

# Selection of the Multimedia Applications for Learning using FAHP and TOPSIS Methods

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*Abstract:* - The aim of the research is to develop a fuzzy decision making model for the selection of a suitable multimedia application for learning using subjective judgments of decision makers. The proposed approach is based on FAHP and TOPSIS methods. FAHP method is first used to determine the weight criteria for decision-making, and then with TOPSIS method order of multimedia applications is defined. Criteria are defined according to the Bloom's digital taxonomy. In this paper empirical study of the selection of multimedia applications for learning is shown and discussed.

*Key-Words:* - Multimedia applications, FAHP, TOPSIS, Bloom's digital taxonomy, learning, fuzzy logic

## 1 Introduction

According to the American psychologist Benjamin Samuel Bloom forms of learning can be divided into three categories: i) cognitive (knowledge), ii) affective (attitudes) and iii) psychomotor (skills) [1]. Within the cognitive category Bloom differs six different hierarchical levels of learning. These are, from the simplest level to the most complex cognitive domain level: i) knowledge, ii) comprehension, iii) application, iv) analysis, v) synthesis and vi) evaluation. Bloom's taxonomy is a useful tool that can help teachers in directing cognitive activities of students in all categories of thinking, especially those associated with higher mental operations.

Revised Bloom's taxonomy [2] was published after six year work of numerous team of experts among whom were Bloom's student Lorin Anderson and his associate David Krathwohl. Nouns that marked levels they replaced by verbs. Then they extended the synthesis to creation and changed the order of the two highest levels. And the most importantly, they expanded the cognitive domain of learning (knowledge) to include both affective (attitude) and psychomotor domain of learning (skills). Their intention was to adjust Bloom's taxonomy for the 21st century teachers and students.

Teacher and enthusiast Andrew Churches went one step further when he tried to accommodate taxonomy in the digital environment of 21st century, including additional learning opportunities which provide new Web 2.0 technologies [3]. Every level of Bloom's taxonomy he supplemented with new active verbs and he proposed approach to specific digital tools. This paper discusses the selection of most suitable multimedia application for learning based on Bloom's digital taxonomy. As we are talking about more than one criteria for multimedia application selection, most suitable approach is using multiple criteria decision making (MCDM) methods.

Analytic Hierarchy Process (AHP) method is one of the most famous and in recent years most used method for deciding, when the decision-making process or the choice of some of the available alternatives and their ranking is based on several attributes that have different importance and that are expressed using different scales. AHP method allows flexibility of the decision making process and helps decision makers to set priorities and make good decisions, taking into account both qualitative and quantitative aspects of the decisions [4].

Fuzzy Analytic Hierarchy Process (FAHP) is an extension of AHP method that uses fuzzy logic, fuzzy sets and fuzzy numbers. It facilitates

determining the ranking of certain criterias using fuzzy numbers instead of specific numerical values [5]. Understanding and managing with quantitative and qualitative data used in MCDM problems is much easier with FAHP method. In this approach triangular fuzzy numbers are used to determine the benefits of single criteria to another.

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method is used for the final ranking of multimedia applications on multiple criteria, whose importance is determined using a FAHP method. Best alternative multimedia application is the one that is closest to the positive ideal solution and the farthest from the negative ideal solution by this method [6].

FAHP and TOPSIS methods are used together in complex decision problems [7], [8]. Suitable multimedia applications for learning can be selected using both FAHP and TOPSIS methods.

## 2 Criterias of the multimedia applications for learning

Criterias of the multimedia applications for learning are relying on the Bloom's digital taxonomy [3]:

$C_1$  Remembering – Key terms: recognising, listing, describing, identifying, retrieving, naming, locating and finding. Digital additions: bullet pointing, highlighting, bookmarking or favouriting, social networking, social bookmarking and searching or „googling“.

$C_2$  Understanding – Key terms: interpreting, summarising, inferring, paraphrasing, classifying, comparing, explaining and exemplifying. Digital additions: advanced and Boolean searching, blog journalling, categorising, tagging, commenting, annotating and subscribing.

$C_3$  Applying – Key terms: carrying out, using, executing, implementing, showing and exhibiting. Digital additions: running and operating, playing, uploading, sharing, hacking and editing.

$C_4$  Analysing – Key terms: comparing, organising, deconstructing, attributing, outlining, finding, structuring and integrating. Digital additions: smashing, linking, reverse-engineering and cracking.

$C_5$  Evaluating – Key terms: checking, critiquing, hypothesising, experimenting, judging, testing, detecting and monitoring. Digital additions: Blog/vlog commenting and reflecting, posting,

moderating, collaborating and networking, testing and validating.

$C_6$  Creating – Key terms: designing, constructing, planning, producing, inventing, devising and making. Digital additions: programming, filming, animating, videocasting, podcasting, mixing, remixing, directing, producing and publishing.

Multimedia applications for learning are valued on the basis of the above mentioned criterias marked from  $C_1$  to  $C_6$ . Weight of each criteria is determined with MCDM methods. Finally applications are ranked on the basis of all six criterias. The applications are marked as APP1, APP2 and APP3.

## 3 Fuzzy sets and fuzzy numbers

Fuzzy logic is an extension of classical Boolean logic that is able to use the concept of partial truth. Standard Boolean logic supports only two values: 0 (false) and 1 (true), while fuzzy logic supports a range of values from a complete lie to the complete truth covering the whole range of values from 0 to 1 [9]. In classic set theory for each element is strictly determined if it belongs or does not belong to a particular set. Fuzzy set is an extension of the classic set. With fuzzy sets one element may partially belong to the set. Fuzzy number is a generalization of real numbers. It is specified with interval of real numbers between 0 and 1. It is possible to use different fuzzy numbers according to the situation, but in practice trapezoidal and triangular fuzzy numbers are most used [10]. Triangular fuzzy number is shown in figure 1.

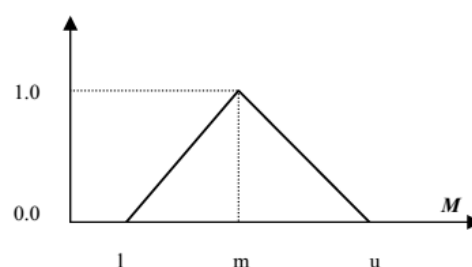


Fig. 1 A triangular fuzzy number

Triangular fuzzy number is defined by three real numbers, expressed as ordered triplet  $(l, m, u)$ . The parameters  $l$ ,  $m$  and  $u$  respectively show the lowest possible value, the most expected value and the maximum value that describes fuzzy event. If we define two positive triangular fuzzy number  $(l_1, m_1, u_1)$  and  $(l_2, m_2, u_2)$  then:

$$(l_1, m_1, u_1) + (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \quad (1)$$

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

$$(l_1, m_1, u_1)^{-1} \approx (1/u_1, 1/m_1, 1/l_1) \quad (3)$$

For  $x < l$  or for  $x > u$  membership function  $\mu(x/M)$  takes the value 0. For  $l \leq x \leq m$  membership function takes the value  $(x-l)/(m-l)$ , while for  $m \leq x \leq u$  function became  $(u-x)/(u-m)$ .

### 4 FAHP method

The AHP is based on the subdivision of the problem in a hierarchical form. The traditional AHP method is problematic in that it uses an exact value to express the decision-maker's opinion in a pair-wise comparison of alternatives. Chang [5] introduced a new approach for handling FAHP, with the use of triangular fuzzy numbers for pair-wise comparison scale of FAHP, and the use of the extent analysis method for the synthetic extent values of the pair-wise comparisons.

Let

$$X = \{x_1, x_2, \dots, x_n\} \quad (4)$$

be an object set, and

$$U = \{u_1, u_2, \dots, u_n\} \quad (5)$$

be a goal set.

According to the Chang's extent analysis method [5], each object is taken and extent analysis for each goal is performed respectively:

$$M_{gi}^1, M_{gi}^2, \dots, M_{gi}^m \quad i = 1, 2, \dots, n \quad (6)$$

where all the  $M_{gi}^j (j = 1, 2, \dots, m)$  are triangular fuzzy numbers. The value of fuzzy synthetic extent with respect to the  $i_{th}$  object is defined as:

$$S_i = \sum_{j=1}^m M_{gi}^j \otimes \left[ \sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1} \quad (7)$$

To obtain  $\sum_{j=1}^m M_{gi}^j$ , perform the fuzzy addition operation of  $m$  extent analysis values for a particular matrix such that the degree of possibility of  $M_1 > M_2$  is defined as:

$$V(M_1 \geq M_2) = \text{SUP}_{x \geq y} [\min(\mu M_1(x), \mu M_2(y))] \quad (8)$$

where  $V(M_1 \geq M_2)$  is 1 if  $m_1 \geq m_2$ , 0 if  $l_2 \geq u_1$  and  $\frac{l_2 - u_1}{(m_1 - u_1) - (m_2 - l_2)}$ , otherwise.

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

$$V(M \geq M_1, M_2, \dots, M_k) = \min V(M \geq M_i) \quad (9)$$

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

$$W' = (d'(A_1), d'(A_2), \dots, d'(A_n))^T \quad (10)$$

where  $A_i$  are  $n$  elements.

Via normalization, the normalized weight vectors are

$$W = (d(A_1), d(A_2), \dots, d(A_n))^T \quad (11)$$

where  $W$  is a non-fuzzy number.

FAHP method is used to determine the weight criteria for decision-making. In the FAHP procedure, the pair-wise comparisons in the judgement matrix are fuzzy numbers.

### 5 TOPSIS method

TOPSIS method was firstly proposed by Hwang and Yoon [6]. According to this technique, the best alternative would be the one that is nearest to the ideal positive solution and farthest from the ideal negative solution. The method is calculated as follows [11]. Decision matrix is normalized:

$$r_{ij} = \frac{w_{ij}}{\sqrt{\sum_{j=1}^J w_{ij}^2}} \quad (12)$$

where  $j = 1, 2, \dots, J; i = 1, 2, \dots, n$ .

Weighted normalized decision matrix is formed:

$$v_{ij} = w_{ij} * r_{ij}, j = 1, 2, \dots, J, i = 1, 2, \dots, n \quad (13)$$

Positive ideal solution (PIS) and negative ideal solution (NIS) are calculated:

$$A^* = \{v_1^*, v_2^*, \dots, v_n^*\} \quad (14)$$

$$A^- = \{v_1^-, v_2^-, \dots, v_n^-\} \quad (15)$$

The distance of each alternative from PIS and NIS are calculated:

$$d_i^* = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^*)^2}, j = 1, 2, \dots, J \quad (16)$$

$$d_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^-)^2}, j = 1, 2, \dots, J \quad (17)$$

The closeness coefficient of each alternative is calculated:

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-}, i = 1, 2, \dots, J \quad (18)$$

By comparing  $CC_i$  values, the ranking of alternatives is determined.

### 6 Empirical study

A numerical example is illustrated and trial data is used for selecting best multimedia application. In our study we are ranking three applications by FAHP and TOPSIS methods. In step 1 with the help of improved AHP by fuzzy set theory, the procedure is as follows: first we should make the hierarchy structure. Proposed tree shows in Tables 1 and 2.

Table 1. Evaluation matrix

	$C_1$	$C_2$	$C_3$	$C_4$	$C_5$	$C_6$
$C_1$	1	2	1	1	2	1
$C_2$	0.5	1	0.5	0.75	0.75	0.5
$C_3$	1	2	1	2	2	1
$C_4$	1	1.33	0.5	1	0.5	0.5
$C_5$	0.5	1.33	0.5	2	1	2
$C_6$	1	2	1	2	0.5	1

Table 2. Fuzzy Evaluation matrix

	$C_1$	$C_2$	$C_3$	$C_4$	$C_5$	$C_6$
$C_1$	(1, 1, 1)	(1, 2, 3)	(0.75, 1, 1.25)	(0.75, 1, 1.25)	(1, 2, 3)	(0.75, 1, 1.25)
$C_2$	(0.33, 0.5, 1)	(1, 1, 1)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.75, 1, 1.25)	(0.33, 0.5, 1)
$C_3$	(0.8, 1, 1.33)	(1.33, 2, 4)	(1, 1, 1)	(1, 2, 3)	(1, 2, 3)	(0.75, 1, 1.25)
$C_4$	(0.8, 1, 1.33)	(1, 1.33, 2)	(0.33, 0.5, 1)	(1, 1, 1)	(0.33, 0.5, 1)	(0.25, 0.5, 0.75)

$C_5$	(0.33, 0.5, 1)	(0.8, 1, 1.33)	(0.33, 0.5, 1)	(1, 2, 3)	(1, 1, 1)	(1, 2, 3)
$C_6$	(0.8, 1, 1.33)	(1, 2, 3)	(0.8, 1, 1.33)	(1.33, 2, 4)	(0.33, 0.5, 1)	(1, 1, 1)

In step 2 below results are obtained and have been brought in Tables 3, 4 and 5.

Table 3. The sums of horizontal and vertical directions

Criteria	Row Sums	Column Sums
$C_1$	(5.25, 8, 10.75)	(4.06, 5, 6.99)
$C_2$	(3.16, 4.25, 6)	(6.13, 9.33, 14.33)
$C_3$	(5.88, 9, 13.58)	(3.46, 4.5, 6.33)
$C_4$	(3.71, 4.83, 7.08)	(5.58, 8.75, 13.25)
$C_5$	(4.46, 7, 10.33)	(4.41, 7, 10.25)
$C_6$	(5.26, 7.5, 11.66)	(4.08, 6, 8.25)
Sum of row or column sums	(27.72, 40.58, 59.4)	

The example of calculating fuzzy synthetic extent value  $SC_1$  for the criteria  $C_1$  is shown below. For other criteria, their fuzzy synthetic extent values are shown in Table 4.

$$SC_1 = (5.25, 8, 10.75) \otimes (27.72, 40.58, 59.4)^{-1} = (0.8838, 0.1971, 0.3878)$$

Table 4. The fuzzy synthetic extent of each criteria

Criteria	$SC_i$
$C_1$	(0.8838, 0.1971, 0.3878)
$C_2$	(0.0531, 0.1047, 0.2164)
$C_3$	(0.0989, 0.2217, 0.4898)
$C_4$	(0.0624, 0.1190, 0.2554)
$C_5$	(0.0750, 0.1724, 0.3726)
$C_6$	(0.0885, 0.1848, 0.4206)

The fuzzy values are compared by using Eq. (8) and priority weights are calculated by using Eq. (10).

$$W' = (0.9238, 0.5008, 1, 0.6035, 0.8473, 0.8969)$$

After the normalization of these values priority weights respect to main goal are calculated using Eq. (11) as:

$$W = (0.1935, 0.1049, 0.2095, 0.1264, 0.1775, 0.1879)$$

Weighted normalization matrix is formed by multiplying each value with their weights.

Table 5. Weighted normalization matrix

	$C_1$	$C_2$	$C_3$	$C_4$	$C_5$	$C_6$
APP1	0.057	0.076	0.118	0.061	0.113	0.062
APP2	0.144	0.050	0.088	0.061	0.113	0.125
APP3	0.115	0.050	0.148	0.092	0.075	0.125

In step 3 positive and negative ideal solutions are determined by talking the maximum and minimum values for each criteria using Eq (14) and Eq. (15):

$$A^* = (0.144, 0.076, 0.148, 0.092, 0.113, 0.125)$$

$$A^- = (0.057, 0.050, 0.088, 0.061, 0.075, 0.062)$$

Then the distance of each alternative from PIS and NIS with to respect to each criteria is calculated with the help of Eq. (16) and Eq. (17). Then closeness coefficient of each multimedia application is calculated by using Eq. (18).

Table 6. Ranking of the multimedia applications

	$d_i^*$	$d_i^-$	$CC_i$	Rank
APP1	0.115	0.0543	0.321	3
APP2	0.071	0.113	0.613	2
APP3	0.053	0.108	0.667	1

Considering the Table 6, preferred multimedia application for learning is APP3 for decision maker's preference. Different rankings can be obtained by using different decision maker's preference values.

## 4 Conclusion

In this paper FAHP and TOPSIS are integrated for selection of the best multimedia application for learning and teaching. FAHP method is used for determining the weights of criteria and priority values of multimedia applications. Then the TOPSIS method is used for determining the ranking of multimedia applications. The integration of FAHP and TOPSIS approaches enables teacher to

efficiently select a more suitable multimedia applications for learning.

In future studies other multi-criteria methods like fuzzy PROMETHEE and ELECTRE can be used to improve process of selecting multimedia applications for learning.

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