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Selection of Suitable E-Learning Approach Using TOPSIS Technique with Best Ranked Criteria Weights

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Abstract. This paper compares the performances of four rank-based weighting assessment techniques, Rank Sum (RS), Rank Reciprocal (RR), Rank Exponent (RE), and Rank Order Centroid (ROC) on five identified e-learning criteria to select the best weights method. A total of 35 experts in a public university in Malaysia were asked to rank the criteria and to evaluate five e-learning approaches which include blended learning, flipped classroom, ICT supported face to face learning, synchronous learning, and asynchronous learning. The best ranked criteria weights are defined as weights that have the least total absolute differences with the geometric mean of all weights, were then used to select the most suitable e-learning approach by using TOPSIS method. The results show that RR weights are the best, while flipped classroom approach implementation is the most suitable approach. This paper has developed a decision framework to aid decision makers (DMs) in choosing the most suitable weighting method for solving MCDM problems.

INTRODUCTION

E-learning is usually defined as distance learning and includes synchronous learning and asynchronous learning, and sometimes, it is also defined as a type of learning supported by Information and Communication Technology (ICT) [1], [2]. Recent strategies rely on the use of modern technology to activate digital learning: distance learning, blended learning, and flipped classroom. The flipped classroom has taken place in education as a modern teaching method [3]. It is a shift in the process from teacher-centred learning to student-centred learning [4], [5]. The flipped classroom is a concept for active learning where students are provided with study materials like video lectures or online textbooks before they attend the class [6]. Another method of modern teaching methods is a blended learning. It blends processes of traditional learning and e-learning [7]. However, there are various ways to apply e-learning in the process of instruction. Nevertheless, despite the growth of e-learning, there is still little quantitative information on e-learning approaches particularly about selecting the best approach to be applied in higher education. This paper aims to evaluate e-learning approaches and choose the best approach to five modern teaching techniques under study by using Multi-criteria decision-making (MCDM) techniques.

The main idea of this paper is to evaluate the five e-learning approaches mentioned above by using Technique for Order Preference by Similarity to Ideal Solutions (TOPSIS) technique. In order to use the TOPSIS method, the weights of the evaluation criteria should be determined in advance. Therefore, prior to that, four ranking methods, Rank-order centroid (ROC), Rank Exponent (RE), Rank Reciprocal (RR), and Rank Sum (RS) were utilized to

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analyse weights of the reviewed evaluation criteria from literature. The difference between this paper and previous studies is the comparison among ranking methods of weights and choosing the most accurate weights for criteria by proposed procedure. These weights are based on priority rankings of criteria obtained through questionnaire as preferred by the decision makers (DMs). All 35 DMs are working in a public university in Malaysia, and they are experts in the administrative area and teaching methods. Performances of the four ranking weighting methods were compared, and the best weights were used in TOPSIS technique in evaluating the five e-learning approaches. Since the study is conducted in Universiti Utara Malaysia (UUM), one of the public universities in Malaysia, the outcome of the survey is expected to help the management in selecting the suitable approach of e-learning to be applied in UUM.

DETERMINATION OF CRITERIA WEIGHTS

Multi-Criteria problems include criteria of differing importance to decision-makers. Then, details regarding the relative importance of the criteria are needed, and this typically realized by assigning a weight to each criterion [8], [9]. Therefore, the derivation of weights is the main step in generating the decision maker's preferences. For that, a weight can be defined as a value allocated to an assessment criterion that shows its importance about other criteria. The weights are typically normalized to sum to one [8]. A number of criteria weighting methods have been proposed in the MCDM literature. Some of the most popular weights methods are RS, RR, ROC, and RE [10]. Each weighting method differs in terms of accuracy, ease of use, complexity for users, and theoretical foundations and produces different sets of criteria weights. In addition, different weights methods may yield different ranking for criteria. Thus, the true meaning and the validity of these criteria weights are important through determining best weights for avoiding misuse of the MCDM problems. This paper tries to solve MCDM problems especially in selecting the best weights method.

RANKING METHODS

In the ranking methods, each criterion under consideration is ranked in order of the DMs preference from the most to the least important, the most important = 1, next important = 2, and so on [11]. [12] proposed three kinds of ranking to assign the weights for criteria: RS method, RR method, and RE method. [13], [14] proposed ROC method. The following four subsections discuss each of the four ranking methods. These methods have been chosen due to their easiness of use and effectiveness characteristics.

Rank Sum (RS) Method

The RS method is formulated such that the individual weight in RS is normalized by the sum of all attributes' weights [12], where each attribute is weighted $(K - r_i + 1)$, K is the number of attributes under consideration, r_i is the rank position of the criterion or attribute i, $i = 1, \dots, K$. The weight, w_i , is the normalized weight for each criterion i, is calculated as given in Equation (1).

$$w_i(RS) = \frac{K - r_i + 1}{\sum_{j=1}^{K} K - r_j + 1} \tag{1}$$

Rank Reciprocal (RR) Method

The RR weights are normalized reciprocals of criteria's rank, or by dividing each attribute's reciprocal rank by the sum of the reciprocals of all criteria's ranks [12] as given in Equation (2).

$$w_i(RR) = \frac{1/r_i}{\sum_{j=1}^{K} (1/r_j)} \tag{2}$$

Rank Exponent (RE) Method

The RE method is a generalization of the RS, which is calculated as given in Equation (3).

$$w_i(RE) = \frac{(K - r_i + 1)^p}{\sum_{j=1}^{K}(K - r_j + 1)^p} \quad (3)$$

Where p parameter is describing the attributes, $i = 1,2, \dots, n$. The parameter may be assessed by a DM using the weight of the most important attribute or via interactive scrolling.

Rank Order Centroid (ROC) Method

[15] found that weights obtained from this method were very stable. They showed that the expected value of the weight of each attribute can be computed using Equation (4).

$$w_i(ROC) = \frac{1}{K}\sum_{n=i}^{K}\frac{1}{n} \quad (4)$$

Where K is the number of criteria, n is the rank position of criterion i, $i = 1, 2, \dots, K$.

TOPSIS TECHNIQUE

The TOPSIS technique was developed by Yoon and Hwang [16]. The basic concept of this method is that the selected alternative should have the shortest distance to the positive ideal solution and the farthest distance from the negative ideal solution [17]. The TOPSIS method assumes that each criterion tends toward a monotonically increasing or decreasing utility [17]. Therefore it is easy to define the positive and negative ideal solutions. The Euclidean distance approach was proposed to evaluate the relative closeness of the alternatives to the ideal solution. Thus, the preference order of the alternatives can be derived by a series of comparisons of these relative distances [17]. The relative closeness to the positive ideal solution can be determined by using Equation (5) [8].

$$RC_i^+ = \frac{S_i^-}{S_i^+ + S_i^-} \ , i = 1,2, \dots, m \quad (5)$$

METHODOLOGY

The methodology consists of two main parts. The first part focuses on the weights of e-learning criteria, while the second part is about the selection of suitable e-learning approach to be implemented in the selected university. The data were collected from the Universiti Utara Malaysia (UUM) in 2016 through two sets of questionnaires which have been established by using google drive and then sent to participants through email. The first set is about the ranking of importance of the criteria towards implementation of e-learning, while the second set of the questionnaire concerns about the rating of the performance of each of the e-learning approach under every criterion. A total of 35 participants took part in the survey. They were from university management, members of relevant university bodies, members of bodies responsible for implementation of e-learning methodology and technology, and academic staff.

E-learning Criteria Weights

In order to demonstrate weighting process and to obtain different sets of criteria weights utilizing different ranking weighting methods, we hypothesized that the average of several weighting methods is the best manner to get the more accurate criteria weights [10]. The e-learning criteria have been selected from literature [18]. The rankings were analysed by using four different ranking weighting methods, RS, RR, ROC, and RE as given respectively as equations (1), (2), (3) and (4). The scoring or ranking has been done on five criteria from 35 participants about e-learning implementation in UUM by giving a rank for each criterion from 1 to 5.

Evaluation of E-learning Approaches

Based on the identified e-learning criteria, another set of the questionnaire were developed that focuses on the evaluation of the selected e-learning approaches. The scoring or ranking has been done on five e-learning approaches from 35 participants based on five identified e-learning criteria by given rank for each e-learning approach under each criterion from 10 to 100, where ten means less important and 100 means most important.

RESULTS

Five criteria and five alternatives have been chosen for e-learning implementation in UUM as shown in Table 1.

TABLE 1. Criteria and Alternatives about E-Learning Approaches

No.	Criteria	No.	Alternatives
1	Human resources	1	Blended learning
2	Specific ICT infrastructure for e-learning	2	Flipped classroom
3	Basic ICT infrastructure for e-learning	3	ICT supported face to face learning
4	Strategic readiness for e-learning implementation	4	Synchronous learning
5	Legal and formal readiness for e-learning implementation	5	Asynchronous learning

Ranks and Weights of Criteria

Based on the ranking of each criterion given by each respondent, the weights were calculated by using Equations (1)-(4). Then, the geometric average of all 35 weights for each criterion was calculated and the results are shown as Geometric mean (G. mean). After that, the G. mean weights were normalized by dividing each G. mean weight with the sum of G. mean weights to guarantee that the sum of these final weights is equal to one. The normalized weights from each method, RS, RR, RE and ROC for each criterion are summarized in Table 2. After that, the G. mean was used once again to get the geometric weights for each criterion. Then the weights were normalized once again to make sure that the sum of weights is one. These normalized weights are declared as the Ideal Weights (IW). The summary of the geometric weights and their normalized weights with the ranking of criteria are given in Table 2.

TABLE 2. The Normalized Weights from Each Method and Ideal Weights

No.	Methods	C1(rank)	C2(rank)	C3(rank)	C4(rank)	C5(rank)
1	RS	0.2863(1)	0.1347(4)	0.1116(5)	0.2853(2)	0.1821(3)
2	RR	0.2867(2)	0.1282(4)	0.1175(5)	0.2994(1)	0.1682(3)
3	RE	0.361(1)	0.0798(4)	0.0548(5)	0.3583(2)	0.1461(3)
4	ROC	0.3268(2)	0.1018(4)	0.0805(5)	0.3327(1)	0.1582(3)
	G. mean	0.3136	0.1088	0.0872	0.3176	0.1631
	Ideal weights (IW)	0.3167(2)	0.1099(4)	0.088(5)	0.3207(1)	0.1647(3)

Comparison of Weights

Based on Table 2, it can be seen that different weighting methods yield different set of weights and ranking. Now, in order to determine which ranked criteria weights are the best or which method give the more accurate weights, the absolute difference between each criterion weight for each method with the IW for the same respective criterion was calculated. The results are displayed in columns 3 to 7 in Table 3.

TABLE 3. Comparison Weights Methods with the IW

No.	Absolute differences	CR1	CR2	CR3	CR4	CR5	Sum	Rank
1	| RS – IW |	0.0304	0.0248	0.0236	0.0354	0.0174	0.1316	3
2	| RR – IW |	0.03	0.0183	0.0295	0.0213	0.0035	**0.01026**	**1**
3	| RE– IW |	0.0443	0.0301	0.0332	0.0376	0.0186	0.1638	4
4	| ROC – IW |	0.0101	0.0081	0.0075	0.012	0.0065	0.0442	2

After that, the sum of all absolute differences for each weighting method was calculated as summarized in column 8 as in Table 3. The method that has the smallest sum of absolute difference would be the most accurate method. Logically, the real meaning of criteria weights was achieved by using various weighting methods. This is important for avoiding misuse of the MCDM methods and obtaining reliable outcomes.

Best Ranked Criteria Weights

Based on Table 3, RR weights have the least sum of absolute differences with the score of 0.01026. So RR weights are declared as the best-ranked criteria weights. The best-ranked criteria weights (RR weights) about e-learning implementation are shown in Table 4. This set of weights would be used in evaluating the e-learning approaches by using TOPSIS method as discussed in the following subsection.

TABLE 4. Final Result of Criteria Weights

No.	Criteria	Weights	Rank
1	Human resources	0.2867	2
2	Specific ICT infrastructure for e-learning	0.1282	4
3	Basic ICT infrastructure for e-learning	0.1175	5
4	Strategic readiness for e-learning implementation	0.2994	1
5	Legal and formal readiness for e-learning implementation	0.1682	3

Evaluation of Five E-Learning Approaches Using TOPSIS Method

The following Table 5 displays the rank for each alternative by TOPSIS technique for the five e-learning approaches: blended learning, flipped classroom, ICT supported face to face learning (ICT & F-to-F), synchronous learning, and asynchronous learning. The result of the ranking of approaches is derived using Equation (5). The first alternative is considered as the best maximization of expected benefits for e-learning implementation in UUM.

TABLE 5. The Result of Ranking

E-learning approaches	S_i^+	S_i^-	$S_i^+ + S_i^-$	$S_i^- / S_i^+ + S_i^-$	Rank
Flipped classroom	0	21.1	21.1	**1**	**1**
Blended learning	5.69	15.94	21.63	0.73	2
ICT & F-to-F learning	10.75	10.47	21.22	0.49	3
Synchronous learning	17.38	3.77	21.15	0.17	4
Asynchronous learning	21.1	0	21.1	0	5

As seen from the Table 5, the result based on the TOPSIS analysis found that the priority of flipped classroom learning approach becomes the main priority to implementation in UUM as suggested approach to the management of the university. The second one and the next are blended learning approach, ICT & F-to-F, synchronous learning, and asynchronous learning respectively.

CONCLUSION

This paper shows the utilization of multi-criteria methods in evaluating e-learning approaches under five identified criteria. Four types of ranking weighting methods (Rank Sum, Rank reciprocal, Rank Exponent, and Rank-order centroid) have been compared to select the most suitable method. The rank reciprocal method is the most appropriate method for calculating criteria weights about e-learning implementation. The results weights obtained by rank reciprocal method for criteria was 29% with Strategic readiness for e-learning implementation as the most important, the second importance for criteria was 28% with Human resources, the least important of

criteria was 11% with Basic ICT infrastructure for e-learning. TOPSIS method has been used for determining the best approach of e-learning. flipped classroom approach is the most suitable for implementation in the Universiti Utara Malaysia. Finally, in future, we would like comparing more than four weighting methods including pairwise comparison method. This practice will also help decision-makers to choose the best weighting method for their decision-making process.

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