Evaluation of E-Learning Approaches Using AHP-TOPSIS Technique

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***Abstract*—Strategic preparation of e-learning application includes decision making regarding the most suitable type of e-learning on different levels. The survey has been carried out on the sample of 95 respondents consisted of administrative and academic staff, and postgraduate students in Malaysia. They were asked to assess the relative importance of five e-learning evaluation criteria to be analysed by using AHP technique. Furthermore, they also rated the performance of five identified e-learning approaches under each of the requirements. The overall performance of each e-learning approach was computed by using TOPSIS method. The results suggested that Flipped Classroom is the most suitable e-learning approach, while 'Strategic readiness for e-learning implementation' found to be the most important criterion. The paper is suggesting a quantitative evaluation method for decision-makers who are strategising modern technologies in higher educational settings.**

***Index Terms*—E-Learning; Weight; AHP; TOPSIS.**

I. Introduction

Numerous universities have understood the need for E-Learning. According to one of the Times Educational Supplement, there is growth towards e-Learning as there was as in face-to-face pedagogy [1]. Nowadays, many educational institutes are also designing online courses because of strong student learning results in online programs. E-Learning is typically defined as a kind of learning supported by Information and Communication Technology (ICT) that enhances the quality of learning and teaching. Application of e-learning contributes to the development of higher education. E-learning system is an effective tool for accomplishing strategic objectives of the university through serving the society by teaching and research, and it contributes to the progression on the institutional level in addition to the personal level, including both teaching staff and students [2].

Universities in Malaysia are on the move of implementing ICT in their teaching and learning activities. The current methods such as traditional learning have become unsuitable for development operations of the educational process because of the rapid development of IT. Therefore, the educational process needs to reform to keep up with the ICT evolution, especially in universities of Malaysia. Modern learning strategy concentrates on the direct interaction between students and positive learning techniques with guidance from the teacher including the student's ability to participating and researching. Also, there is a need to develop teaching methods, strategies and the use of modern teaching strategies based on the employment of modern technologies in the development of the educational process [3].

Therefore, Malaysian universities should apply e-learning techniques because of many functional benefits that e-learning brings since e-learning can serve as a catalyst for change in teaching and learning. It supports skills needed in knowledge-based society, such as collecting, analysing and applying information appropriately and includes different teaching methods, for example, information management, creative thinking, critical thinking, problem-solving and collaborative learning [4].

As a developing country, Malaysia is still having problems to keep up with the ICT evolution due to lack of resources, infrastructure, and readiness. A study is required to evaluate potential e-learning to be implemented in universities. Therefore, the paper discusses a study on the evaluation of five e-learning based on five identified criteria by using multi-criteria methods. The survey was conducted in the Universiti Utara Malaysia (UUM) by sending the questionnaire to more than 700 people through emails, but only a total of 95 respondents answered the survey. The respondents consisted of 38 lecturers, 22 administrative staff, and 35 postgraduates students who evaluated the importance of the criteria and performances of the five e-learning approaches under each of the five criteria. Two Multi-criteria (MC) methods were used to analyse the relative importance of the criteria and to aggregate the overall performance of each e-learning approach. This paper is organised as follows. The next section provides an overview of each e-learning approaches. It is followed by sections on MC methods, methodology, results and discussions, and conclusions of the study.

II. E-Learning Approaches and Criteria

Five e-learning approaches were selected as the potential e-learning approaches to be implemented in the selected public university, which were ICT supported Face-to-Face teaching, Flipped Classroom, Blended Learning, Synchronous and Asynchronous Learning. The Flipped Classroom has taken place in education as a modern teaching method [4]. It is a shift in the process from teacher-centred learning to student-centred learning [5], and it 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]. Researchers in [7] stated that the introducing a Flipped Classroom can mean additional work and may require new skills for the instructor. One more method of modern teaching methods is the Blended-Learning. It blends processes of traditional learning and e-learning [8]. The e-learning is usually defined as a distance learning includes Synchronous and Asynchronous Learning, and sometimes, it is also defined as a type of learning supported by ICT [9],[10]. The five e-learning approaches under study and the five evaluation criteria [9],[11] are as summarised in Table 1.

Table 1
E-Learning Approaches and Evaluation Criteria

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

III. DETERMINATION OF CRITERIA WEIGHTS

MC problems include criteria of differing importance to decision-makers. Then, details regarding the relative importance of the criteria are needed, and this typically realised by assigning a weight to each criterion. 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 normalised to sum to one. A number of criteria weighting methods have been recommended in the MCDM literature. For instance, some of the most popular techniques in the spatial MCDM are rating, ranking, and pairwise comparisons or AHP method [12],[13]. In this paper, AHP method was used to determine criteria weights as explained in the following sub-section.

IV. THE ANALYTIC HIERARCHY PROCESS (AHP)

The AHP [14] is a flexible and effective decision-making process which is useful in establishing priorities and making the best decision when both quantitative and qualitative aspects of a decision need to be considered [15], [16]. AHP is one of the most extensive decision-making techniques in cases when the decision is based on several criteria. The AHP has been applied in various fields, management, governance, agriculture, industry, allocation and distribution of resources for making strategic decisions of major importance and responsibility, this study implemented in the scope of e-learning. Complex decision problem solving, which this method uses, is based on the problem decomposition into a hierarchy structure which consists of the goal, the criteria, sub-criteria and the alternatives [11]. However, AHP is widely criticised for being such a tedious process, especially with inconsistency judgments. Calculating the weights in this method has five major steps [17],[18]:

Step 1: Develop a matrix comparing the attributes pair wisely by using Saaty's scale (see Table 2). The diagonal in the Pairwise Comparisons Matrix (PCM) is always 1, and the lower left values are inverted values. Let $A = [a_{ij}]_{nxn}$ be the pairwise comparison matrix with $a_{ji} = 1/a_{ij}$.

Table 2
Scale of Relative Importance

Scale of Importance for Pairwise Comparisons	Numeric Rating
Extreme Importance	9
Very Strong Importance	7
Strong Importance	5
Moderate Importance	3
Equal Importance	1

Step 2: Calculate the criteria weights by taking the Geometric Mean (G-Mean) of elements in each row as:

$$\bar{a}_{ij} = \frac{a_{ij}}{\sum_i a_{ij}}$$
$$w_i = \left(\prod_{j=1}^{n} \bar{a}_{ij}\right)^{\frac{1}{n}} \quad (1)$$

Step 3: Calculate the Lambdamax (λ_{max}) value which should equal to the number of factors in the comparison n for total consistency as follows:

$$\lambda_{max} = \sum_{i=1}^{n} \left(\sum_{i=1}^{n} a_{ij}\right) w_j \quad (2)$$

Step 4: Calculate the Consistency Index (CI) measures as follows:

$$CI = \frac{\lambda_{Max} - n}{n-1} \quad (3)$$

Step 5: Calculate a Consistency Ratio (CR). If the CR is less than 0.10 (CR<0.1), then the ratio shows an acceptable level of consistency in the AHP. If CR is more than 0.10 (CR>0.1), the ratio is inconsistent as follows:

$$CR = \frac{CI}{RI} < 0.1 \sim 10\% \quad (4)$$

with Random Index (RI) as given in Table 3.

Table 3
Random Index

No. of Criteria	1	2	3	4	5	6	7	8	9
R. I.	0	0	0.52	0.89	1.11	1.25	1.35	1.4	1.45

In this method, the input data were collected from a set of questionnaires. In this study, the participants were the administrative staff, academics, and postgraduate students in UUM. The AHP questionnaire was designed after listed all the criteria and explained the list to the participants. The participants were briefed on how to fill the AHP table and then asked to give importance based on Saaty Scale 1-9 through the comparison in between criteria. Furthermore, all the participants were assumed to have a reasonable knowledge of the e-learning criteria and alternatives.

V. TOPSIS METHOD

The technique for order preference by similarity to ideal solution (TOPSIS) technique was established by Hwang and Yoon [19]. The fundamental concept of this technique is that the chosen alternatives should have the shortest distance to the positive ideal solution and the farthest distance from the negative ideal solution [20]. The TOPSIS approach presumes that each criterion tends toward a monotonically decreasing or increasing utility [21]. Consequently, it is easy to specify the positive and negative ideal solutions. The Euclidean distance strategy was suggested to assess the relative closeness of the selected alternatives to the ideal solution. Therefore, the preference order of the alternatives could be obtained by a series of comparisons of these relative distances [22]. The distance between each alternative and the positive ideal point can be determined using Equation (5). Utilizing the same separation measure, the distance between each alternative and the negative ideal point can be determined using Equation (6) [12].

$$S_i^* = \sqrt{\sum_{j=1}^{n}(A_j^* - v_{ij})^2} \quad (5)$$

$$S_i^- = \sqrt{\sum_{j=1}^{n}(A_j^- - v_{ij})^2} \quad (6)$$

The Relative Closeness (RC_i^*)to the positive ideal solution can be calculated by Equation (7).

$$RC_i^* = \frac{S_i^-}{S_i^* + S_i^-} \quad (7)$$

where the RC_i^* index value lies between 0 and 1. The larger index value means the better the performance of the alternative.

The TOPSIS technique usually deals with benefit and cost data. In this paper, the Positive Ideal Solution (PIS) is the one with the lowest cost, and most benefits of all alternatives, the Negative Ideal Solution (NIS) is the one with the highest cost and lowest benefits of all alternatives. In this paper, all data are of profit or benefit type where higher is better, but when it is a loss, the lower is better.

VI. METHODOLOGY

The method consists of two main parts. The first part focused on the weights of e-learning criteria, while the second part was about the selection of suitable e-learning approach to be implemented in the selected university. The data were collected from a public university in Malaysia in 2016 through two sets of questionnaires which had been established by using Google Drive and then sent to participants through email. A total of 95 participants took part in the survey. The first set is about the importance of criteria towards implementation of e-learning. Here, The Analytic Hierarchy Process (AHP) was used as weighting method for the criteria. The respondents were asked to compare every two criteria and give points between 1 and 9 to the most important criterion than another. The 95 evaluations were aggregated by using the geometric average method. The second set of the questionnaire concerns about the rating of the performance of each of the e-learning approaches under every criterion. The scale of the rating is 10 to 100, where the higher the rating means, the higher the performance of the approach under the evaluation criteria. The geometric average method was used once again to aggregate the 95 performances of each approach under each criterion. TOPSIS method was used to aggregate the weights of criteria, and the performances of the e-learning approach to determine the overall performance of the e-learning approaches.

VII. RESULTS AND DISCUSSIONS

Table 4 displays the criteria weights produced by AHP method. The weights of criteria were positioned C4, 'Strategic readiness for e-learning implementation' as the most important criterion, while C1, 'human resource' as the second most important criterion. The criterion, C5, 'legal and formal readiness for e-learning implementation' is at the third ranking of importance, followed by C2, 'specific ICT infrastructure for e-learning' and, C3, 'basic ICT structure for e-learning.'

Table 4
The Weights for the Criteria Using AHP Method

No.	Criteria	Weights	Rank
C1	Human resources	0.265	2
C2	Specific ICT Infrastructure for E-Learning	0.142	4
C3	Basic ICT Infrastructure for E-Learning	0.135	5
C4	Strategic Readiness for E-Learning Implementation	0.276	1
C5	Legal and Formal Readiness for E-Learning Implementation	0.182	3

The following decision matrix (see Table 5) displays the average of the judgments based on a scale of 10-100 for each alternative under each criterion as given by 95 participants on the five e-learning models, regarding e-learning implementation in UUM.

Table 5
Decision Matrix of Criteria Weights and Average Evaluations of Each E-Learning Approach

Criteria Weights	0.265	0.142	0.135	0.276	0.182
Alternatives	C_1	C_2	C_3	C_4	C_5
Blended Learning	75	80	80	75	75
ICT & F-to-F Learning	65	60	60	60	60
Flipped Learning	85	85	80	85	85
Synchronous Learning	40	40	40	40	40
Asynchronous Learning	30	25	30	25	30

The result of the ranking of approaches is derived using RC_i^* as in Equation (7) are shown in Table 6. The alternative at first rank is considered as the best maximization of expected benefits for e-learning implementation in University Utara Malaysia (UUM).

Table 6
Results of TOPSIS Technique

Alternatives	S_i^*	S_i^-	$S_i^* + S_i^-$	RC_i^+	Rank
Blended Learning	4.98	16.88	21.86	0.77	2
ICT & F-to-F Learning	11.41	10.23	21.64	0.47	3
Flipped Learning	0	21.58	21.58	1	1
Synchronous Learning	18.79	2.81	21.6	0.13	4
Asynchronous Learning	21.58	0	21.58	0	5

The results based on the TOPSIS technique shown that the Flipped classroom have the highest score which suggested that the evaluators preferred this approach as compared to the other four approaches. The Blended Learning was the second most importance model based on the survey participants and followed by ICT & F-to-F model, Synchronous, and Asynchronous Learning models.

VIII. Conclusion

This paper shows the utilisation of multi-criteria methods in evaluating e-learning approaches under five identified criteria. The use of this type of quantitative method is very practical for evaluation purposes. Besides, the evaluation was carried out by those who were involved whether directly or indirectly in the implementation of e-learning in a university. The results of the assessment show that 'Strategic readiness for e-learning implementation' found to be the most essential basis of criterion from the perspective of the respondents from a public university in Malaysia. This finding has to be taken seriously since no matter how great the technology is, the readiness for e-learning implementation still play the leading role in improving the educational process. Furthermore, the flipped classroom is the most preferred e-learning approach out of five methods under study. The results of this study would give an idea to the management of the university in their process of implementing modern technologies in the teaching and learning process.

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