the vector above, such that:

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \quad (4)$$

Step 2: As $M_1^{\sim} = (l_1 m_1 u_1)$ and $M_2^{\sim} = (l_2 m_2 u_2)$are two TFNs, the degree of possibility of $M_2 = (l_2 m_2 u_2) \geq M_1 = (l_1 m_1 u_1)$defined as:

$$V(M_2^{\sim} \geq M_1^{\sim}) = sup_{y \geq x}\left[min\left(\mu_{M_1^{\sim}}(x), \mu_{M_2^{\sim}}(y)\right)\right] \quad (5)$$

and can be equivalently expressed as follows:

$$V(M_2^{\sim} \geq M_1^{\sim}) = hgt(M_1^{\sim} \cap M_2^{\sim}) = \mu_{M_2}(d) = \begin{cases} 1, if\, m_2 \geq m_1 \\ 0, if\, l_1 \geq u_2 \\ otherwise, \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} \end{cases} \quad (6)$$

Step 3: The degree possibility for a convex fuzzy number to be greater than k convex fuzzy $M_i(1, 2, k)$ numbers can be defined by

$$\begin{aligned} &V(M \geq M_1, M_2, \ldots\ldots M_k) = V[(M \geq M_1) \\ &\text{and } (M \geq M_2) \text{ and } \ldots\text{and } (M \geq M_k)] \\ &= \min V(M \geq M_i),\ i = 1, 2, 3, \ldots, k \end{aligned} \quad (7)$$

Assume that $d(A_i) = minV(S_i \geq S_k)$ for $k = 1, 2, \ldots\ldots, n;\ k \neq i$. Then the weight vector is given by

$$W' = \left(d'(A_1), d'(A_2), \ldots . d'(A_n)\right)^T \quad (8)$$

where $A_i = (i = 1, 2, \ldots, n)$ are n elements.

Step 4: By normalization, the normalized weight vectors are

$$W = \left(d(A_1), d(A_2), \ldots . d(A_n)\right)^T \quad (9)$$

where W is a non-fuzzy number.

Step 5: Check the consistency of matrices to ensure that the judgments of decision makers are consistent.

Step 6: Aggregate the relative weights of decision elements to obtain an overall rating for the alternatives.

TABLE II: TFN PAIR-WISE COMPARISON MATRIX OF CRITERIA

	Multilanguage	Cost	Evaluative Tools	Compatibility	Support	Sustainability	Reliability	Source Code	Management
Multilanguage	1, 1, 1	0.66, 1,1.5	0.66,1,1.5	0.66,1,1.5	0.66,1,1.5	0.66,1,1.5	0.40,0.50, 0.66	0.66,1,1.5	0.285,0.250, 0.285
Cost		1, 1, 1	0.285,0.250, 0.285	0.66,1,1.5	0.66,1,1.5	1,1,1	0.222,0.250, 0.285	1,1,1	0.285,0.250, 0.285
Evaluative Tools			1, 1, 1	0.66,1,1.5	0.66,1,1.5	0.66,1,1.5	0.285,0.250, 0.285	1.5,2,2.5	0.66,1,1.5
Compatibility				1, 1, 1	0.66,1,1.5	0.66,1,1.5	0.285,0.250, 0.285	0.66,1,1.5	0.40,0.50, 0.66
Support					1, 1, 1	1,1,1	0.285,0.250, 0.285	0.66,1,1.5	0.285,0.250, 0.285
Sustainability						1, 1, 1	0.285,0.250, 0.285	1,1,1	0.285,0.250, 0.285
Reliability							1, 1, 1	2.5,3,3.5	0.66,1,1.5

Source Code	1, 1, 1	0.285,0.250, 0.285
Management		1, 1, 1

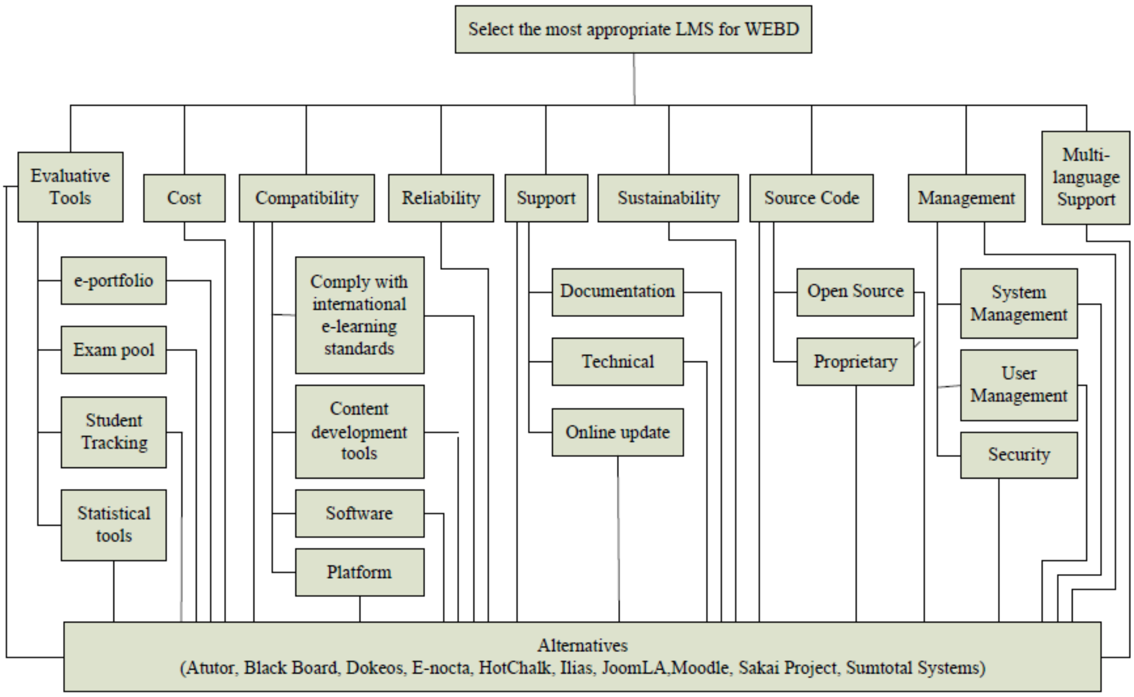

Fig. 1. Decision hierarchy model of the LMS [2].

IV. Results

While applying this comparison matrix, Consistency Ratio(CR) of the criteria is controlled. If the results are greater than 0.1, pair-wise comparisons are continue up to CR value is smaller than 0.1. In this study, three defuzzification methods are used to calculate CR values, as shown in Table III. We found all CR value smaller than 0.1 with three defuzzification methods. Thus, we can say that defined criteria are consistent.

TABLE III: CR Values of Defuzzification Methods

Defuzzification Method	Consistency Ratio(CR)
Centroid	0.095641
Weighted	0.085859
Bisector	0.076077

Weights of the criteria are shown in Table IV. Percentages of the criteria weights based on the TFN representative comparisons can be seen in Fig. 2. Most important criteria are respectively Evaluative Tools, Reliability and Sustainability.

TABLE IV: Weights of the Criteria

Criteria	*Weights*
Multilanguage	0.078191
Cost	0.079297
Evaluative Tools	0.182865
Compatibility	0.082892
Support	0.076385
Sustainability	0.134108
Reliability	0.149208
Source Code	0.112581
Management	0.104468

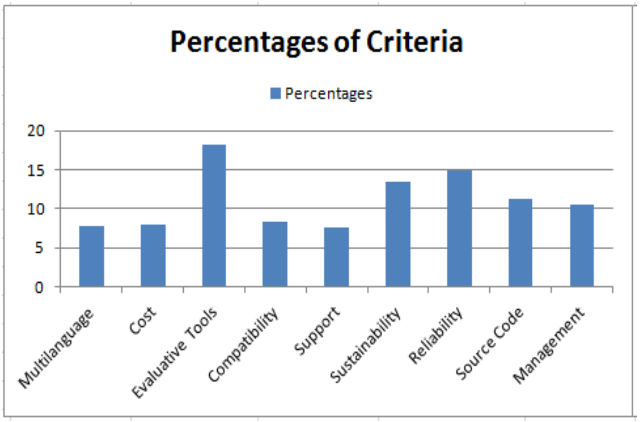

Fig. 2. Weight percentages of TFN scale based judgments of criteria.

TABLE V: Overall Score of the Alternative LMSs

LMS	Percentage of Score (%)
Joomla LMS	11.64015
SumTotal Systems	11.52187
Moodle	10.98746
Dokeos	10.94606
ILIAS	10.87451
Enocta	10.31658
Sakai Project	9.845055
Hotchalk	9.699771
Blackboard	7.307526
Atutor	6.860209

According to the defined criteria, the overall scores of the alternative LMSs are shown in Table V. Results show that Joomla LMS is the best learning management system regarding our priorities. If priorities and preferences are altered, results of this selection MCDM problem can also be changed. Therefore, saying that the Joomla is the best LMS among other LMSs might be misleading. It would be better to say that according to the given priorities Joomla is the best LMS for our study.

V. Conclusion

FAHP is a popular MCDM method. In our study, it is used for the selection of the most appropriate LMS according to our priorities and preferences. Using of FAHP in this type of selection problem, it provide reliable resultsdue to the fact that imprecise and uncertain preferences of the users can be expressed as fuzzy sets (TFNs). In addition, three different defuzzification methods are utilized for the calculation of the CR of pair-wise criteria comparisons. According to our priorities, Joomla LMS is the most appropriate LMS that meets our criteria. Developed software that use FAHP method has a modular infrastructure. Thus, it can be used for different types of MCDM problems.

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