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Toward the MOOC Capitalization Using Fuzzy Analytical Hierarchy Process

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ABSTRACT

The Massive Open Online Courses (MOOC) concept has apprehended the interest of all actors in higher education. MOOC platforms are considered as a crucial source of information for both learners and professors by offering hundreds of courses around the world. However, this technology has faced many challenges, particularly their low completion rates. The present paper proposes the architecture of a framework using Fuzzy Analytic Hierarchy Process algorithm (Fuzzy-AHP) to determine the triangular weight of the courses from the most widespread MOOCS in the literature. Weights of the courses are calculated by fuzzy numbers in line with the learning profile. The outcome of the proposed framework is to improve teaching effectiveness, facilitate learning among learners, encourage long life learning and maximize motivation as well as reducing the dropout rates.

KEYWORDS

MOOC, reusability, Fuzzy AHP, dropout rate.

1 INTRODUCTION

One of the challenges faced by institutions of higher education is the increasing number of university students and the low rate of supervision. Thereby, many universities have embraced technological aspects of MOOCs [1].

However, to produce quality and pertinent MOOCs, diverse backgrounds are involved such content developers, domain experts, instructional designers, pedagogues, graphic designers and programmers, etc. MOOCs are expensive to produce as is a team effort, involving considerable amount of time investment of several actors. If some large universities can afford them, it is not the case for smaller ones [2].

Subsequently, after many meeting we have decided to reuse and capitalize the remaining MOOC in the literature in accordance with their privacy policy and our requirements. In parallel, we will develop courses that meet the competencies of our team.

We are interested in this paper to the issue of the reusability of the most prominent MOOC in the literature to build the appropriate pedagogical path suiting the learner needs, capacities, preferences, etc.

The remainder of this paper is structured as follow. We will firstly begin by presenting the AHP Method and the fuzzy AHP. We discuss next, the MOOC capitalization concept as a solution to benefit. Afterwards, we explore and present the architecture of the proposed system that implements Fuzzy AHP. Finally, we discuss the ability of this work to achieve the worth reusability of the existing MOOC.

2 BACKGROUND

2.1 The AHP Method

Analytic hierarchy process (AHP) is a Complex Decision Analysis Theory proposed by Thomas Saaty, a consultant for the US government and a professor at the Wharton School of Business in 1980, and it was subsequently extended by Graan and Lootsma 1981, which allows the most credible decisions to be made by taking several factors into account. The AHP structures the criteria hierarchically, then compares them in peers, in order to design, prioritize, justify, and choose the right solution for the most complex situations.

The first step is to designate the general objective on which we will base our decision, then the possible solutions or alternatives, and the criteria to be taken into consideration [3] [4].

In some cases, (complex decisions) we can have several levels of criteria (Criteria, sub-criteria ...) the figure below presents the hierarchical architecture of the AHP method [5].

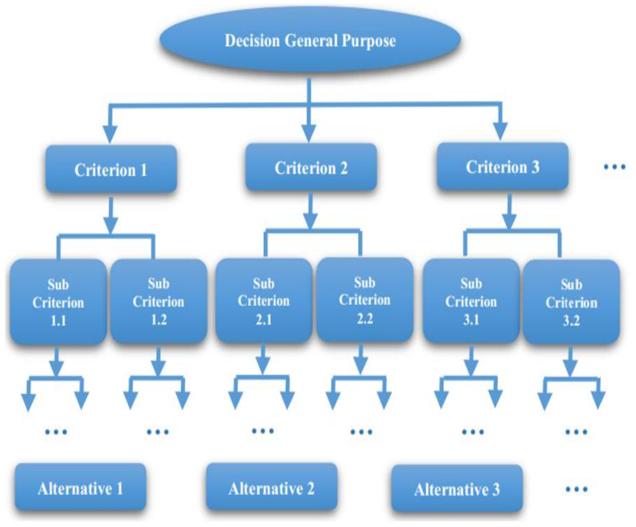

Fig 1. Hierarchical architecture of the AHP method [6]

The next step is to evaluate the set of criteria for each hierarchical level in relation to that of the higher hierarchical level, according to a value scale proposed by Saaty [7]:

Table 1. Value scale proposed by Saaty

Degrees of importance	Definition	Description
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment strongly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Very strong importance	An activity is strongly favored and its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed
Reciprocals	If activity i has one of the above numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	
Rationals	Ratios arising from the scale	If consistency were to be forced by obtaining n numerical values to span the matrix

This allows us to build comparative matrices; its general form is as follows:

$$M = \begin{pmatrix} C_{11} & C_{12} & C_{13} & \cdots & C_{1n} \\ C_{21} & C_{22} & C_{23} & \cdots & C_{2n} \\ C_{31} & C_{32} & C_{33} & \cdots & C_{3n} \\ \vdots & \vdots & \vdots & & \vdots \\ C_{n1} & C_{n2} & C_{n3} & \cdots & C_{nn} \end{pmatrix} \quad (1.1)$$

With

$$\left| \begin{array}{c} C_{ij} \textit{ is the value obtained from comparing the criteria } i \textit{ and } j \\ C_{ii} = 1 \\ C_{ji} = \frac{1}{C_{ij}} \end{array} \right|$$

Then, to obtain the weight of each criterion (The higher the weight value is, the greater is the criterion),
It is necessary to first construct the normalized matrix, for this, it is necessary to calculate the sum of each column: $\sum_{i=1}^{n} C_{ij}$ Then each of the values of the column is divided by this sum: $\frac{C_{ij}}{\sum_{i=1}^{n} C_{ij}}$.The normalized matrix is thus obtained in the following form:

$$M_n = \begin{pmatrix} N_{11} & N_{12} & N_{13} & \cdots & N_{1n} \\ N_{21} & N_{22} & N_{23} & \cdots & N_{2n} \\ N_{31} & N_{32} & N_{33} & \cdots & N_{3n} \\ \vdots & \vdots & \vdots & & \vdots \\ N_{n1} & N_{n2} & N_{n3} & \cdots & N_{nn} \end{pmatrix} \quad (1.2)$$

With $\left| N_{ij} = \frac{C_{ij}}{\sum_{i=1}^{n} C_{ij}} \right|$

The weight of each criterion i is calculated by calculating the mean of the corresponding line:

$$Pi = \frac{\sum_{j=1}^{n} N_{ij}}{n} \quad (1.3)$$

With $\left|\sum_{i=1}^{n} P_i = 1\right|$ $|n \textit{ is the number of the compared criteria}|$

These steps are repeated for each hierarchical level.
Finally, it is necessary to check the consistency and the reliability of the result. The inconsistency in our results may be due to the fact that a criterion is poorly jugged compared to one or more other criteria. The consistency ratio (RC) will allow us to detect any anomaly in our calculations.

First of all, it is necessary to calculate the index of consistency CI (Consistency Index) [8]:

$$CI = \frac{\lambda_{max} - n}{n-1} \quad \& \quad b_i = \frac{\sum_{j=1}^{n} P_i * N_{ij}}{P_i} \tag{1.4}$$

With $\begin{vmatrix} n \text{ is the size of the matrix} \\ \lambda_{max} : \text{Maximum eigenvalue.} \end{vmatrix}$

Then the Consistency Ratio is calculated as follows:

$$RC = \frac{CI}{IA} \tag{1.5}$$

IA is the random index obtained from the following table[1]:

Table 2. Value of the random index

Size of the matrix	3	4	5	6	7	8	9	10
IA	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49

The RC value must be less than or equal to 10% [7] [9], Otherwise comparisons must be repeated in pairs to reduce inconsistencies.
We notice that The consistency ratio cannot be calculated for a size 2 matrix, which in this case the inconsistency does not exist.
The AHP is easy to implement, it is widely used within companies, and taught in many universities. This method allows to divide the most complex decision problems into hierarchical levels (the criteria of each level are interdependent), with a scale of values that expresses the preferences of the decision-makers, it also allows to rally the qualitative and quantitative criteria [10] where each criterion contributes to the final decision [11]. However, this method has had some criticism mainly on the fact that, the association of a numerical scale with another semantic is restrictive, so it introduces inaccurate numerical values [12]. To cure these criticisms, the method has undergone several extensions, the case of taking into account the uncertainty (stochastic AHP), and the blur (fuzzy AHP) in the expression of judgments [12].

[1] Saaty has defined values for comparison matrices of different sizes [7].

2.2 The AHP Method and the Fuzzy Logic:

The fuzzy extension of the AHP method (Fuzzy AHP) was born thanks to the work of Van Laarhoven and W. Pedrycz in 1983. Both researchers rely on the fact that the ratios displayed in a Matrix, from which the appropriate weights can be extracted, are generally fuzzy. These ratios express a decision maker's preferences about the importance of a pair of factors. Therefore, the FAHP (Fuzzy AHP) method invites decision-makers to express their opinions via fuzzy values with triangular membership functions [13].
For example, when the two criteria C1 and C2 are compared and the first one is much larger than the other, according to the AHP method, the value associated with this judgment is 5. According to The FAHP method, a triangular fuzzy number (TFN) is associated with each verbal judgment $\tilde{x} = (l; m; u)$, from the example given we obtain the TFN : $\tilde{x}$ 12 = (4,5,6). There are several scales that associate triangular fuzzy numbers with numerical values and verbal judgments. Below are the most used scales:

Table 3. First example of the triangular fuzzy numbers of the AHP method [14] [15]

Numeric value	Verbal judgment	TFN	Reciprocal TFN
1	Equal importance of the two criteria	(1,1,1)	(1,1,1)
2	Intermediate value	(1/2, 3/4, 1)	(1, 4/3, 2)
3	One criterion is a little more important than the other	(2/3, 1, 3/2)	(2/3, 1, 3/2)

4	Intermediate value	(1, 3/2, 2)	(1, 3/2, 2)
5	One criterion is much more important than the other	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)
6	Intermediate value	(2, 5/2, 3)	(1/3, 2/5, 1/2)
7	One criterion is very much more important than the other	(5/2, 3, 7/2)	(2/7, 1/3, 2/5)
8	Intermediate value	(3, 7/2, 4)	(1/4, 2/7, 1/3)
9	One criterion is extremely more important than the other	(7/2, 4, 9/2)	(2/9, 1/4, 2/7)

Table 4. Second example of the triangular fuzzy numbers of the AHP method [16]

Numeric value	**Verbal judgment**	**TFN**	**Reciprocal TFN**
1	Equal importance of the two criteria	(1,1,1)	(1,1,1)
2	Intermediate value	(1, 2, 3)	(1/3, 1/2, 1)
3	One criterion is a little more important than the other	(2, 3, 4)	(1/4, 1/3, 1/2)
4	Intermediate value	(3, 4, 5)	(1/5, 1/4, 1/3)
5	One criterion is much more important than the other	(4, 5, 6)	(1/6, 1/5, 1/4)
6	Intermediate value	(5, 6, 7)	(1/7, 1/6, 1/5)
7	One criterion is very much more important than the other	(6, 7, 8)	(1/8, 1/7, 1/6)
8	Intermediate value	(7, 8, 9)	(1/9, 1/8, 1/7)
9	One criterion is extremely more important than the other	(8, 9, 10)	(1/10, 1/9, 1/8)

Table 5. Third example of the triangular fuzzy numbers of the AHP method [16]

Numeric value	**Verbal judgment**	**TFN**	**Reciprocal TFN**
1	Equal importance of the two criteria	(1,1,1)	(1,1,1)
2	Intermediate value	(1, 2, 4)	(1/4, 1/2, 1)
3	One criterion is a little more important than the other	(1, 3, 5)	(1/5, 1/3, 1)
4	Intermediate value	(2, 4, 6)	(1/6, 1/4, 1/2)
5	One criterion is much more important than the other	(3, 5, 7)	(1/7, 1/5, 1/3)
6	Intermediate value	(4, 6, 8)	(1/8, 1/6, 1/4)
7	One criterion is very much more important than the other	(5, 7, 9)	(1/9, 1/7, 1/5)
8	Intermediate value	(6, 8, 9)	(1/9, 1/8, 1/9)
9	One criterion is extremely more important than the other	(7, 9, 9)	(1/9, 1/9, 1/7)

The same as the AHP, the first step of the FAHP method is to construct the fuzzy judgment matrix:

$$\tilde{A}=\begin{pmatrix} (1,1,1) & l_{12},m_{12},u_{12} & l_{12},m_{12},u_{12} & \cdots & l_{1n},m_{1n},u_{1n} \\ l_{21},m_{21},u_{21} & (1,1,1) & l_{22},m_{22},u_{22} & \cdots & l_{2n},m_{2n},u_{2n} \\ l_{21},m_{21},u_{21} & l_{22},m_{22},u_{22} & (1,1,1) & \cdots & l_{2n},m_{2n},u_{2n} \\ \vdots & \vdots & \vdots & (1,1,1) & \vdots \\ l_{n1},m_{n1},u_{n1} & l_{n2},m_{n2},u_{n2} & l_{n2},m_{n2},u_{n2} & \cdots & (1,1,1) \end{pmatrix} \quad (2.1)$$

With $\left| \begin{matrix} \tilde{a}_{ij} \textit{ is a triangular fuzzy number} \\ \tilde{a}_{ji} = [\tilde{a}_{ij}]^{-1} = (\frac{1}{u_{ij}}, \frac{1}{m_{ij}}, \frac{1}{l_{ij}}) \end{matrix} \right|$

Then, we must determine the fuzzy synthetic extent for each criterion [17]:

$$\tilde{S}_i=\sum_{j=1}^{n} \tilde{a}_{ij} \odot \left[\sum_{k=1}^{n} \sum_{j=1}^{n} \tilde{a}_{kj}\right]^{-1} \text{ with} |i, j, k = 1, \ldots, n| \quad (2.2)$$

Then we must calculate the degree of possibility V that a fuzzy number $\tilde{S}_i$ is superior to another $\tilde{S}_j$ [18].

$$V(\tilde{S}_i \geq \tilde{S}_j) = \begin{Bmatrix} 1 & \text{If } m_i \geq m_j \\ 0 & \text{If } l_j \geq u_i \\ \frac{l_j - u_i}{(m_i - u_i) - (m_j - l_j)} & \text{If Not} \end{Bmatrix} \quad (2.3)$$

With $|i, j = 1, \ldots, n \text{ et } j \neq i|$

And the degree of possibility for each $\tilde{S}_i$ compared to n fuzzy numbers as follows [18]:

$$V(\tilde{S}_i \geq \tilde{S}_j \mid j = 1, \ldots, n; j \neq i) = \min_{j \in \{1,\ldots,n\}, j} V(\tilde{S}_i \geq \tilde{S}_j) \quad (2.4)$$

This last makes it possible to know the importance of the criterion i compared to a set of criteria [12].
Finally, the priority vector W = (w1,…, wn) must be defined for the fuzzy judgment matrix [19]:

$$W_i = \frac{V(\tilde{S}_i \geq \tilde{S}_j \mid j=1,\ldots,n; j\neq i)}{\sum_{k=1}^{n} V(\tilde{S}_k \geq \tilde{S}_j \mid j=1,\ldots,n; j\neq k)} \qquad (2.5)$$

With $|i = 1, \ldots, n|$

3 SYSTEM ARCHITECTURE:

In this section we illustrate some functionalities of our system which implements the FAHP presented above. The architectural design of the proposed system is composed by three main components:

- **Information collector:** On one hand, from the user's personal information, extracted during his first inscription at the platform (User Profile Information). Each information is qualified either as a Domain Dependent Data, for instance the information related to the Academics Background, Background Knowledge, and Qualifications. Or as a Domain Independent Data, as for the information related to Motivation, Interests, and skills.
  On the other hand, from the learning preferences, (user preferences) that the user will bring when he will need to search for a course, chapter...

- **Automatic update of data base:** using the research algorithms that we will develop, our database will automatically be feed with new online courses tailored by universities, schools, and platforms that interest us.

- **Weight calculator:** The selection of the research criteria of the learning materials by the user, will allow us to calculate the weight of each of its criteria via the Fuzzy AHP method, and to classify the courses, route, chapter, ... by priority order.

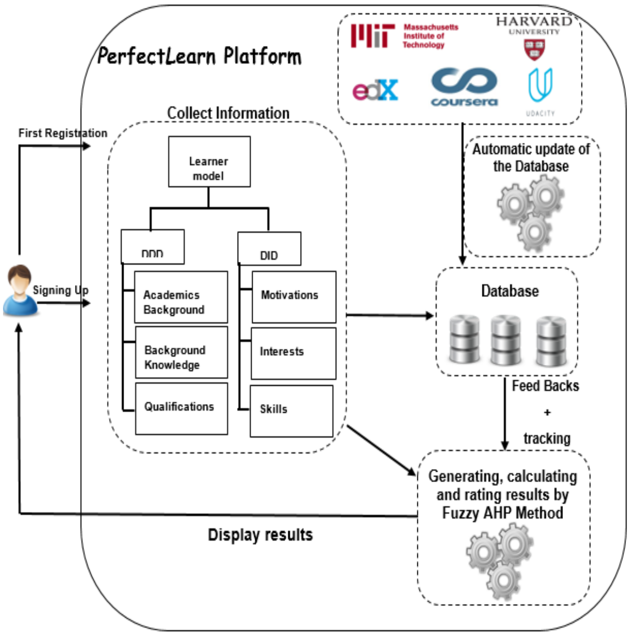

Fig 2. Process of managing a request sent by a user

During his first visit to the platform, the user is required to fill in a registration form. , and then he is automatically redirected to the platform, where he can select his searching preferences according to a set of criteria: language (L), Course Type (N), Simple courses, Chapter, course; With or without certification (C); Duration (D); Free or paid (G / P).
So based on this information, we will extract all the data that responds to the criteria, and rank them in order of priority using the Fuzzy AHP method. After completing his course, chapter ..., the user is asked to answer some few questions (satisfied or not, suggestions to improve the platform ...).

4 THE FUZZY AHP APPLIED TO OUR CASE:

The first step is to determine the linguistic values that we will attribute to our criteria, as well as the corresponding triangular fuzzy numbers:

Table 6. Verbal judgments and corresponding triangular fuzzy values

Verbal judgment	li	mi	ui
Extremely important (EI)	7/2	4	9/2

more important (MI)	5/2	3	7/2
very important (FI)	3/2	2	5/2
A little important (LI)	2/3	1	3/2
Equal importance (IE)	1	1	1

Then, in order to construct our fuzzy judgment matrix, we will first of all compare our criteria based on the table above:

Table 7. Criterias peer comparison

	L	**N**	**C**	**D**	**G/P**
L	1	TI	TI	EI	PI
N	1/TI	1	PI	EI	1/TI
C	1/TI	1/PI	1	EI	TI
D	1/EI	1/EI	1/EI	1	1/TI
G/P	1/PI	TI	1/TI	TI	1

Now we shall obtain our fuzzy judgment matrix as follows:

$$\tilde{A} = \begin{pmatrix} (1,1,1) & (2.5,3,3.5) & (2.5,3,3.5) & (3.5,4,4.5) & (0.6,1,1.5) \\ (0.28,0.33,0.4) & (1,1,1) & (0.6,1,1.5) & (3.5,4,4.5) & (0.28,0.33,0.4) \\ (0.28,0.33,0.4) & (0.6,1,1.5) & (1,1,1) & (3.5,4,4.5) & (2.5,3,3.5) \\ (0.22,0.25,3.5) & (0.22,0.25,3.5) & (0.22,0.25,3.5) & (1,1,1) & (0.28,0.33,0.4) \\ (0.6,1,1.5) & (2.5,3,3.5) & (0.28,0.33,0.4) & (2.5,3,3.5) & (1,1,1) \end{pmatrix}$$

Using (2.2) we obtain the fuzzy synthetic extent for each criterion:

$$\tilde{S}_L = (10.1,12,14) \odot \left(\frac{1}{54.5},\frac{1}{38.4},\frac{1}{32.48}\right) = (0.18,0.31,0.43)$$

$$\tilde{S}_N = (5.66,6.66,7.8) \odot \left(\frac{1}{54.5},\frac{1}{38.4},\frac{1}{32.48}\right) = (0.10,0.17,0.24)$$

$$\tilde{S}_C = (7.88,9.33,10.9) \odot \left(\frac{1}{54.5},\frac{1}{38.4},\frac{1}{32.48}\right) = (0.14,0.24, 0.33)$$

$$\tilde{S}_D = (1.94,2.08,11.9) \odot \left(\frac{1}{54.5},\frac{1}{38.4},\frac{1}{32.48}\right) = (0.03, 0.05,0.36)$$

$$\tilde{S}_{G/P} = (6.88,8.33,9.9) \odot \left(\frac{1}{54.5},\frac{1}{38.4},\frac{1}{32.48}\right) = (0.12, 0.21, 0,30)$$

Then using (2.3) and (2.4) we obtain the degree of possibility for each $\tilde{S}_i$ as follows:

$V(\tilde{S}_L \geq \tilde{S}_N, \tilde{S}_C, \tilde{S}_D, \tilde{S}_{G/P})$ = Min(1, 1, 1, 1) = 1

$V(\tilde{S}_N \geq \tilde{S}_L, \tilde{S}_C, \tilde{S}_D, \tilde{S}_{G/P})$ = Min(0.30, 0.58, 1, 0.75) = 0.3

$V(\tilde{S}_C \geq \tilde{S}_L, \tilde{S}_N, \tilde{S}_D, \tilde{S}_{G/P})$ = Min(0.68, 1, 1, 1) = 0.68

$V(\tilde{S}_D \geq \tilde{S}_L, \tilde{S}_N, \tilde{S}_C, \tilde{S}_{G/P})$ = Min(0.40, 0.68, 0.53, 0.60) = 0.40

$V(\tilde{S}_{G/P} \geq \tilde{S}_L, \tilde{S}_N, \tilde{S}_C, \tilde{S}_D)$ = Min(0.54, 1, 0.84, 1) = 0.54

Finally, we obtain the weight vectors W = (1, 0.3, 0.68, 0.40, 0.54) via (2.5). It will allow us to classify the criteria, also the courses offered to the learners in order of priority.

5 CONCLUSION AND FUTURE WORK:

Our approach is to use the fuzzy AHP method to provide learners with courses that goes with their requirements to the maximum. This method will enable us to classify the courses requested by our learners in priority order, according to the criteria and preferences of this latter. There is no point in offering a course for a learner who needs only one chapter. This will allow us to compensate in some way some issues related to the drop-out rate.
As a first step, we intend to add other criteria in the selection of courses. Therefore, we seek to examine the possibility of giving learners the possibility of choosing the weight of each criterion compared to each other in order to better meet the needs of the learners.

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