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Research paper

Uncovering the Satisfying MOOC Gamification Elements via fuzzy Analytic Hierarchy Process

Nie Hui Ling [1], Chwen Jen Chen[2]*, Chee Siong Teh[3]

[1]*Faculty of Cognitive Sciences and Human Development, Universiti Malaysia Sarawak, Sarawak, Malaysia*
**Corresponding author E-mail: cjchen@unimas.my*

Abstract

The constantly high drop-out rate in MOOCs remains as a concern of many MOOC providers. Gamification elements in MOOCs are seen to be able to alleviate this problem. As satisfaction is crucial to sustain learners' engagement in MOOCs, this study aims to uncover the satisfying gamification elements for MOOC via Fuzzy Analytical Hierarchy Process (FAHP) approach. The study reveals learner-learner interaction as a significant criterion to provide a sense of satisfaction among MOOC learners and the most satisfying gamification elements are leaderboard, badge and opponent and thus, should be considered to be incorporated into MOOCs.

Keywords: *MOOC; Satisfaction; Gamification; Fuzzy Analytic Hierarchy Process.*

1. Introduction

Today, Massive Open Online Course (MOOC) is seen as a technology that is dramatically changing the landscape of education. The advent of MOOCs affords huge and mostly free access to educational contents by millions of people without geographical and time zone constraints [1]. Massive Open Online Courses (MOOCs) is gaining significant acceptance among students and educators. Yet, many recent studies claimed that this MOOC fever seems to be cooling, and it has been reflected from the constantly high drop-out rate in MOOCs in recent years [2], [3].

In the context of learning, motivation acts as an important criterion to facilitate the learning processes, to accomplish learning goals, and to keep moving towards self-directed learning [4]. Various studies suggested that the implementation of gamification elements into MOOC is a potential solution to address the high drop-out rate in MOOC [5], [6], [7]. According to the renown ARCS motivational model proposed by [8], satisfaction is an important dimension of motivation. Willems et al. [9] asserted that the challenges for developing a gamified online learning environment is to select the appropriate elements in beneficial way since the wrong selection can potentially harm the learning experience or even demotivate learners. Since there is no one-size-fits-all solution, the selection of appropriate and satisfying gamification elements should be taken into consideration. Hence, it would be insightful to uncover the satisfying gamification elements for MOOCs. This study aims to uncover the satisfying gamification elements for MOOC via Fuzzy Analytical Hierarchy Process (FAHP) approach.

2. Fuzzy Analytical Hierarchy Process (FAHP)

Multiple-criteria Decision-making (MCDM) is a process of identifying or choosing alternatives described in terms of goal-related evaluative criteria and sub-criteria. This process can be done by ranking the evaluated criteria and sub-criteria [10]. Fuzzy Analytic Hierarchy Process (FAHP) emerges as the solution to solve the MCDM problem which is a hybrid technique of fuzzy logic and analytic hierarchy process. Fuzzy analytic hierarchy process decomposes a complex MCDM problem into hierarchy structure that consists of decision elements such as goal, criteria, sub-criteria, and alternatives of the MCDM problem, computes the local and global weights of the criteria and sub-criteria, and adopts human fuzziness to deal with uncertainty in human judgment [10].

FAHP methodology basically consists of three main stages: data gathering, FAHP measurement, and decision making [10], [11]. Fig. 1 shows the stages of FAHP.

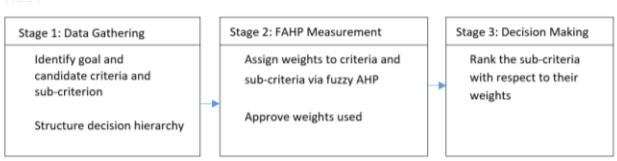

Fig. 1: FAHP Methodology

In the first stage of FAHP methodology, the goal of the study is identified and decomposed into its related criteria and sub-criteria. Subsequently, the decision elements are organized in a hierarchical manner in which the goal is often arranged at the first level, followed by criteria at the second level, and lastly the sub-criteria at the subsequent level(s) of the AHP hierarchy tree [12].

The second stage is FAHP measurement. This stage starts with the collection of pair-wise comparison data using a pair-wise comparison questionnaire. The pair-wise questionnaire is the most common tool to obtain pair-wise comparison data as its use has been demonstrated in many related studies [11], [13]. In the pair-wise questionnaire, the decision criteria and sub-criteria are organized in pair-wise manner for comparison purpose. Additionally, each criterion in the questionnaire is assessed on a 17-point ratio scale [11], [14]. Subsequently, the FAHP approach computes the weights for the criteria and sub-criteria based on the following six sub-steps [11], [15], [16].

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Sub-step one is to construct the fuzzy comparison matrix. The TFNs from $\tilde{1}$ to $\tilde{9}$ were used to construct the fuzzy comparison matrix in which the matrix is to represent the preference of each participant's assessments of the pair-wise comparisons between two gamification criteria or sub-criteria. To illustrate this process, let consider a problem at one level with n criteria i to j is represented by TFNs $\tilde{M}$ ij = (Lij, Mij, Rij) where

Lij : The left value of the fuzzy membership function of the collected participant assessment of design mechanic j of decision criteria i

Mij: The middle value of the fuzzy membership function of the collected participant assessment of design mechanic j of decision criteria i

Rij: The right value of the fuzzy membership function of the collected participant assessment of design mechanic j of decision criteria i

For instance, if one participant decided that factor i is strongly more satisfying than the factor j, then the TFNs between i and j is $\tilde{M}$ ij = (4, 5, 6). Alternatively, if the participant decided that factor j is strongly more satisfying than factor i, then the TFNs between i and j is $\tilde{M}$ ij = (1/6,1/5,1/4). Finally, the fuzzy comparison matrix is then computed based on the TFNs.

Sub-step two is to integrate the collected subjects' assessment of each decision element. Since each individual produces his or her own fuzzy comparison matrix to represent the opinion from one decision maker, the aggregation of the collected subjects' assessment of each decision element is necessary to achieve a group consensus of all the participants. In a conventional FAHP approach, there are two basic approaches to aggregate the individual preferences into a group preference which are namely aggregation of individual judgments and aggregation of individual priorities. Both of the approaches can be used in FAHP approach. This study employed the aggregation of individual judgments approach.

In contrast to some studies that apply statistical parameters namely minimum, maximum, mean and mode to represent the fuzzy numbers, this study used the geometric mean method that was proposed by Buckley [17]. The computation is stated as follows:

$$\tilde{m}\,ij = \left(\frac{1}{n}\right) \otimes (\tilde{m}^{1}ij \oplus \tilde{m}^{2}ij \oplus \ldots \oplus \tilde{m}^{n}ij)$$

where

$\tilde{m}$ij : Integrated triangular fuzzy numbers

$\tilde{m}^{n}$ij : The value of the pair comparison of the collected participant assessments of the design element j of decision criteria i

n : The number of participants

Sub-step three is to compute the fuzzy weight. After aggregating the collected data and computing the corresponding triangular fuzzy numbers, this study then applied the approximation method proposed by Buckley [17] to compute the fuzzy weight. The formula for computing the fuzzy weight is defined as follows:

$$\tilde{Z}i = (\tilde{a}i_1 \otimes \tilde{a}i_2 \otimes \ldots \otimes \tilde{a}in)^{\frac{1}{n}}, Vi = 1, 2, \ldots, n$$

$$\tilde{w}i = \tilde{z}i\,(\tilde{z}_1 \otimes \tilde{z}_2 \otimes \ldots \otimes \tilde{z}n)^{-1}$$

where

$\tilde{Z}$i : The geometric mean value of the triangular fuzzy number

$\tilde{a}$in : The triangular fuzzy number of row i and column j in the fuzzy comparison matrix

$\tilde{W}$i : The fuzzy weight of each row of the fuzzy comparison matrix

Sub-step four is to defuzzify the decision elements. At this step, the computed weights of the decision elements still defined in fuzzy values. Yet, in real situation, the fuzzy weight values need to be converted into crisp weight values in order to examine the relative satisfaction of the criteria. Hence, the defuzzification process is executed to assign a distinct crisp value to each of the decision elements. Specifically, the method of Center of Gravity of defuzzification is used to calculate the center of gravity of the triangular fuzzy number. Let a triangular fuzzy number and its three sides denoted by $\tilde{A}$= (Lij, Mij, Rij), the defuzzified weight, DFij is computed as follows:

$$DFij = [(Rij - Lij) + (Mij - Lij)]/3 + Lij$$

Sub-step five is to normalize the defuzzified weights. To examine and compare the relative satisfaction of different decision element at different levels of the FAHP hierarchy model, the defuzzified weights need to be normalized. The normalized weights, NWi of each decision element is denoted as follows:

$$NWi = DFij / \sum DFij$$

Sub-step six is to calculate the synthesised weight for each element at each level. Here, the process solely calculates the normalized weights for each element at each level after step five. Nonetheless, as to determine the priority of each gamification element, it needs to synthesise weights for each decision element at each decision level. Therefore, the synthesised weights of each decision element at each level is calculated as follows:

$$NWk = NWi \times NWij \times NWijk$$

To ensure a decision's quality and consistency, the consistency evaluation has to be examined. There are basically two types of evaluations: Consistency Index (CI) and Consistency Ratio (CR). The formulae for CI and CR are described as follows:

$$CI = \frac{\lambda max - n}{n-1}$$

where

λmax : The maximum eigenvalue

n: The number of decision component

$$CR = \frac{CI}{RI\,(n)}$$

where

RI: The average index for randomly generated weights obtained from a table of random consistency indices that depends on n, as presented in Table 1.

Table 1: The Table of Random Consistency Indices that depends on n.

N	3	4	5	6	7	8	9
R(n)	0.58	0.9	1.12	1.24	1.32	1.41	1.45

In general, if the CR of a comparison matrix is equal to or less than 0.1, the consistency of the decision is considered to be acceptable. On the contrary, if the CR is lower than 0.1, the pairwise comparisons should be repeated.

Lastly, if the value of CR is acceptably consistent, the FAHP methodology ends with the last decision making stage. The evaluation of the criteria based on the computed local weights and global weights is examined. Therefore, the MCDM problem is solved by ranking and selecting the higher ranked of the criteria(s) that contributes to the goal.

3. Research Design

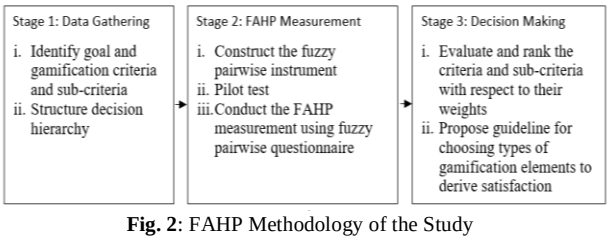

Fig. 2: FAHP Methodology of the Study

As illustrated in Fig. 2, the study employed FAHP approach as the main methodology. Three stages are involved; namely data gathering, FAHP measurement, and decision making.

In Stage 1, the goal of the study was identified, and a set of MOOC gamification elements criteria and sub-criteria was derived. The goal is to uncover the satisfying gamification elements for MOOCs. Accordingly, the goal was decomposed into its candidate criteria and sub-criteria. In order to derive the candidate criteria and sub-criteria, a review on gamification-related refereed literature within the years of 2011 to 2016 such as books, journals, theses and online resources was done. Subsequently, based on this review, appropriate gamification elements to be incorporated in both e-learning platform and MOOC were chosen for this study. Table 2 presents the list of derived candidate criteria and sub-criteria.

Table 2: Derived Gamification Elements Criteria and Sub-Criteria.

Engaging gamification elements criterion	Engaging gamification elements sub-criterion
Learner-content interaction (Moore, 1989) The one-way interaction between the learner and the content of the learning material in distance education.	***Acknowledgements*** [9] ***Avatar*** [11], [18], [7] ***Levels*** [7], [9] ***Time limit*** [18]
Learner-learner interaction *(Moore, 1989)* The inter-learner interaction, one learner either interacts with another learner or a group of learners to facilitate the process of distance learning.	***Cooperation*** [11] ***Leaderboard*** [7], [19] ***Learning forums*** [11] ***Opponent*** [11]
Learner-instructor interaction *(Moore, 1989)* The interaction between learner and the expert who prepared the learning material in distance education.	***Badges*** [5], [20], [21] ***Points*** [11], [5]

After that, the derived gamification criteria and sub-criteria were categorised into the gamification criteria. The gamification sub-criteria of avatar, acknowledgement, levels, and time limit were classified as learner-content interaction in which all these sub-criteria involve interaction between the learner and course content. Moreover, cooperation, leaderboard, learning forum, and opponent gamification sub-criteria were categorised under learner-learner interaction as these three sub-criteria involve inter-learner interaction. Furthermore, the badge and point sub-criteria were classified as learner-instructor interaction as badge and point are reward given the instructor to the learner. Accordingly, the goal, criteria, and sub-criteria were structured into the FAHP hierarchy model. Fig. 3 illustrates the AHP hierarchy model of this study.

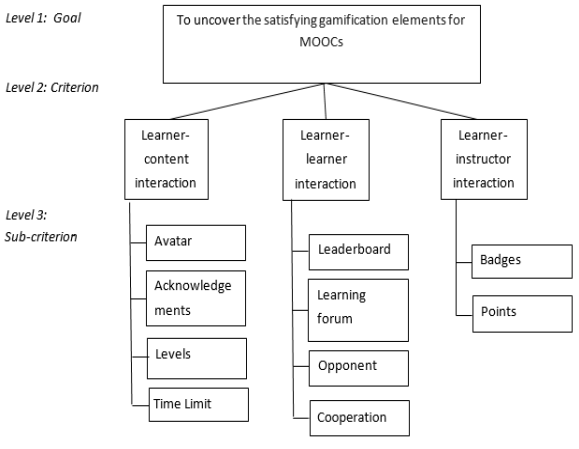

Fig. 3: AHP Hierarchy Model of the Study

In Stage 2 of FAHP methodology, learners' assessment with respect to their satisfaction was performed. The assessment was done by comparing gamification criterion and sub-criterion in pairwise comparison-data input manner. The instrument used to gather the assessments was adapted from AHP questionnaire in Chang and Wei's study [11]. Subsequently, the data analysis was conducted via FAHP measurement as to interpret the data collected via the questionnaire. The FAHP measurement was done when the local weights and global weights of all the gamification criteria and sub-criteria were computed. Besides, the consistency index (CI) and consistency ratio (CR) were also calculated for consistency checking on the performed pairwise comparisons of the criteria and sub-criteria.

Eventually, the decision making in Stage 3 was done by using the local weights and global weights of the gamification criteria and sub-criteria from the analysis stage. Then, the ranking of the gamification criteria and sub-criteria were done according to the computed local weights and global weights. Finally, the top gamification criterion and top three gamification sub-criteria were identified to synthesis a set of guidelines for implementing the appropriate satisfying gamification elements in MOOC.

IV. Results and Discussion

Satisfaction refers to the positive feelings about the learners' own accomplishments and learning experiences that could sustain the motivation of the learner [22]. 120 participants who have experienced in using MOOCs were invited to provide to report their satisfaction towards the gamification criteria and sub-criteria. In this study, TFNs are used to represent subjective pairwise comparisons of participants, namely, "Equally Agree", "Weakly Agree", "Strongly Agree", "Very Strongly Agree", "Absolutely Agree". When making comparisons of all gamification sub-criteria with respect to the gamification criteria, the comparison matrices of participants were derived. The CR values for all matrices were calculated and less than 0.1. This indicates acceptable consistency in each matrix. Table 3-6 show the group judgement matrices.

Table 3: The Group Judgement Matrix of the Satisfying Gamification Criteria

	Learner-content interaction (A1)	Learner-learner interaction (A2)	Learner-instructor interaction (A3)
A 1	(1,1,1)	(0.294, 0.356, 0.416)	(0.738, 0.938, 1.278)
A 2	(2.405, 2.811, 3.407)	(1,1,1)	(0.902, 0.962, 1.035)
A 3	(0.782, 1.067, 1.354)	(0.966, 1.040, 1.109)	(1,1,1)

Table 4: The Group Judgement Matrix of the Satisfying Gamification Sub-Criteria with Respect to Learner-Content Interaction

	Acknowledgement (A11)	Avatar (A12)	Levels (A13)	Time Limit (A14)
A 11	(1,1,1)	(0.732, 0.810, 0.916)	(0.319, 0.383, 0.461)	(0.217, 0.253, 0.300)
A 12	(1.092, 1.234, 1.366)	(1,1,1)	(0.267, 0.348, 0.450)	(0.263, 0.310, 0.368)
A 13	(2.171, 2.606, 3.130)	(2.223, 2.877, 3.744)	(1,1,1)	(0.237, 0.292, 0.368)
A 14	(3.331, 3.939, 4.614)	(2.718, 3.226, 3.800)	(2.720, 3.420, 4.218)	(1,1,1)

Table 5: The Group Judgement Matrix of the Satisfying Gamification Sub-Criteria with Respect to Learner-Learner Interaction

	Cooperation (A21)	Leaderboard (A22)	Opponent (A23)	Learning Forum (A24)
A 21	(1,1,1)	(0.172, 0.194, 0.226)	(0.276, 0.321, 0.382)	(0.376, 0.463, 0.599)
A 22	(4.427, 5.150, 5.813)	(1,1,1)	(1.578, 1.943, 2.416)	(2.572, 3.216, 4.082)

A 23	(2.619, 3.114, 3.629)	(0.414, 0.514, 0.634)	(1,1,1)	(1.814, 2.256, 2.707)
A 24	(1.670. 2.156, 2.663)	(0.245, 0.311, 0.389)	(0.369, 0.443, 0.551)	(1,1,1)

Table 6: The Group Judgement Matrix of the Satisfying Gamification Sub-Criteria with Respect to Learner-Instructor Interaction

	Badge (A31)	Point (A32)
A31	(1,1,1)	(1.055, 1.388, 1.856)
A32	(0.539, 0.720, 0.947)	(1,1,1)

Table 7: The Ranking of the Satisfying Gamification Criteria and Sub-Criteria.

Criterion	Local weight	Sub-criterion	Local weight	Global weight	Ranking
Learner-content interaction (A1)	0.228	Acknowledgement (A11)	*0.111*	*0.025*	*10*
		Avatar (A12)	*0.126*	*0.027*	*9*
		Levels (A13)	*0.256*	*0.058*	*7*
		Time Limit (A14)	*0.535*	*0.122*	*5*
Learner-learner interaction (A2)	0.454	Cooperation (A21)	*0.087*	*0.039*	*8*
		Leaderboard (A22)	*0.499*	***0.227***	*1*
		Opponent (A23)	*0.288*	***0.130***	*3*
		Learning Forum (A24)	*0.155*	*0.070*	*6*
Learner-instructor interaction (A3)	0.334	Badge (A31)	*0.598*	***0.200***	*2*
		Point (A32)	*0.429*	*0.143*	*4*

Table 7 lists the ranking of the most satisfying gamification criteria and sub-criteria. Based on the results stated in Table 3, the learner-learner interaction (0.454) scored the highest weight among all the gamification criteria. In addition to that, the top three gamification sub-criteria for incorporating in MOOC are leaderboard (0.227), badge (0.200), and opponent (0.130). Therefore, to create higher satisfaction among MOOC learners, the learner-learner interaction and gamification strategies based on learderboard, badge, and opponent should be given more emphasis.

To explain this, the learner-learner interaction refers to the interaction in which the learner either interacts with another learner or a group of learners as a team to facilitate the process of learning [23]. The friendly coopetition that occurs in such interaction is effective in creating the learner's sense of satisfaction, particularly when the learner has achieved rewards that their peers are not able to accomplish.

The most satisfying gamification sub-criterion was leaderboard which describes a graphical representation of a list of learners ordered according to their achievements in an e-learning platform to allow the learners in the platform acknowledges each other's achievements [9]. An example found in existing e-learning platform was from Talent LMS in which this platform created a ranking list to provide an overview learners' achievements based on the points that the learners have accumulated [24]. Verhoeff [25] highlighted that the role of competition in education is a good measure of how well a discipline is accepted and integrated into the curriculum as to effectively stimulate learner's satisfaction. So, the leaderboard which is a friendly competition gamification sub-criterion is appropriate to be incorporated into MOOC.

Likewise, the badge was nominated as the second most satisfying gamification sub-criterion. The badge, also known as a feedback aids, reward the learner by developing a sense of satisfaction. Learners receive recognition and evidence of success via badges that support their intrinsic feeling of satisfaction and they believe they have been treated fairly [22]. Thus, badge is considered as a crucial criterion in creating the sense of satisfaction.

The third most satisfying gamification sub-criterion is known as the opponent. Opponent basically refers to the phenomena of a learner participating in a learning task against another online learner and the result is shown at the end of the learning task. Such gamification element is demonstrated in the Kahoot learning platform [26]. In fact, the opponent gamification sub-criterion shares some similarity with the leaderboard sub-criterion in terms of their competition nature.

V. Conclusion

This study provides evidence on the feasibility of the FAHP methodology to uncover the satisfying gamification elements of MOOCs. A satisfying MOOC requires more emphasis on learning activities that encourage interaction between learners and MOOC developers may consider the incorporation of leaderboard, badge and opponent to create satisfying gamified MOOCs. The current study focuses solely on satisfaction. Thus, future work may look into other dimensions such as engagement, emotion, perceived learning as well as comparison between learners of diverse characteristics.

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