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The Best Open and Distance Learning (ODL) Platforms for Mathematics Subjects Based on Student's Perspective Using Fuzzy Analytical Hierarchy Process (FAHP)

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ABSTRACT

COVID-19 is an unprecedented crisis that has affected almost all industry players, including education. Many universities and institutions have decided to execute the Open and Distance Learning (ODL) approach as a replacement for face-to-face learning. Most educators and students use a variety of online learning platforms to achieve greater integration and communication. Students studying mathematics may find ODL challenging because this subject requires computations that are difficult to show using an online learning platform. In addition, it is challenging to determine the exact and suitable criteria for the ODL platforms because there are numerous aspects to consider. This paper presents a finding from research that implements the Fuzzy Analytical Hierarchy Process to rank and identify the best teaching platforms for mathematics subjects during ODL. The eight most popular platforms were evaluated according to six main criteria: design, functionality, accessibility, usability, security and privacy, and maintenance, followed by twenty-five sub-criteria. The result shows Google Classroom is the most preferred information platform and Google Meet is the most preferred video meeting platform by students for ODL.

Keywords: COVID-19, Fuzzy Analytical Hierarchy Process, Open and Distance Learning

1 INTRODUCTION

As the recent Coronavirus Disease 2019 (COVID-19) outbreak has forced many universities and institutions to practice Open and Distance Learning (ODL), selecting the best ODL platform has become more critical. This learning method provides a new experience to educators and students because many aspects need to be emphasized. It includes the platforms on how the ODL will be conducted, the effectiveness of the chosen platforms, and the problems faced during ODL. ODL also causes constraints in two-way communication between educators and students because of a lack of face-to-face interaction. Thus, most educators and students use a variety of e-learning platforms to achieve greater integration and communication.

These various platforms make it difficult for educators to choose the best and most convenient platforms according to the learning content. In this research, the problems are being focused on students studying mathematics. In the event of a COVID-19 pandemic, institutions have limited time to determine the preparations they should have and how they meet the needs of students at various levels and fields of study [1]. In addition, it is challenging to determine the exact and suitable criteria for the ODL platforms because there are numerous aspects to consider. Hence, decision-making plays an important role. Decision-making is the study of choosing the best alternative among multiple alternatives based on the decision maker's preferences [2].

This research aims to rank and identify the best ODL platforms for mathematics subjects using one of the Multi-Criteria Decision Making (MCDM) techniques, the Fuzzy Analytical Hierarchy Process (FAHP) which is an advanced approach to Analytical Hierarchy Process (AHP). This method is used because many decision-making problems have fuzziness and vagueness, which may contribute to decision-makers imprecise assessments in traditional AHP procedures. FAHP has been widely considered a good way to alleviate the uncertainty of the AHP method, which employs fuzzy comparison ratios based on fuzzy scales of relative importance.

2 LITERATURE REVIEW

In this section, a review of past research is discussed. The Analytic Hierarchy Process method has been introduced by Thomas L. Saaty in 1980 as one of the methods in the decision-making tool. The fuzzy Analytic Hierarchy Process (FAHP) is an extension of the traditional Analytical Hierarchy Process (AHP), which was developed by [3]. There are some improvements to the Analytical Hierarchy Process that have been made throughout the years. As a result, the FAHP approach in use today is an adapted version of the traditional AHP because this method can overcome the vagueness and ambiguity of decision-making. The first extension of AHP was performed by [4]. In the fuzzy extension of AHP, the problem of deciding between a variety of options in the face of a conflicting judgment based on decision criteria had been highlighted.

This problem is solved by using a simple fuzzy triangular membership function to express a fuzzy ratio. Afterward [5] presented the geometric mean method for obtaining fuzzy weights for each fuzzy matrix, and this method was also used to obtain fuzzy weights for alternatives. Next, [6] introduced the correct normalization procedure for the method proposed by [4]. Chang introduces extent analysis as a new method for dealing with FAHP [7]. Lastly, [8] proposed a new questionnaire design for determining fuzzy numbers in the consulting process. This new questionnaire is designed to solve the difficulties in constructing a consistent judgment matrix and determining fuzzy numbers in FAHP.

However, because of its lack of ability with uncertain and imprecise values, FAHP has been introduced as an expanded method to overcome the problem. The FAHP is frequently employed in various sectors. According to past research by [9], FAHP is also implemented in the education sector. In [10] and [11], the FAHP method is applied to demonstrate the performance of the universities according to the evaluated criteria model, and the universities are ranked in prioritized order. Other than that, [13] used the FAHP to analyze the best program to further postgraduate studies. The FAHP technique is being used to determine the relative weights of course website quality components between groups with a lot of and a little bit of experience with online learning. By proposing a FAHP approach, it empowers a more exact depiction of the multiple attribute choices making process.

Based on previous research from [14], the FAHP approach is also applied in the ICT service industry and permits to capture and fostering of Intellectual Capital (IC) dynamics. Numerous IC components are intangible in the actual world, making them impossible to quantify. However, by using the FAHP, it is possible to access the contribution of each IC component to the esteem-generating process. According to [15] findings, FAHP, Fuzzy Measurement Alternatives, and Ranking according to Compromise Solution (F-MARCOS) are also used in the airline industry to evaluate e-service quality in the airline industry considering an uncertain, imprecise environment. In this research, the criteria influencing e-service quality in airlines have been prioritized. A real-world case study based on passenger evaluation and this approach can be used in different domains.

3 RESEARCH METHOD

The problem was modeled by using the FAHP method. A few factors used in the problem were weighted according to this method.

3.1 Problem Definition and Data Collection

This research identified six main criteria for ODL platforms which are: design, functionality, accessibility, usability, security and privacy, and maintenance, as well as twenty-five sub-criteria based on a systematic literature review. A group of students with an online learning experience through multiple platforms was chosen to achieve a better outcome. This problem was being focused on students studying mathematics because it can be difficult for them to understand concepts linked to computation when they are learning online.

As a result, a group of one hundred students taking mathematics subjects in UiTM Seremban 3 was chosen. A hierarchy structure for choosing the best ODL platforms consists of four levels starting with the goal, followed by main criteria, sub-criteria, and alternatives. The list of main criteria and sub-criteria are shown in Table 1.

Table 1 : List of Main Criteria and Sub-criteria

Main Criteria	Definition	Sub-criteria
Design (C1)	Design mainly refers to the internal design of the platform.	Page layout (C11) Colour (C12) Text (C13) Attractiveness (C14) Browser compatibility (C15)
Functionality (C2)	Functionality refers to the quality of the platform being useful, practical, and right for the purpose of online learning.	Scale (C21) Technical support (C22) Hypermediality (C23) Responsiveness (C24)

Accessibility (C3)	Accessibility is the practice of making the platforms usable by as many people as possible.	Network connection (C31) Cost of use (C32) Multilanguage (C33) Additional equipment (C34)
Usability (C4)	Usability is a measure of how well the user can use the platform satisfactorily.	Navigation (C41) Consistency (C42) Efficiency (C43) Clarity (C44)
Security and privacy (C5)	Privacy relates to the user's right to control personal information and security refers to how the personal information is protected.	Data privacy (C51) Data storing (C52) User permissions (C53) System recovery (C54)
Maintenance (C6)	Maintenance is the regular platform checking for issues and mistakes and keeping it updated and relevant.	New features updates (C61) Fix bugs timely (C62) Scheduled maintenance (C63) Licenses check (C64)

3.2 Concept of Fuzzy Set

Linguistic variables were used to evaluate the relative importance of the main criteria and sub-criteria. The scale of importance that had been introduced by [16] which is between 1 (equally important) to 9 (absolutely very important) had been implemented. These linguistic scales had been transformed into triangular fuzzy scales by [15]. Table 2 shows the linguistic scales and corresponding triangular fuzzy scales.

Table 2 : Linguistic Scales and Corresponding Triangular Fuzzy Scales

Linguistic Variable	**Linguistic Scale**	**Triangular Fuzzy Scale**	**Reciprocal Triangular Fuzzy Scale**
Equally important	1	(1,1,1)	(1,1,1)
Weakly more important	3	(2,3,4)	$\left(\frac{1}{4},\frac{1}{3},\frac{1}{2}\right)$
Strongly important	5	(4,5,6)	$\left(\frac{1}{6},\frac{1}{5},\frac{1}{4}\right)$
Very strongly more important	7	(6,7,8)	$\left(\frac{1}{8},\frac{1}{7},\frac{1}{6}\right)$
Absolutely more important	9	(9,9,9)	$\left(\frac{1}{9},\frac{1}{9},\frac{1}{9}\right)$
	2	(1,2,3)	$\left(\frac{1}{3},\frac{1}{2},1\right)$

	4	(3,4,5)	$\left(\frac{1}{5},\frac{1}{4},\frac{1}{3}\right)$
The intermediate values between two adjacent scale	6	(5,6,7)	$\left(\frac{1}{7},\frac{1}{6},\frac{1}{5}\right)$
	8	(7,8,9)	$\left(\frac{1}{9},\frac{1}{8},\frac{1}{7}\right)$

The triangular fuzzy scales can be described by a membership function. A grade of membership is assigned to each triangular fuzzy scale, denoted by $\mu_A(x) \rightarrow [1,0]$. A fuzzy set is defined by (1).

$$\overline{A} = \left\{\left(x, \mu_{\overline{A}}(x)\right) \mid x \in X, \mu_{\overline{A}}(x) \in [0,1]\right\} \tag{1}$$

the first element x belongs to the classical set X, the second element $\mu_A(x)$ belongs to the interval [0, 1] which is called the membership function. This membership function is represented using a fuzzy number as shown in Figure 1.

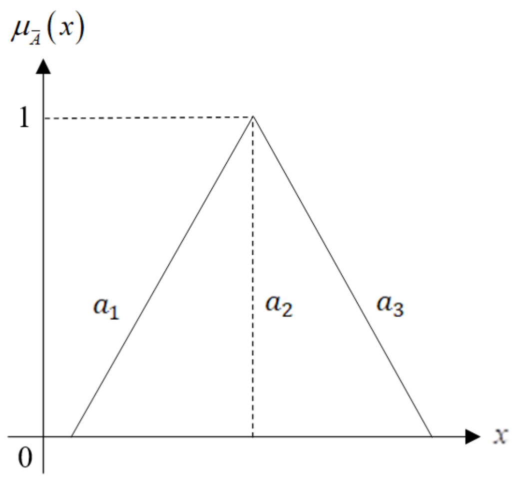

Figure 1 : Triangular Fuzzy Number

The triangular membership function of the fuzzy number which is associated with a real number in the interval [0,1] can be defined using (2).

$$\mu_{\bar{A}}(x) = \begin{cases} \dfrac{x-a_1}{a_2-a_1}, & x \in [a_1, a_2] \\ \dfrac{a_3-x}{a_3-a_2}, & x \in [a_{2,} a_3] \\ 0, & otherwise \end{cases} \tag{2}$$

3.3 Determine Weights for Main Criteria

There are five steps to determine weights for the main criteria. These steps are essential and are the cornerstone of the FAHP process.

3.3.1 Step 1: Perform pairwise comparison and construct a fuzzy pairwise comparison

A questionnaire was distributed to one hundred UiTM Seremban 3 students taking mathematics subjects. Based on the results of this survey, one hundred fuzzy pairwise comparison matrices were constructed using an excel spreadsheet. Table 3 shows the example of a fuzzy pairwise comparison matrix for respondent 1 (R1). For the first row in Table 3, R1 gives equally important criteria C2, and C4, strongly important for criteria C3 and C5, and Very strongly more important for C6 when compared with C1.

Table 3 : The Fuzzy Pairwise Comparison Matrix of the Student Evaluation

	C1	C2	C3	C4	C5	C6
C1	(1.000000, 1.000000, 1.000000)	(1.000000, 1.000000, 1.000000)	(0.166667, 0.200000, 0.250000)	(1.000000, 1.000000, 1.000000)	(0.166667, 0.200000, 0.250000)	(0.125000, 0.142900, 0.166700)
C2	(1.000000, 1.000000, 1.000000)	(1.000000, 1.000000, 1.000000)	(6.000000, 7.000000, 8.000000)	(0.142857, 0.166667, 0.200000)	(1.000000, 1.000000, 1.000000)	(0.142857, 0.166667, 0.200000)
C3	(4.000000, 5.000000, 6.000000)	(0.125000, 0.142857, 0.166667)	(1.000000, 1.000000, 1.000000)	(1.000000, 2.000000, 3.000000)	(0.166667, 0.200000, 0.250000)	(1.000000, 1.000000, 1.000000)
C4	(1.000000, 1.000000, 1.000000)	(5.000000, 6.000000, 7.000000)	(0.333333, 0.500000, 1.000000)	(1.000000, 1.000000, 1.000000)	(1.000000, 1.000000, 1.000000)	(0.125000, 0.142857, 0.166667)
C5	(4.000000, 5.000000, 6.000000)	(1.000000, 1.000000, 1.000000)	(4.000000, 5.000000, 6.000000)	(1.000000, 1.000000, 1.000000)	(1.000000, 1.000000, 1.000000)	5.000000, 6.000000, 7.000000
C6	(6.000000, 7.000000, 8.000000)	(5.000000, 6.000000, 7.000000)	(1.000000, 1.000000, 1.000000)	(6.000000, 7.000000, 8.000000)	(0.142857, 0.166667, 0.200000)	(1.000000, 1.000000, 1.000000)

3.3.2 Step 2: Aggregate Fuzzy Pairwise Comparison Matrix

After obtaining the fuzzy judgment matrices from all students, the matrices were aggregated by taking the geometric mean. The aggregated TFN of n students' judgment in a certain case $u_{ij} = \left(l_{ij}, m_{ij}, u_{ij}\right)$ as (3).

$$\left(\prod_{i=1}^{n} \tilde{a}_{ijk}\right)^{\frac{1}{n}} \tag{3}$$

where $\tilde{a}_{ijk}$ indicates the Triangular Fuzzy Number for the relative importance of the k^{th} viewpoint of the student and n is the total number of students. Table 4 shows the aggregated fuzzy pairwise comparison matrix.

Table 4 : The Aggregated Fuzzy Pairwise Comparison Matrix

	C1	C2	C3	C4	C5	C6
C1	(1.000000, 1.000000, 1.000000)	(0.452598, 0.488208, 0.533590)	(0.306157, 0.340838, 0.387855)	(0.380027, 0.418864, 0.472814)	(0.293125, 0.324324, 0.367765)	(0.292032, 0.325853, 0.365311)
C2	(1.874097, 2.048308, 2.209465)	(1.000000, 1.000000, 1.000000)	(1.059462, 1.126619, 1.190761)	(0.915676, 0.979898, 1.055394)	(0.640599, 0.669453, 0.703736)	(1.134448, 1.225948, 1.314825)
C3	(2.578284, 2.933941, 3.266303)	(0.839799, 0.887611, 0.943875)	(1.000000, 1.000000, 1.000000)	(0.929515, 0.992936, 1.061482)	(0.655788, 0.694696, 0.736726)	(1.098306, 1.201190, 1.311746)
C4	(2.114995, 2.387412, 2.631389)	(0.947513, 1.020514, 1.092090)	(0.942079, 1.007114, 1.075829)	(1.000000, 1.000000, 1.000000)	(0.574250, 0.613378, 0.655967)	(0.950051, 1.016223, 1.086956)
C5	(2.719127, 3.083334, 3.411519)	(1.420987, 1.493756, 1.561038)	(1.357357, 1.439478, 1.524882)	(1.524467, 1.630317, 1.741403)	(1.000000, 1.000000, 1.000000)	(1.345592, 1.445256, 1.544301)
C6	(2.737391, 3.068869, 3.424284)	(0.760558, 0.815695, 0.881486)	(0.762343, 0.832508, 0.910493)	(0.920000, 0.984036, 1.052575)	(0.647542, 0.691919, 0.743168)	(1.000000, 1.000000, 1.000000)

3.3.3 Step 3: Consistency Test of the Comparison Matrix

The defuzzification method of fuzzy triangular numbers by [17] transformed the fuzzy comparison matrices into crisp matrices, which were then used for the consistency test. The defuzzification formula is shown in (4).

$$\overline{A} - crisp = \frac{4m + l + u}{6} \tag{4}$$

where $\bar{A}$ is a fuzzy triangular number denoted as $\bar{A}=(l,m,u)$. The Consistency Ratio is calculated using (5).

$$C.R.=\frac{C.I}{R.I}=\frac{0.008592}{1.24}=0.006929 \tag{5}$$

where C.I. is the Consistency Index and R.I is the Random Consistency Index. The consistency ratio calculated is 0.006929 which indicates that the consistency ratio is less than 0.1 and the fuzzy pairwise comparison matrix is consistent.

3.3.4 Step 4: The Geometric Mean of Fuzzy Comparison Values

According to [5], from a positive reciprocal matrix $\bar{A}=\left[\bar{a}_{ij}\right]$, the geometric mean of each row is calculated using (6).

$$\bar{r}_i=\left(\prod_{j=1}^{m}\bar{a}_{ij}\right)^{\frac{1}{m}} \tag{6}$$

where $\bar{r}_i$ is fuzzy geometric mean value, m is the total number of main criteria, and $\bar{a}_{ij}$ is the main criteria's preference of i^{th} criterion over j^{th} criterion via fuzzy triangular numbers. The geometric mean of fuzzy comparison values is shown in Table 5.

Table 5 : Geometric mean of fuzzy comparison

Main Criteria		$\bar{r}_i$	
C1	0.406436	0.441101	0.485811
C2	1.047527	1.108556	1.170309
C3	1.063837	1.136755	1.211546
C4	1.004936	1.073389	1.140810
C5	1.485790	1.581080	1.671879
C6	0.990708	1.060051	1.136057
Total	5.999234	6.400931	6.816412
Reverse Vector	0.146705	0.156227	0.166688

Then, the fuzzy weights are calculated using (7).

$$\bar{w}_i=\bar{r}_i\otimes\left(\bar{r}_1\oplus\bar{r}_2\oplus\ldots\oplus\bar{r}_m\right)^{-1} \tag{7}$$

$$\bar{w}_{C1}=0.406436\otimes 0.146705=0.059626$$

where $\left(\bar{r}_1 \oplus \bar{r}_2 \oplus \ldots \oplus \bar{r}_m\right)^{-1}$ is the reverse vector and multiply each $\bar{r}_i$ with this reverse vector. The fuzzy weights for all main criteria are shown in Table 6.

Table 6 : Fuzzy Weights

Main Criteria		$\bar{w}_i$	
C1	0.059626	0.068912	0.080979
C2	0.153677	0.173187	0.195076
C3	0.156070	0.177592	0.201950
C4	0.147429	0.167693	0.190159
C5	0.217972	0.247008	0.278682
C6	0.145342	0.165609	0.189367

3.3.5 Step 5: Defuzzification and Normalization

The non-fuzzy weights for all main criteria, M_i were calculated by defuzzifying the fuzzy weights using the Center of Area (COA) method. This method takes the average of fuzzy numbers for each main criterion. Next, the non-fuzzy weights were normalized to obtain the normalized weights, N_i used for further calculation. The defuzzified and normalized fuzzy weights are shown in Table 7.

Table 7 : Defuzzified and Normalized Fuzzy Weights

Main Criteria	**Defuzzified Weights,** M_i	**Normalized Weights,** N_i
C1	0.069839	0.069461
C2	0.173980	0.173038
C3	0.178537	0.177571
C4	0.168427	0.167515
C5	0.247887	0.246545
C6	0.166773	0.165870
Total	1.005443	1.000000

The final weight for all main criteria is shown in Figure 2.

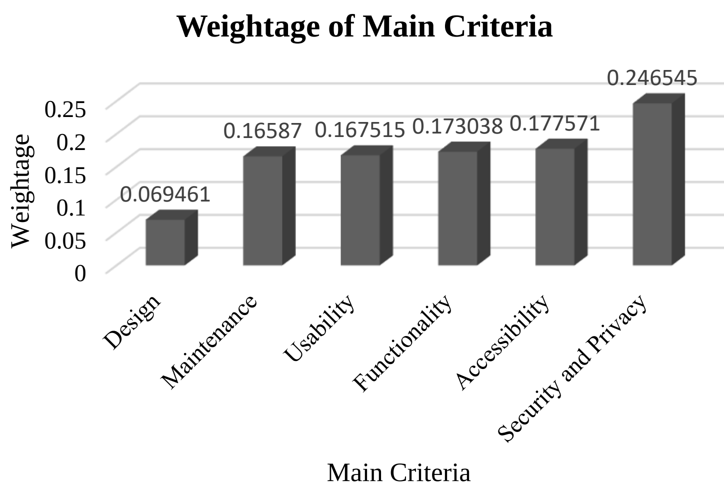

Figure 2: Final Weight for All Main Criteria

4 ANALYSIS OF ALTERNATIVES

The ODL platforms were then integrated with the main criteria and sub-criteria to get the weight for each ODL platforms. Comparing the decision alternatives under each sub-criterion separately will get a better result for which alternatives are most preferable. The weights for ODL platforms concerning each sub-criterion were calculated using the same prioritization method based on the student answer from the survey. Table 8 shows the alternatives for the ODL platforms in two categories which are information platforms and video meeting platforms.

Table 8: The list of alternatives

Types of ODL Platforms	ODL Platforms
Information Platforms	Google Classroom (A1)
	Microsoft Teams (A2)
	Telegram (A3)
	WhatsApp Messenger (A4)
Video Meetings Platforms	Google Meet (A5)
	Zoom Cloud Meetings (A6)
	Webex (A7)

Table 9-14 shows the weights of ODL platforms with respect to sub-criteria of each main criteria. Table 15 shows the global scores and normalized global scores of ODL platforms.

Table 9 : Weights of ODL Platforms with Respect to Sub-criteria of Design

Sub Criteria	**ODL Platforms**						
	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**
C11	7.787537	7.390987	6.885620	6.748639	7.618710	6.311437	5.963512
C12	7.444292	7.245336	7.111068	6.928100	7.331797	6.448062	6.050885
C13	7.266530	6.930872	7.248600	6.930770	7.178248	6.295704	5.868915
C14	7.550930	6.742411	6.812590	7.062309	7.217667	6.145603	5.960253
C15	7.515275	6.761424	7.326759	7.113795	7.308260	6.063201	6.011303
Global Weights	2.609266	2.436063	2.457847	2.416099	2.546065	2.171624	2.073744
Normalized Global Weights	0.137565	0.128434	0.129582	0.127381	0.134233	0.114492	0.109332

Table 10 : Weights of ODL Platforms with Respect to Sub-criteria of Functionality

Sub Criteria	**ODL Platforms**						
	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**
C21	7.733692	7.368992	7.625115	6.975261	6.961845	6.715015	6.501616
C22	7.282564	6.812703	6.772241	7.058390	7.175906	6.302550	6.077869
C23	7.446944	7.116905	7.060583	7.048413	7.323010	6.298509	6.112169
C24	7.310955	6.883088	7.161209	7.095538	6.917667	6.526705	6.235648
Global Weights	5.152066	4.876508	4.952206	4.875801	4.910552	4.471788	4.313375
Normalized Global Weights	0.136709	0.129397	0.131405	0.129378	0.130300	0.118658	0.114454

Table 11 : Weights of ODL Platforms with Respect to Sub-criteria of Accessibility

Sub Criteria	**ODL Platforms**						
	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**
C31	7.253103	6.153672	7.251023	5.591361	6.611441	6.152246	6.016729
C32	4.330640	4.861550	4.213410	4.124631	4.697408	4.982170	5.040290
C33	3.526163	3.489432	3.374277	5.058424	3.639111	3.812416	3.862991
C34	6.204452	6.268327	6.168496	6.363821	6.605500	5.887533	5.949655
Global Weights	3.784808	3.688675	3.730267	3.753534	3.827265	3.699575	3.705843
Normalized Global Weights	0.127579	0.124338	0.125740	0.126525	0.129010	0.124706	0.124917

Table 12 : Weights of ODL Platforms with Respect to Sub-criteria of Usability

Sub Criteria	ODL Platforms						
	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**
C41	6.957427	6.647545	6.800567	6.793221	6.675793	6.109492	5.933711
C42	7.210048	6.825613	6.976416	6.801741	6.834894	6.418052	6.106142
C43	7.371243	6.813246	6.930481	6.956017	7.095185	6.565429	5.888749
C44	7.378566	6.848410	7.188140	7.068414	7.134436	6.436625	6.205064
Global Weights	4.844081	4.545491	4.672934	4.626665	4.646920	4.276593	4.042753
Normalized Global Weights	0.135805	0.127434	0.131006	0.129709	0.130277	0.119895	0.113339

Table 13 : Weights of ODL Platforms with Respect to Sub-criteria of Security and Privacy

Sub Criteria	ODL Platforms						
	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**
C51	7.398405	7.316523	6.992299	6.946857	6.992064	6.576756	6.574422
C52	7.381972	7.178248	7.419021	6.875619	6.776552	6.464305	6.244432
C53	7.432332	7.149240	6.957065	6.731082	7.136336	6.553571	6.543682
C54	6.942718	6.595488	6.834268	6.591408	6.587359	5.746100	5.832557
Global Weights	7.188137	6.962319	6.953235	6.692467	6.778103	6.247641	6.211735
Normalized Global Weights	0.133803	0.129599	0.129430	0.124576	0.126170	0.116296	0.115628

Table 14 : Weights of ODL Platforms with Respect to Sub-criteria of Maintenance

Sub Criteria	ODL Platforms						
	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**
C61	6.868380	6.799848	6.912938	6.485422	6.791609	5.985769	6.020227
C62	6.546546	6.136406	6.396289	6.365511	6.209906	5.784798	5.713396
C63	6.440629	6.115679	6.271800	6.223327	6.236993	5.804431	5.731708
C64	6.219662	6.183141	6.208474	6.087056	6.164455	5.852624	5.636161
Global Weights	4.325087	4.185733	4.277695	4.173499	4.213581	3.885931	3.831836
Normalized Global Weights	0.132363	0.128099	0.130913	0.127724	0.128951	0.118924	0.117268

Table 15 : The Global Scores and Normalized Global Scores of ODL Platforms

ODL Platforms	Global Scores	Normalized Global Scores
A1	0.803824	0.133971
A2	0.767301	0.127883
A3	0.778078	0.129680
A4	0.765294	0.127549
A5	0.778942	0.129824
A6	0.712970	0.118828
A7	0.694938	0.115823

The ranking of ODL platforms was established based on the normalized global scores in Table 15. This ranking can be categorized into two types of ODL platforms, namely information platforms, and video meeting platforms. Students can use information platforms to get information from their lecturers on their coursework, tests, quizzes, and other key course material. Video meeting platforms can be used for a video conference to facilitate interaction between students and lectures.

5 RESULTS AND DISCUSSION

Table 16 shows the ranking ODL platforms in terms of their weights according to two types of platforms, information platforms, and video meeting platforms.

Table 16 : Ranking of ODL Platforms

Types of ODL Platforms	ODL Platforms	Weightage	Ranking
Information Platforms	Google Classroom	0.133971	1
	Telegram	0.129680	2
	Microsoft Teams	0.127883	3
	WhatsApp Messenger	0.127549	4
Video Meetings Platforms	Google Meet	0.129824	1
	Zoom Cloud Meetings	0.118828	2
	Webex	0.115823	3

The first ranking for information platforms is Google Classroom, with a weightage of 0.133971. During the early days of the COVID-19 pandemic, Google Classroom is among the platforms initially used by lecturers and students to obtain learning materials and submit assignments, test answers, or quizzes. The second ranking is Telegram, with a weightage of 0.12968. The third ranking is Microsoft Teams, with a weightage of 0.127883, and the fourth is WhatsApp Messenger, with a weightage of 0.127549.

On the other hand, Google Meet is the first ranking for the video meetings platform with a weightage of 0.129824. Google Meet is a platform for video conferences that are particularly popular during the COVID-19 pandemic. It has features that enable students and lecturers to present learning materials such as slides, videos, and others. The second-ranking for video meetings platform is Zoom Cloud

Meetings, with a weightage of 0.118828. Zoom Cloud Meetings has the same features as Google Meet but is better suited to webinars or organization meetings.

The last ranking for video meetings platform is Webex with a weightage of 0.115823. Even though Google Meet is the most preferred video meeting platform by students, it currently has the limitation of not being able to record the meetings. This function is extremely beneficial to students since students who are unable to attend the lecture can watch the recorded meeting later and they will not be left behind. Hence, concerning this situation, students and lecturers can also use Zoom Cloud Meetings and Webex since both have the same recording function.

6 CONCLUSION

This research used the FAHP approach to solve the problem of choosing the best ODL platforms for mathematics subjects based on students' perspectives. FAHP was used among other MCDM methods since it can consider both qualitative and quantitative measures. It can also handle fuzziness in making decisions; this will help students choose the best ODL platforms with high precision. Triangular fuzzy numbers were utilized in constructing pairwise comparisons of criteria and alternatives by one hundred UiTM Seremban 3 students. The geometric Mean method by [5] was used to calculate the weights of criteria and alternatives.

After applying the FAHP method in this research, it was found that security and privacy are the most important criteria in choosing an ODL platform, followed by accessibility on the second and functionality on the third. Subsequently, Google Classroom is the most preferred information platform, followed by Telegram on the second and Microsoft Teams on the third. Meanwhile, Google Meet is the most preferred video meeting platform among students during ODL, followed by Zoom Cloud Meetings on the second and Webex on the third. The results indicate that FAHP can qualify the qualitative judgment to produce a more precise comparison in the pairwise comparison step. The results of this research are reliable and prove that FAHP has the power in solving MCDM problems. Thus, these results will assist students in choosing the best ODL platforms.

Future research might consider a large sample of decision-makers who come from many universities and not focus only on UiTM. In addition, the external factors of students and the individual differences in learning abilities and special needs should be addressed in selecting a group of students to establish a quality evaluation model. Future research might also explore more MCDM methods, such as Fuzzy Analytic Network Process (FANP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), and Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE). Additionally, FAHP can also be used with other MCDM methods such as TOPSIS to establish a hybrid method.

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