APPLICATION OF ANALYTICAL HIERARCHY PROCESS TO MATHEMATICS PERFORMANCE OF FSKM STUDENT'S DURING ONLINE DISTANCE LEARNING

Sumarni Abu Bakar[1], **Nur Ayuni Mohammad**[2] **and Siti Marjan Aziz**[3*]

[1,2,3]*Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, 40450 Shah Alam, Selangor Malaysia*

[1]sumarni@tmsk.uitm.edu.my, [2]nurayunimohammad98@gmail.com, [3*]marjanaziz98@gmail.com

(indicates the corresponding author)*

ABSTRACT

COVID-19 pandemic has taken a significant role on people all across the world including Malaysia. It has affected people of all nationality, level of education, income and gender. The COVID-19 pandemic had a severe impact on higher education as universities need to close their premises and countries shut their borders due to lockdown measures. Therefore, all the higher education institutions including UiTM decided to continue the students' learning by using open distance learning (ODL) platform. The transition from face-to-face learning to online learning is one of the current concerns, as this method has not been widely used previously and may have an impact on student performance. This study explored the factors contributing towards mathematics performance of Faculty of Computer and Mathematical Science (FSKM) students in UiTM Shah Alam during the online distance learning (ODL). A survey was conducted to get the preference order of rank on the factors that contribute to mathematics performance of FSKM student and the quantitative data are collected from more than thirty students. The method that has been implemented in this study is Analytical Hierarchy Process (AHP). The main factors to be analyse were students' attitude, environment around students and mathematics anxiety. The sub-factors are patience, willingness, confidence, accessibility, conducive surrounding, commitment, interest, teaching style and situational. The findings indicated how these main factors and sub-factors contribute towards the students' mathematics performance during online learning and the most significant factor affecting students' mathematics performance. The results of the study reveal that patience, accessibility and commitment are the top three factors that contribute towards mathematics performance in which patience has the highest ranking.

Keywords*: Mathematics Performance, Multi Criteria Decision Making, Open Distance Learning,*

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1. Introduction

Online distance learning (ODL) method become more popular in education system as it is applied by majority of the higher institutions in Malaysia due to Covid-19 pandemic. The learning and teaching process using ODL method is completely virtual and use various technologies to facilitate student-teacher and student-student communication. Thus, ODL method creates huge learning advantages to the student as it offers less cost, easy access, flexibility and time saving due to the fact that the student is no longer needed to be in the classroom physically. On the other hand, it also creates a big challenge to them as they need

to stay focused and monitor their learning momentum in order to fully understand the materials. Aguilera-Hermida (2020) also agreed that the biggest challenge to the student is to stay concentrate in the online classes while being at home.

There are many factors that contribute to the student in order to stay focused during their learning process using ODL method. Some of the factors include ability to adapt themselves to the ODL method. There are students who involve in taking care of their family members or students that might be involved with employment responsibilities (Gillet-Swan, 2017). As most of the university students are having online classes at home, they are expected to help their parents and families with house chores. There are also some students that need to take care and monitor their younger sibling's studies material while their parents are working. There are also students who need to work part-time to support their families financially during this pandemic. These situations have multiple their burdens in a huge way and their focus during online classes is absolutely affected.

Besides attitude and behaviour (patience, confidence and willingness) (Mohd et al., 2011), of the student, accessibility to the internet network is also considered as factor that significantly contributes to the flow of the learning process. Accessibility has a profound effect on students' engagement and academic performance therefore it will greatly impact the success of the learner (Gilbert, 2015). Thus, despite student acknowledgement of the benefits in supporting their learning through the technology, a difficulty arises through the limits around the technical capability of the software particularly in terms of its functionality (Gillet-Swan, 2017). There are also students who are unable to run simple programmes such as Microsoft Word, PowerPoint, and Excel, which might result in their failing to handle files and complete the tasks which eventually slow the process of learning.

Other factor that also play important role to the failure of a student is a feeling of anxiety. It is obvious when relates to Mathematics course. Mathematics anxiety is commonly defined as a feeling of tension, apprehension, or fear that interferes with math performance (Sevindir et al., 2014). The atmosphere that is intangibly created only felt to disturb the students emotionally that caused them the difficulty in learning Mathematics (Langoban, 2020). The literatures support high anxiety during online classes. In mathematics classes, possibly, the main reason for their anxiety is the subject matter itself. Given the new setting with limited communication for feedback from the instructors, students' anxiety may have worsened. Although many factors have been discussed, improvement to the teaching method and facilities can be suggested to the institution based on the priority of the factor. Thus, knowing which factor should be given priority is in need since the result will help the institution to formulate the right strategy to help the student's learning process and thus increase their academic performance especially in Mathematics course. Hence, this work aims to represent the use of AHP to rank the factors that contribute to the Mathematic performance of FSKM students in UiTM Shah Alam, Malaysia during ODL. The rest of this paper is organized as follows. Section 2 discussed on the AHP process and methodology used, and the result is elaborated in Section 3. This paper ends with a conclusion in Section 6.

2. Analytic Hierarchy Process (AHP)

Analytical Hierarchy Process (AHP) is a powerful and widely used in Multi-criteria decision analysis (MCDA) technique. It is similar to the value measurement modelling approach (Alharthi, Sultana, Al-amoudi & Basudan, 2015). The AHP is used to find the best decision and alternative that highly reaches the goals and help in solving the problem. According to Chai et al. (2013), the AHP method makes it possible to assign a value representing the preference degree for a given alternative to each additional alternative.

AHP has been implemented in many areas such as in telecommunication, landscape, road traffic and chemical industry. For example, AHP method was used in selecting personnel by using real data of a real case in the Telecommunication sector in Iran (Afshari et al., 2010), in examining the success factors of autonomous landscape development in rural communities (Liang & Peng, 2017), in measuring relative importance of different parameters contributing

towards sustainable development at regional level based (Kwatra et al., 2021). Fernandez et al., (2019) tackled the application of AHP in determining how the mastery of traffic signs affects the road user's prioritization of the factors that cause road accidents in Manila and Abrahamsen, et al., (2020) used AHP in prioritising safety measures in the chemical industry to reduce hazard or risk management that might occurred. The crucial parts in AHP method include arranging the criteria and sub-criteria into a suitable hierarchy structure, collecting data for the pairwise comparisons of each level, and calculating the weights of factors in each level. The hierarchy structure involving three levels is illustrated in Figure 1. The first level is the goal of the study. This is followed by the main criteria level and the sub-criteria level in level 2 and 3 respectively.

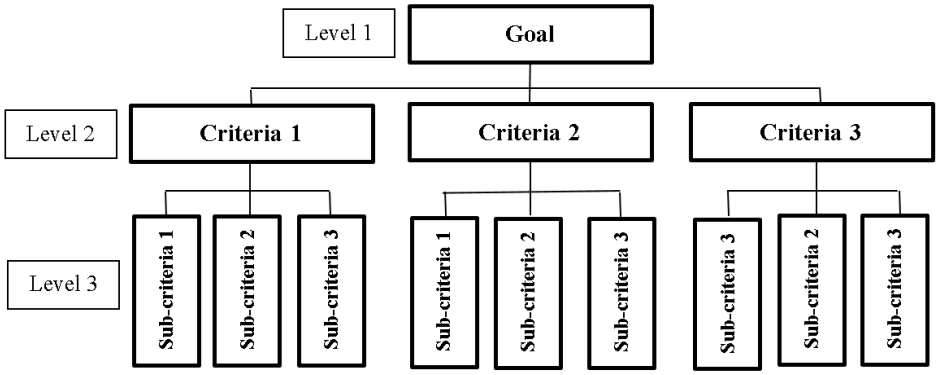

Figure 1: AHP Structure with Three Level

3. Methodology

In this study, there are eight steps involved in the process of ranking using Analytical Hierarchy Process (AHP) as shown in the following Figure 2.

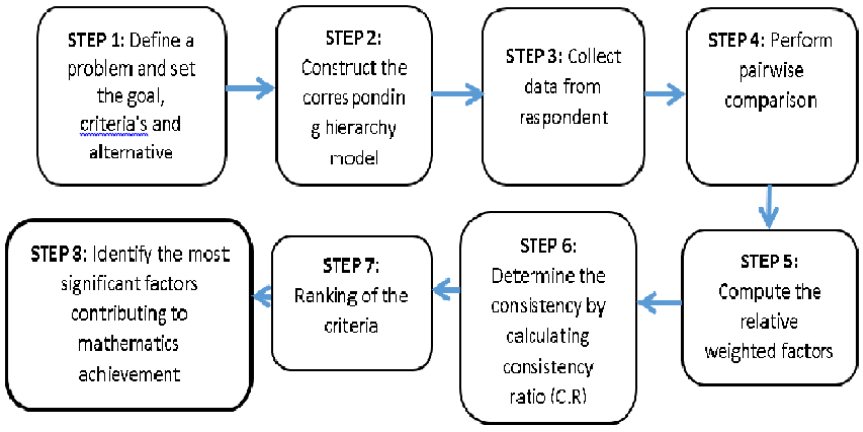

Figure 2. Steps involved in this study

Details of the steps is explained as follows:

Step 1: Setting the goal and criteria**.**

The goal of this study is to determine the most significant factor that contributes to mathematics performance. The main criteria's are the list of main factors which are attitude, environment and Mathematics anxiety. Each of main factor has its own sub-criteria. In this study, the sub-criteria that contributes to mathematics performance are patience towards mathematics problem solving, willingness towards mathematics problem solving, confidence

towards problem solving, accessibility, commitment, conducive surrounding, interest in Mathematics, teaching style and situational.

Step 2: Construction of the hierarchy model.

In this study, a three-level hierarchy is used where the highest level is the goal to reach, the second level is the criteria which are the main factor and the third level is the sub-criteria which is the sub-factor of the main factor. The decision of the contributing factors can be resolved by decomposing it into sub-problems within a hierarchy structure as shown in Figure 3.

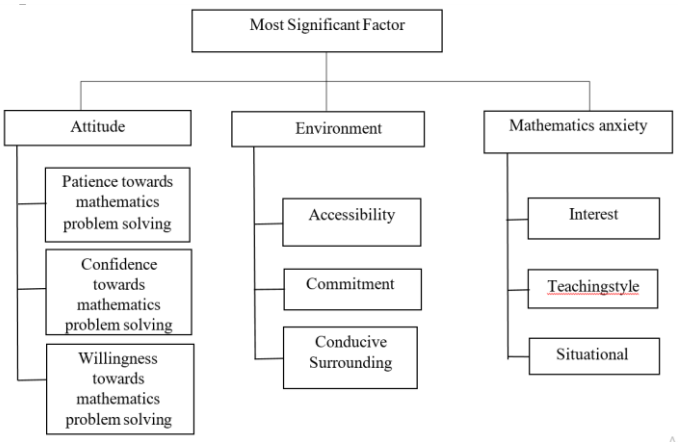

Figure 3. AHP Hierarchy Model of contributing factors affecting Mathematics Performance

Step 3: Collecting data from respondent

Online questionnaire is distributed at random for 10 respondents of Mathematics student's in FSKM in order to determine their perception on the ranking of factors and sub-factors contributing towards mathematics performance. Two factor's are compared based on the following scale (score) in Table 1.

Table 1: AHP pairwise scale used in questionnaire (Saaty, 1980)

Intensity of importance (Score)	Description
Scale 1 (Equal)	Both criteria have equal importance
Scale 3 (Moderate)	One of the criteria is slightly more important than the other one.
Scale 5 (Strong)	One of the criteria is strongly more important than the other one.
Scale 7 (Very strong)	One of the criteria is very strongly important than the other one.
Scale 9 (Extreme)	One of the criteria is extremely important than the other one.
Scale 2, 4, 6, 8	In between their two neighbors

Step 4: Calculation of Pairwise Comparison matrix

The score data collected from Step 3 is then represented using pairwise comparison matrix as illustrated below:

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \dots & a_{2n} \\ \vdots & \vdots & 1 & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \dots & 1 \end{bmatrix}$$

Here, each a_{ij} entry in matrix A represents the relative importance of the ith criterion with respect to the jth criterion, which is characterized by:

i) $a_{ij} \cdot a_{ji}=1$
ii) $a_{ij}>0$
iii) $a_{ii}=1$

Step 5: Computation of weight factor

The formula to find weighted factor, W is as below:

$$\text{Let } B = \begin{bmatrix} (a_{11} \times a_{12} \times \dots \times a_{1n})^{\frac{1}{n}} \\ (a_{21} \times a_{22} \times \dots \times a_{2n})^{\frac{1}{n}} \\ (a_{31} \times a_{32} \times \dots \times a_{3n})^{\frac{1}{n}} \\ \vdots \\ (a_{n1} \times a_{n2} \times \dots \times a_{nn})^{\frac{1}{n}} \end{bmatrix} = \begin{bmatrix} b_{11} \\ b_{21} \\ b_{31} \end{bmatrix}$$

then,

$$W = \begin{bmatrix} \frac{b_{11}}{b_{11}+b_{21}+b_{31}} \\ \frac{b_{21}}{b_{11}+b_{21}+b_{31}} \\ \frac{b_{31}}{b_{11}+b_{21}+b_{31}} \end{bmatrix} = \begin{bmatrix} w_1 \\ w_2 \\ w_3 \end{bmatrix}$$

The similar calculation is repeated in the calculation of weight for each sub-factor.

Step 6: Calculation of consistency ratio

The formula used to calculate the consistency index (CI) and consistency ratio (CR) for each pairwise comparison matrix for the factors and sub-factors are given as follow:

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

$$CR = \frac{CI}{RI} < 0.1$$

where λ_{max} is the largest eigenvalue and *n* is the size of comparison matrix. Random Index (RI) is chosen based on Random Index Table 2 below.

Table 2. Random Index

n	1	2	3	4	5	6	7	8	9	10
Random Index	0	0	0.52	0.89	1.11	1.23	1.33	1.40	1.45	1.49

Step 7: Ranking of the factor

Here, overall weight for each sub-factor is calculated by multiply the weight of the sub-factors by the weight of its main factor. Next, the priority weights of the factors represent the level of importance of these factors. The factor that has the largest value of weight is the most important factor while factor with the lowest weight represent the least importance factor. The factor was ranked accordingly based on the weight in ascending order from the lowest value to the highest value of weight.

4. Implementation

In this study, ten Mathematics students of FSKM are selected at random to answer the questions on their opinion on factors that contributes to their academic performance in Mathematics based on the scale in Table 1. The respondents are from five different courses offered in FSKM, UiTM Shah Alam. The courses are Bachelor of Science (Hons.) Statistics (CS241), Bachelor of Science (Hons.) Actuarial Science (CS242), Bachelor of Information Technology (Hons.) Intelligent Systems Engineering (CS243), Bachelor of Science (Hons) Mathematics (CS249) and Bachelor of Information Systems (Hons.) Intelligent Systems Engineering (CS259). Most of the respondents are from semester 6.

The main factors involved in the study are Attitude, Environment and Mathematics anxiety and the sub-factors for each main factor are as depicted in Figure 1. The data obtained for comparison between factors in Level 2 and Level 3 in Figure 1 is then represented in a form of pairwise comparison matrices. Example of the pairwise comparison matrices for main factor and sub-factor for respondent 1 are as in Table 3. Consistency index for each pairwise comparison matrix for 10 respondents are calculated and the value of the consistency index, CI < 0.1 which shows that the matrix is conforms to the consistency standard. Next, the pairwise comparison matrix and relative weight matrix for the rest of the participants are then calculated and the average weight, AV for each factor and sub-factor are tabulated in Table 3.

Table 3. Pairwise comparison matrix, Relative weight matrix and Average weight for main factor and sub-factor

Main factor and sub-factor	Pairwise comparison matrix for respondent 1	Relative weight matrix for respondent 1	Average weight, AV
Main factor 1. Attitude 2. Enviroment 3. Mathematics anxiety	$\begin{bmatrix} 1 & \frac{1}{9} & 1 \\ 9 & 1 & 5 \\ 1 & 1/5 & 1 \end{bmatrix}$	$W_{T1} = \begin{bmatrix} 0.1040 \\ 0.7695 \\ 0.1265 \end{bmatrix}$	$AW_T = \begin{pmatrix} w_1 \\ w_2 \\ w_3 \end{pmatrix} = \begin{pmatrix} 0.3737 \\ 0.4172 \\ 0.2091 \end{pmatrix}$
Sub-factor for main factor1-Attitude	$\begin{bmatrix} 1 & 7 & 9 \\ \frac{1}{7} & 1 & 3 \\ \frac{1}{9} & \frac{1}{3} & 1 \end{bmatrix}$	$W_{P1} = \begin{bmatrix} 0.7854 \\ 0.1488 \\ 0.0658 \end{bmatrix}$	$AW_P = \begin{pmatrix} w_4 \\ w_5 \\ w_6 \end{pmatrix} = \begin{pmatrix} 0.4290 \\ 0.3032 \\ 0.2678 \end{pmatrix}$
Subfactor for main factor 2-Environment	$\begin{bmatrix} 1 & 7 & 5 \\ \frac{1}{7} & 1 & 1 \\ \frac{1}{5} & 1 & 1 \end{bmatrix}$	$W_{Q1} = \begin{bmatrix} 0.7471 \\ 0.1194 \\ 0.1336 \end{bmatrix}$	$AW_Q = \begin{pmatrix} w_7 \\ w_8 \\ w_9 \end{pmatrix} = \begin{pmatrix} 0.3703 \\ 0.3555 \\ 0.2742 \end{pmatrix}$
Subfactor for main factor 3-Mathematics anxiety	$\begin{bmatrix} 1 & 1 & 5 \\ 1 & 1 & 3 \\ \frac{1}{5} & \frac{1}{3} & 1 \end{bmatrix}$	$W_{R1} = \begin{bmatrix} 0.4806 \\ 0.4054 \\ 0.0658 \end{bmatrix}$	$AW_R = \begin{pmatrix} w_{10} \\ w_{11} \\ w_{12} \end{pmatrix} = \begin{pmatrix} 0.3703 \\ 0.3555 \\ 0.2742 \end{pmatrix}$

The overall weight for each sub-factor is calculated based on the method whereby Patience = $w_1 \times w_4$, Willingness = $w_1 \times w_5$, Confidence = $w_1 \times w_6$, Accessibility = $w_2 \times w_7$, Commitment = $w_2 \times w_8$, Conducive surrounding = $w_2 \times w_9$, Interest = $w_3 \times w_{10}$, Teaching Style = $w_3 \times w_{11}$ and Situational = $w_3 \times w_{12}$. The rank of main factors is based on the value of AW_T while the rank of sub-factors is based on the value of overall weight for each subfactor.

5. Results and Discussion

Table 4 shows the final ranking of factors and sub-factors that contributes to the Mathematics Performances during ODL for 10 respondents of FSKM students.

Table 4. Final ranking

Main Factor	**Weight**	**Rank**	**Sub-Factor**	**Weight**	**Rank**	**Overall Weight**	**Rank**
Attitude	0.3737	2	Patience	0.4290	1	0.1603	1
			Willingness	0.3032	2	0.1133	5
			Confidence	0.2678	3	0.1001	6
Environment	0.4172	1	Accessibility	0.3703	1	0.1545	2
			Commitment	0.3555	2	0.1483	3

			Conducive surrounding	0.2742	3	0.1144	4
Mathematics Anxiety	0.2091	3	Interest	0.3624	2	0.0758	8
			Teaching Style	0.4011	1	0.0839	7
			Situational	0.2366	3	0.0495	9

From Table 4, the analysis shows that Environment > Attitude > Mathematics anxiety. Patience is the most significant factor contributing towards mathematics performances. According to Ismail et al. (2011), it assumed that the level of patience plays an important role in Mathematics achievement. The students need to be aware of the steps and working of solving mathematics questions which requires a lot of patience especially during this online distance learning period. Meanwhile, the second rank is accessibility with an overall weight of 0.1545 and the third rank is commitment with an overall weight of 0.1483 where both are the sub-factors that correspond to main factor environment. Accessibility to internet connection while studying online is higher than student's commitment towards non-academic activities. It is because everything is done virtually and everything needs a good connection to interact and get the task completed.

From overall weight value of the sub-factors, the analysis shows that Patience > Accessibility > Commitment > Conducive surrounding > Willingness > Confidence > Teaching Style > Interest > Situational. Situational is the least significant factor contributing towards Mathematics performance of FSKM students. It indicates that the situation of the past experience with mathematics does not play a big role towards Mathematics performances during online distance learning compared to other factors.

6. Conclusion and Recommendation

This paper presented findings on the ranking of factors contributing towards Mathematics performance during online learning period among the FSKM students using AHP method. The main finding of this study shows that patience is the most significant factor contributing towards the Mathematics performance of FSKM students during online learning. Besides, Accessibility, Commitment and Conducive surrounding are among the main factors that contributed to the Mathematics performance of the students. Although the sample size is too small to make a generalization but the findings could give an alarm to the person in charge in the university to take further actions. The recommendation for this research is to enlarge the sample and scope of the research in the future. Students from various faculties at the university may also be included in the sample to widen the information. Other contributing factors that involved and related to this study are suggested to be identified.

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