Journal of Mathematics and Computing Science, 2023,
Volume 9, No 2, 76-88

Application of Fuzzy Analytical Hierarchy Process in the Selection of Social Networking Sites

Nor Aida Nabilah Anuar[1], Suziana Aida Othman[2*], Nurin Fareeha Ibrahim[3], Nur Azyyati Zakaria[4], Wan Nurul Husna Wan Nordin[5] and Masnira Ramli[6]

[1,2,3,4,5,6]College of Computing, Informatics and Mathematics, Universiti Teknologi MARA Cawangan Kelantan, Kampus Machang, 18500 Machang, Kelantan, Malaysia

Authors' email: 2021155963@student.uitm.edu.my, suziana554@uitm.edu.my*, 2021113567@student.uitm.edu.my, 2021132181@student.uitm.edu.my, husna78@uitm.edu.my and masnira@uitm.edu.my

*Corresponding author

Received 18 October 2023; Received in revised 7 November 2023; Accepted 26 November 2023
Available online 18 December 2023

Abstract: Social networking sites (SNS) have become a ubiquitous part of modern life, with millions of people using SNS to stay in touch, to network, and to share information. SNS also provides a platform for university management to communicate with students and keep them informed about events, deadlines, and other important information. Besides, SNS allows students to access information, resources, and knowledge from a variety of sources, including university staff, other students, and subject-matter experts. With so many options of SNS available, the university management must identify which platform is commonly used by students. Hence, this study proposes a Fuzzy Analytic Hierarchy Process (FAHP) approach to evaluate and rank five popular SNSs: Instagram, Facebook, TikTok, Twitter, and YouTube among students in Universiti Teknologi MARA Cawangan Kelantan (UiTMCK). Five experts were invited to provide a rating of the performance values of criteria, sub-criteria, and alternatives using a linguistic scale. The evaluation is based on four criteria: Content (C_1), Functionality (C_2), Usability (C_3), and Privacy (C_4), with another eight sub-criteria. The results demonstrate the effectiveness of the FAHP in selecting the best SNS and indicate that Facebook (A_1) is at the first ranking followed by Instagram (A_2), TikTok (A_3), Twitter (A_4), and YouTube (A_5). Content is identified as the most important criterion with advertisement as the preferred sub-criterion. The findings of the study highlight the importance of utilizing social media platforms to enhance creativity in promoting programs and events, which can increase student participation and engagement in university activities.

Keywords: Fuzzy AHP, Ranking, Social networking sites

1 Introduction

Social networking sites (SNS) have been making their first appearance in the late 1990s. Friendster was the most popular of the early sites, with varied foci and levels of success. In 2003, social networking sites began to grow quickly after the launch of Myspace. Social media is one of the social networking sites that serves a variety of essential functions inside a community. It provides a platform for residents to perform and get recognition [1]. Besides, [2] mentioned that students use SNS for both social and academic purposes. People from all cultures are gradually using the internet to be involved in SNSs, showing that digital channels are experiencing rapid growth around the world. According to [3], 86% of Malaysians are active social media users and the majority of the users are youths aged 13-34, and most of them are students, showing that almost all students are SNS users.

In 2020, with the onset of the COVID-19 pandemic and lockdown measures, universities and institutions in Malaysia swiftly transitioned to open and distance learning (ODL). As the pandemic evolved, many educational institutions in Malaysia adopted hybrid learning models that combined in-person and ODL elements. Consequently, this transition has a direct impact on managing events or programs that require the participation of students, which results in the start of a virtual event. Due to the huge number of participants in every event that has been held so far, there have been a few times when technical issues have arisen because the platform used was not able to contain huge numbers of users at the same time.

Students nowadays tend to retrieve information from their social networks and rarely visit their university's information boards since social media are so easily accessible. It is most likely that students will receive the information from unauthentic sources, which may result in false information. To prevent false information from spreading, university management must ensure that students do not miss important news, information, and notices, as well as to keep up with the trend. Besides, to attract students' attention and encourage participation, both student councils and university clubs and societies should enhance their creativity in promoting their latest programs. Relying on a single poster alone is insufficient as it fails to effectively capture students' interest or attract them to join. Instead, these committees should explore more innovative methods, such as utilizing social media platforms, which are the most convenient and widely used means of communication in today's society.

Therefore, the university management, the committee of student councils, and university clubs and societies need to know which social networking sites the students regularly use to communicate with them. Hence, this study proposes multi-criteria decision-making (MCDM) methods to select the most suitable SNS as a platform for sharing information or notices. MCDM can be described as a method to prioritize, rank, or choose from a variety of different alternatives or possibilities based on multiple criteria. MCDM has been widely used by researchers in various fields to make decisions. Examples of MCDM techniques include the analytical hierarchical process (AHP), the analytical network process (ANP), a technique for order of preference by similarity to ideal solution (TOPSIS), data envelopment analysis (DEA), and fuzzy decision-making [4].

This study proposes the use of a Fuzzy Analytic Hierarchy Process (FAHP) to develop a more systematic decision-making approach. The AHP, discovered by Thomas Saaty in 1971, is a modern tool suitable for complex decision-making [5]. The AHP is a beneficial method for decision-makers by setting priorities to make efficient decisions. The three major components of AHP are hierarchy construction, priority analysis, and consistency verification. The process in FAHP begins by determining the relevant factors and then structuring these factors into a hierarchy. Then, the hierarchy descends in successive levels from an overall goal to specific dimensions and criteria, with numerical values assigned to each variable [6].

This study aims to identify the most used SNS among UiTMCK students by using FAHP. The selected alternatives are Facebook, Instagram, TikTok, Twitter, and YouTube, while the criteria in consideration include content, functionality, usability, and privacy, with another eight sub-criteria.

2 Literature Review

According to [7], in light of the foregoing, the rising popularity of social networking sites raises crucial considerations concerning the societal consequences of their use. The invention of the internet has allowed us to connect with people globally with a simple click of a button. Connection with this online world can be the best experience for society, despite the development of smartphones and applications merging with social networking technology. However, people can still use it in different ways, such as to get information, socialize, or for entertainment purposes. In the second quarter of 2008, around 75% of internet users engaged in social media activities such as accessing social networks, reading blogs, or leaving reviews on shopping sites, which shows an increase of 56% in 2007 [8]. In contrast to the increasing popularity of SNS, more SNSs have been launched with more attractive layouts and different functions. To compete with recent SNSs that have been launched, social media networks like Facebook, Twitter, Instagram, and YouTube have been improving their website in every aspect to attract more users. For example, in April 2011, YouTube officially introduced live streaming [9] and then in August 2015, Facebook introduced its first live function [10], followed by Instagram in 2016 [11]. Meanwhile, Twitter introduced the Twitter Spaces function which is an audio streaming feature that lets users livestream discussions and allows a wide variety of options for engagement in 2020 [12]. Besides that, a lot more features have been released among those SNSs with similar functions.

A study carried out by [13] compared the three most popular SNSs which are Facebook, Myspace, and Twitter, with usability and sociability being two major factors for evaluating the success of online communities. As a result, their study proposed the National Intellectual Capital Index (NICI) model with four criteria (navigation, interactivity, source credibility, and intelligence), and various measurements for each criterion, and made a comparison on the three popular SNSs. Based on the NICI model, the three social networking sites can be classified into two groups. Facebook and Myspace belong to the same group that provides diversified social services, such as photos, videos, and applications. The study also found that Facebook and Myspace are more interactive than Twitter as they allow users to share more information about themselves. The study concluded that the higher the usability, the more useful features will be emerging, and the more varieties of measurements need to be proposed.

A recent study by [14] identified Facebook, Instagram, and Twitter as the most popular SNS among university students based on four criteria. The study proposed a solution by developing a mathematical technique which is the Fuzzy Analytical Hierarchy Process (FAHP) to estimate the relative importance of site criteria used in deciding the social site. The criteria used in the study are content, functionality, usability, and privacy. The results of the study revealed that students put functionality as their top priority in choosing SNSs. The second criterion that influences the selection of SNS is content. The respondents preferred to choose it because of the advertisements that appear on social media sites. Privacy was the least important criterion of concern in choosing SNS among students. The result of this study shows that Instagram has the first ranking followed by Facebook and Twitter.

Therefore, based on previous studies on SNS, it can be seen that in identifying the most used SNS among students, the characteristics or the criteria of the SNS need to be taken into consideration. This problem can be categorized as an MCDM problem which is considered as the most essential component of operational research. The MCDM refers to decision-making in the presence of multiple criteria to help the decision makers in selecting the best alternative under uncertain situations. In this study, the FAHP will be utilized to determine the most preferred SNS among students in UiTM Cawangan Kelantan.

The AHP was introduced by Thomas Saaty in 1980 and it has become the most widely used technique for multi-criteria decision-making problems because of its simplicity, ease of use, great flexibility, and ability to be combined with any other methods [15]. The AHP have been widely applied in the last four decades, the FAHP, has also been employed in many studies because of its formulation. [16] stated that despite the popularity of AHP, it cannot handle the uncertainty and vagueness of human preferences, which result in less appropriate decisions. Therefore, the FAHP was developed to overcome the weaknesses of AHP. FAHP is implemented in this study to determine the most used SNSs among students in UiTMCK according to the criteria used in previous studies as illustrated in Table 1:

Table 1: The Description of Sub-Criteria

Criteria	**Sub-criteria**	**Description**	**Source**
Content	Advertisement	A notice on a website promoting.	[14], [17]
	Website attractiveness	A key online role enhancing purchases among consumers.	[14], [18]
Functionality	Content Management	Processes and technologies that support the obtaining, managing, and publishing of information on any platform.	[14], [17]
	Interactiveness	The degree to which an individual perceives those important others believe that they should use the new system.	[13], [19]

Usability	Ease of use	The easy use and handling of social sites.	[13], [14], [17], [20], [21]
	Site performance	The speed at which web pages are downloaded and displayed on the user's web.	[13], [14], [17], [20]
Privacy	Privacy settings	Allow users to limit who can access your profile.	[14], [21]
	Information security	Protected against the unauthorized use of information.	[20], [21]

3 Methodology

The objective of this study is to rank the most used social networking sites (SNSs) among students in UiTMCK using Fuzzy Analytical Hierarchy Process (FAHP). The necessary steps are explained in detail and shown in Figure 1:

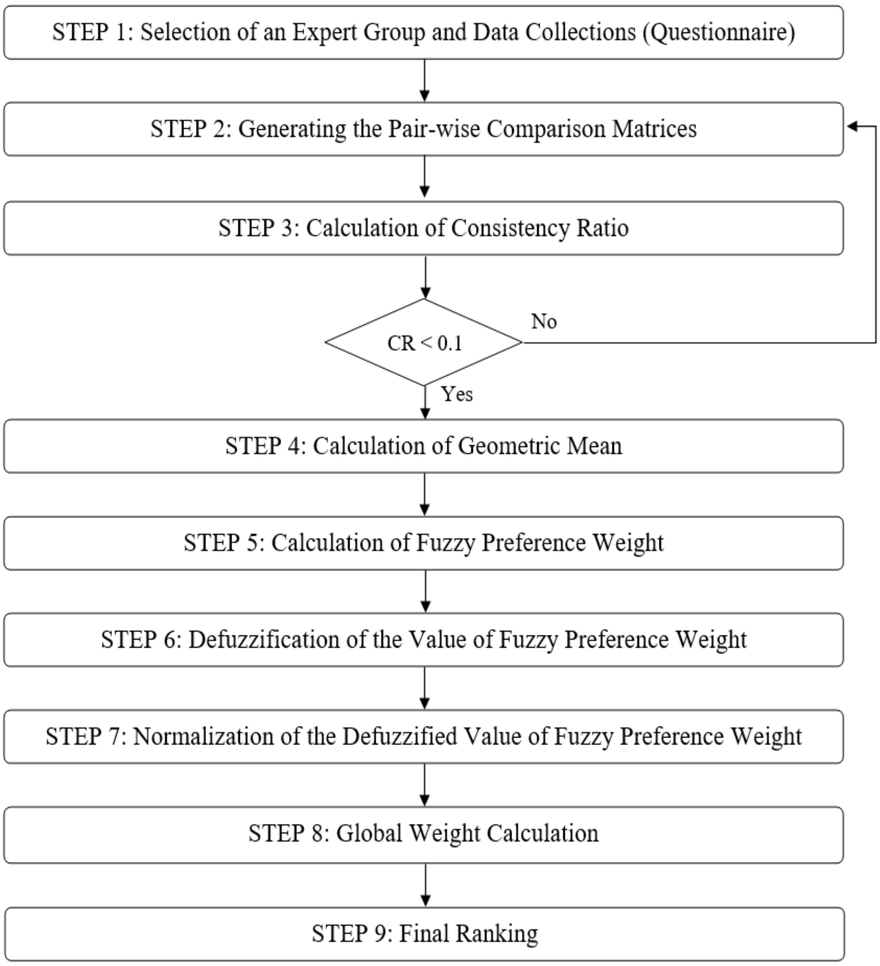

Figure 1: System Architecture for Problem Solving using FAHP Model

Step 1: Selection of an Expert Group and Data Collection

Five experts or decision makers (DMs) consisted of students who are active users of SNSs were chosen to gain information and interpret their responses to the questionnaire into a Triangular Fuzzy Number

(TFN). The chosen experts were asked to answer the fuzzy questionnaire to generate the pair-wise comparison matrices.

Step 2: Generating the Pair-wise Comparison Matrices

In FAHP, the comparison of criteria would be performed through the linguistic variables, which are represented by TFN. Table 2 presents a fuzzy version of the common fuzzy scale, in which the result of each comparison is shown as a triangular fuzzy number and its inverse equivalent, adopted from [22]. A triangular fuzzy number is represented by lower value, *l*; middle value, *m*; and upper value, *u*.

Table 2: Linguistic Scale and the Corresponding Triangular Fuzzy Number

Linguistic Scale	**Triangular Fuzzy Number**	**Reciprocal TFN**
Equally Important	(1, 1, 1)	(1, 1, 1)
Weakly More Important	$\left(1, \frac{3}{2}, 2\right)$	$\left(\frac{1}{2}, \frac{2}{3}, 1\right)$
Strongly More Important	$\left(\frac{3}{2}, 2, \frac{5}{2}\right)$	$\left(\frac{2}{5}, \frac{1}{2}, \frac{2}{3}\right)$
Very Strongly More Important	$\left(2, \frac{5}{2}, 3\right)$	$\left(\frac{1}{3}, \frac{2}{5}, \frac{1}{2}\right)$
Absolutely More Important	$\left(\frac{5}{2}, 3, \frac{7}{2}\right)$	$\left(\frac{2}{7}, \frac{1}{3}, \frac{2}{5}\right)$

Step 3: Calculation of Consistency Ratio

[23] proposed a Consistency Index (*CI*) to measure the consistency of a comparison matrix. The purpose of the consistency ratio is to determine whether the expert's data is reliable or not. The comparison would be accepted when the Consistency Ratio (*CR*) is equal to or less than 0.1. The consistency ratio and consistency index were calculated by using the following equations:

$$CI = \frac{\lambda_{max} - N}{N - 1} \tag{1}$$

$$CR = \frac{CI}{RI} \tag{2}$$

where *CI* is the Consistency Index, λ_{max} is the largest eigenvalue of the comparison matrix, *N* is the dimension of the matrix or the number of criteria, *CR* is the Consistency Ratio and *RI* is the Random Consistency Index. Table 3 illustrates the value of the Random Consistency Index (*RI*) adopted from [23]. If the value of $CR \leq 0.1$, then the calculation will proceed to the next step. Otherwise, the expert's data would be revised to obtain valid data or will be neglected.

Table 3: Saaty's Random Consistency Index, *RI*

N	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Step 4: Calculation of Geometric Mean

The fuzzy geometrical mean technique was implemented to define the fuzzy geometrical mean of each criterion, which was calculated by Eq. (3).

$$r_i = \left(\prod_{j=1}^{n} d_{ij} \right)^{\frac{1}{n}} \quad \text{such that } i = 1, 2, 3, \ldots, n \tag{3}$$

where r_i is the fuzzy geometrical mean and d_{ij} is the fuzzy comparison value from a group of decision-makers with respect to i^{th} dimension over the j^{th} criterion.

Step 5: Calculation of the Fuzzy Preference Weight

The fuzzy preference weight, w_i for each criterion can be computed using Eq. (5) where the value of r_i from Eq. (3) will be multiplied by the inverse of the vector summation obtained from Eq. (4).

$$\text{Vector summation} = \sum r_i \quad \text{such that } i = 1, 2, 3, \ldots, n \tag{4}$$

$$w_i = r_i \otimes \left(r_1 \oplus r_2 \oplus r_3 \oplus \ldots \oplus r_n \right)^{-1} \tag{5}$$

Step 6: Defuzzification of the Value of Fuzzy Preference

The defuzzification of the value for fuzzy preference weight is needed to transform the values into real numbers. The defuzzified value of w_i can be obtained by using the Centre of Area method proposed by [24] as shown in Eq. (6):

$$G_i = \frac{l_{w_i} + m_{w_i} + u_{w_i}}{3} \tag{6}$$

Step 7: Normalization of the Defuzzified Value of Fuzzy Preference Weight

The value of G_i in Step 6 is a non-fuzzy number, then the defuzzified values of fuzzy preference weight need to be normalized. The normalization of each criterion, H_i was calculated using Eq. (7):

$$H_i = \frac{G_i}{\sum_{i=1}^{n} G_i} \tag{7}$$

Following that, the outcomes were arranged by the normalized weights for each criterion.

Step 8: Global Weight Calculation

Global weight calculation involves all the weight vectors (local vectors) from all criteria and alternatives. The value of the local weight for the main criteria would be multiplied by the value of the local weight for sub-criteria and alternatives to determine the global weight which were used in developing a selection score model.

Step 9: Global Weight Calculation

The alternatives were ranked based on the global weight obtained in Step 8.

4 Results and Discussion

In this study, five experts among UiTMCK students were selected as the decision makers (DM_1, DM_2, DM_3, DM_4, and DM_5). They are active users of Instagram, Facebook, TikTok, Twitter, and YouTube and spend almost six to nine hours daily on these platforms. The selected experts were required to answer a fuzzy questionnaire which was used to generate a pairwise comparison matrix. The questionnaire was developed based on the specified selection criteria and sub-criteria for alternatives. The criteria and sub-criteria were obtained by reviewing the literature and obtaining the experts' opinions. Therefore, in this study, the four main criteria, eight sub-criteria, and five alternatives will be considered as shown in Table 4 and Figure 2.

Table 4: Label for Proposed Criteria, Sub-criteria and Alternatives

Criteria	**Labels**	**Sub-criteria**	**Labels**	**Alternatives**	**Labels**
Content	C_1	Advertisement	C_{11}	Facebook	A_1
Functionality	C_2	Website attractiveness	C_{12}	Instagram	A_2
Usability	C_3	Content management	C_{21}	TikTok	A_3
Privacy	C_4	Interactiveness	C_{22}	Twitter	A_4
		Ease of use	C_{31}	YouTube	A_5
		Site performance	C_{32}		
		Privacy setting	C_{41}		
		Information security	C_{42}		

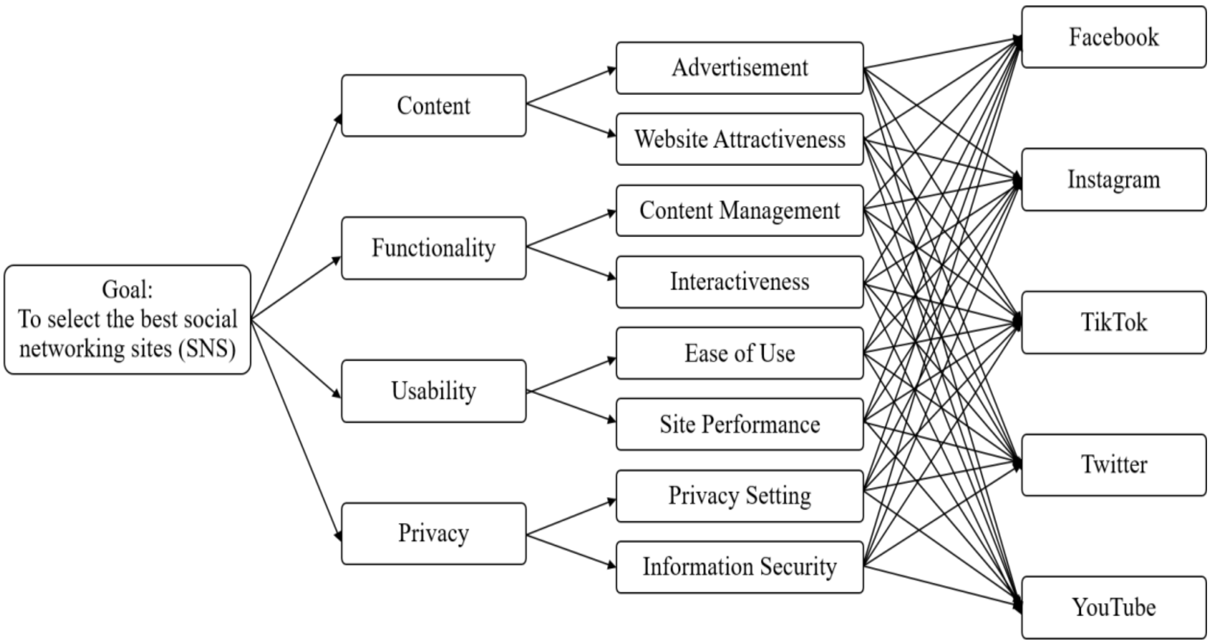

Figure 2: Hierarchical Diagram in Evaluation and Selection of the Best SNS

A pair-wise comparison matrix is formed by transforming the experts' responses from the survey into a Triangular Fuzzy Number (TFN). The value for each linguistic scale can be referred to in Table 2. The pairwise comparison matrices are shown in Table 5. Meanwhile, Table 6 presents the results of the aggregation of these fuzzy values.

Table 5: Pairwise Comparison Matrices for Criteria

Decision-maker	**Criteria**	**C_1**	**C_2**	**C_3**	**C_4**
DM_1	**C_1**	(1, 1, 1)	$\left(\frac{3}{2}, 2, \frac{5}{2}\right)$	$\left(\frac{3}{2}, 2, \frac{5}{2}\right)$	(1, 1, 1)
	C_2	$\left(\frac{2}{5}, \frac{1}{2}, \frac{2}{3}\right)$	(1, 1, 1)	$\left(\frac{3}{2}, 2, \frac{5}{2}\right)$	(1, 1, 1)
	C_3	$\left(\frac{2}{5}, \frac{1}{2}, \frac{2}{3}\right)$	$\left(\frac{2}{5}, \frac{1}{2}, \frac{2}{3}\right)$	(1, 1, 1)	(1, 1, 1)
	C_4	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)
DM_2	**C_1**	(1, 1, 1)	$\left(\frac{3}{2}, 2, \frac{5}{2}\right)$	$\left(1, \frac{3}{2}, 2\right)$	$\left(1, \frac{3}{2}, 2\right)$
	C_2	$\left(\frac{2}{5}, \frac{1}{2}, \frac{2}{3}\right)$	(1, 1, 1)	$\left(1, \frac{3}{2}, 2\right)$	(2, 2.5, 3)
	C_3	$\left(\frac{1}{2}, \frac{2}{3}, 1\right)$	$\left(\frac{1}{2}, \frac{2}{3}, 1\right)$	(1, 1, 1)	$\left(1, \frac{3}{2}, 2\right)$
	C_4	$\left(\frac{1}{2}, \frac{2}{3}, 1\right)$	$\left(\frac{1}{3}, \frac{2}{5}, \frac{1}{2}\right)$	$\left(\frac{1}{2}, \frac{2}{3}, 1\right)$	(1, 1, 1)
DM_3	**C_1**	(1, 1, 1)	$\left(\frac{3}{2}, 2, \frac{5}{2}\right)$	$\left(1, \frac{3}{2}, 2\right)$	$\left(1, \frac{3}{2}, 2\right)$
	C_2	$\left(\frac{1}{2}, \frac{2}{3}, 1\right)$	(1, 1, 1)	$\left(1, \frac{3}{2}, 2\right)$	$\left(2, \frac{5}{2}, 3\right)$
	C_3	$\left(\frac{2}{5}, \frac{1}{2}, \frac{2}{3}\right)$	$\left(\frac{1}{2}, \frac{2}{3}, 1\right)$	(1, 1, 1)	$\left(\frac{5}{2}, 3, \frac{7}{2}\right)$
	C_4	$\left(\frac{2}{7}, \frac{1}{3}, \frac{2}{5}\right)$	$\left(\frac{1}{3}, \frac{2}{5}, \frac{1}{2}\right)$	$\left(\frac{2}{7}, \frac{1}{3}, \frac{2}{5}\right)$	(1, 1, 1)
DM_4	**C_1**	(1, 1, 1)	$\left(2, \frac{5}{2}, 3\right)$	$\left(2, \frac{5}{2}, 3\right)$	$\left(2, \frac{5}{2}, 3\right)$
	C_2	$\left(\frac{1}{3}, \frac{2}{5}, \frac{1}{2}\right)$	(1, 1, 1)	(1, 1, 1)	$\left(\frac{3}{2}, 2, \frac{5}{2}\right)$
	C_3	$\left(\frac{1}{3}, \frac{2}{5}, \frac{1}{2}\right)$	(1, 1, 1)	(1, 1, 1)	$\left(2, \frac{5}{2}, 3\right)$
	C_4	$\left(\frac{1}{3}, \frac{2}{5}, \frac{1}{2}\right)$	$\left(\frac{2}{5}, \frac{1}{2}, \frac{2}{3}\right)$	$\left(\frac{1}{3}, \frac{2}{5}, \frac{1}{2}\right)$	(1, 1, 1)

Decision-maker	Criteria	C1	C2	C3	C4
DM5	C1	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	$\left(\frac{5}{2}, 3, \frac{7}{2}\right)$
	C2	(1, 1, 1)	(1, 1, 1)	$\left(\frac{5}{2}, 3, \frac{7}{2}\right)$	$\left(\frac{5}{2}, 3, \frac{7}{2}\right)$
	C3	(1, 1, 1)	$\left(\frac{2}{7}, \frac{1}{3}, \frac{2}{5}\right)$	(1, 1, 1)	(1, 1, 1)
	C4	$\left(\frac{2}{7}, \frac{1}{3}, \frac{2}{5}\right)$	$\left(\frac{2}{7}, \frac{1}{3}, \frac{2}{5}\right)$	(1, 1, 1)	(1, 1, 1)

Table 6: Aggregated Fuzzy Number for Criteria

Criteria	C1	C2	C3	C4
C1	(1, 1, 1)	$\left(\frac{7}{5}, \frac{9}{5}, \frac{11}{5}\right)$	$\left(\frac{7}{5}, \frac{9}{5}, \frac{11}{5}\right)$	$\left(\frac{9}{5}, \frac{11}{5}, \frac{13}{5}\right)$
C2	$\left(\frac{79}{150}, \frac{46}{75}, \frac{23}{30}\right)$	(1, 1, 1)	$\left(\frac{7}{5}, \frac{9}{5}, \frac{11}{5}\right)$	$\left(\frac{9}{5}, \frac{11}{5}, \frac{13}{5}\right)$
C3	$\left(\frac{79}{150}, \frac{46}{75}, \frac{23}{30}\right)$	$\left(\frac{94}{175}, \frac{19}{30}, \frac{61}{75}\right)$	(1, 1, 1)	$\left(\frac{3}{2}, \frac{9}{5}, \frac{21}{10}\right)$
C4	$\left(\frac{101}{210}, \frac{41}{75}, \frac{33}{50}\right)$	$\left(\frac{247}{525}, \frac{79}{150}, \frac{46}{75}\right)$	$\left(\frac{131}{210}, \frac{17}{25}, \frac{39}{50}\right)$	(1, 1, 1)

Consistency Ratio (*CR*) is used in the FAHP to evaluate the consistency of the pairwise comparison judgments made by decision makers. It provides a measure of the degree of consistency in the rankings provided by decision makers, allowing them to determine if their rankings are reasonable or if they need to be revised. The value for *CR* needs to be equal to or less than 0.1 for the pair-wise comparison matrix so that it can be used. If the value is less than 0.1, the pair-wise comparison matrix must be revised until the *CR* value of less than 0.1 is achieved [23]. As illustrated in Table 7, the judgements provided by the five experts (DMs) were consistent since all matrices had a *CR* value ≤ 0.1.

Table 7: Consistency Ratio of the Five Experts

Expert	Consistency Ratio (CR)
DM_1	0.0449
DM_2	0.05
DM_3	0.0207
DM_4	0.0322
DM_5	0.057

The geometric mean of fuzzy comparison values, r_i was calculated using Eq. (3) by taking the values from the updated pairwise comparison matrix. For instance, the calculation of the geometric mean for content (C_1) is shown below:

$$l: r_{C_1} = \left(1 \times \frac{7}{5} \times \frac{7}{5} \times \frac{9}{5}\right)^{\frac{1}{4}} = 1.3705$$

$$m: r_{C_1} = \left(1 \times \frac{9}{5} \times \frac{9}{5} \times \frac{11}{5}\right)^{\frac{1}{4}} = 1.6340$$

$$u: r_{C_1} = \left(1 \times \frac{11}{5} \times \frac{11}{5} \times \frac{13}{5}\right)^{\frac{1}{4}} = 1.8835$$

Table 8 below shows the values of the geometric mean for all criteria. The notation (*l*, *m*, *u*) was used to indicate a fuzzy triangular number in each column where *l* = lower value, *m* = medium value, and *u* = upper value. The table also includes the total and inverse values, and the last row displays the values in ascending order.

Table 8: Geometric Mean of Fuzzy Comparison Values for Criteria

Criteria	**Geometric Mean, r_i**		
	Lower Value, *l*	**Middle Value, *m***	**Upper Value, *u***
C_1	1.3705	1.6340	1.8835
C_2	1.0733	1.2484	1.4471
C_3	0.8071	0.9144	1.0697
C_4	0.5959	0.6652	0.7496
Total	3.8468	4.4620	5.1499
Inverse	0.26	0.2241	0.1942
Increasing Order	0.1942	0.2241	0.26

Next, the fuzzy preference weights, w_i, for each criterion were computed using Eq. (5) where r_i obtained previously were multiplied by the inverse of the summation vector in the form of increasing order. The calculated fuzzy preference weight for each criterion is shown in Table 9.

Table 9: Fuzzy Preference Weight for Criteria

Criteria	**Fuzzy Preference Weight, w_i**		
	Lower Value, *l*	**Middle Value, *m***	**Upper Value, *u***
C_1	0.2661	0.3662	0.4896
C_2	0.2084	0.2798	0.3762
C_3	0.1567	0.2049	0.2781
C_4	0.1157	0.1491	0.1949

Since w_i are still fuzzy triangular numbers, they need to be defuzzified by applying Eq. (6). Then, the relative non-fuzzy or defuzzified weight, G_i, was normalized by using Eq. (7). The following Table 10 presents the results of defuzzified weight, G_i and normalized weight, H_i for each criterion.

Table 10: Defuzzification and Normalization of Criteria

Criteria	Defuzzified Weight, G_i	Normalized Weight, H_i
C_1	0.3740	0.3540
C_2	0.2881	0.2728
C_3	0.2132	0.2019
C_4	0.1810	0.1713
Total	1.0563	1.0000

Table 10 indicates that the expert assigned the highest local weight to the criterion of content (C_1) compared to the other three criteria with a value of 0.3540. This is followed by functionality (C_2) and usability (C_3) with 0.2728 and 0.2019, respectively. Privacy (C_4) with the least value of local weight with 0.1713, becomes the experts' least preferred criterion. Content is likely the most preferred criterion because it plays a crucial role in attracting and engaging users. High-quality and relevant content can captivate the audience, convey the desired message effectively, and compel users to take the desired actions. In the context of advertisements and website attractiveness, compelling content can be the key differentiating factor that makes a website stands out and leaves a positive impression on users.

Table 11: Normalized Relative Weights of Sub-criteria

Content	**Functionality**	**Usability**	**Privacy**
Advertisement	Content Management	Ease of Use	Privacy Setting
0.7220	0.7095	0.6861	0.5655
Website Attractiveness	Interactiveness	Site Performance	Information Security
0.2780	0.2095	0.139	0.4345

The preference of the experts regarding sub-criteria for each criterion is displayed in Table 11. When it comes to content, they showed a greater preference for the first sub-criterion, advertisements, over the second, website attractiveness. Concerning functionality, experts favored content management over interactiveness. In the context of usability, ease of use was preferred over site performance by the experts. Similarly, regarding privacy, experts showed a preference for privacy settings over information settings.

Finally, the ranking of the alternatives was determined by adding up the global weight values for each alternative and criterion. The highest global weight value was placed at the top of the table, while the lowest was at the bottom. This ranking was achieved through the application of the Fuzzy Analytical Hierarchy Process (FAHP) method, and the results are presented in Table 12.

Table 12: Ranking of Social Networking Site

Alternatives	Global Weight	Rank
Facebook	0.3252	1
Instagram	0.2204	2
TikTok	0.1981	3
Twitter	0.1423	4
YouTube	0.1140	5

Ranking in Table 12 was determined based on the global weight, which is shown in the leftmost column. Upon evaluation, it is evident that Facebook (A_1) has the highest global weight value of 0.3252 among all other alternatives. This outcome confirms that Facebook is the most favored Social Networking Site (SNS) among students at present. These findings align with a study by [25] on social media trends among university students. The study revealed that the majority of students preferred Facebook over other social networking sites (SNSs). Meanwhile, YouTube (A_5) had the lowest value for the global weight (0.1140), indicating it was the least preferred SNS among the students. Instagram (A_2) ranked second (0.2204), followed by TikTok (A_3) and Twitter (A_4) with global weights of 0.1981 and 0.1423, respectively.

5 Conclusion

In conclusion, this study proposed FAHP to achieve the objective of selecting the best SNSs. Five experts among students in UiTMCK who active users of SNSs and spend six to nine hours daily using these sites were selected to answer the fuzzy questionnaire to convey their own opinions. The fuzzy questionnaire consists of four main criteria which are Content (C_1), Functionality (C_2), Usability (C_3), and Privacy (C_4) followed by another eight sub-criteria: Advertisement (C_{11}), Website Attractiveness (C_{12}), Content Management (C_{21}), Interactiveness (C_{22}), Ease of Use (C_{31}), Site Performance (C_{32}), Privacy Setting (C_{41}) and Information Security (C_{42}). Besides, this study has been conducted on five alternatives which are Facebook (A_1), Instagram (A_2), TikTok (A_3), Twitter (A_4) and YouTube (A_5).

The FAHP calculations begin with generating a pairwise comparison matrix based on the responses from experts and then transforming them into a TFN. The global weights computed for each criterion were used to construct the selection score model. The results of this study indicate that Facebook has the highest global weight with a value of 0.3261 compared to other alternatives. The most crucial criterion was determined to be content, with advertisements as the preferable sub-criterion.

Thus, the FAHP approach is a more systematic calculation method and the outcomes would be less biased and equal for all alternatives. Hence, FAHP has developed a model of the best SNSs. This ranking can help university management in decision-making process to select the best alternatives by considering all the required criteria. Besides, other additional studies can also implement various multi-criteria decision-making techniques such as fuzzy TOPSIS and fuzzy PROMETHEE for related applications. For a more accurate and detailed outcome, this study may be conducted using additional criteria and sub-criteria.

Acknowledgements

The authors would like to thank UiTMCK and the reviewers for their insightful comments and suggestions, as well as for allowing them to present their research findings.

References

[1] H. Shepherd and J. Lane, "In the mix: Social integration and social media adoption," *Soc. Sci. Res.*, vol. 82, pp. 1–17, 2019.
[2] H. Moongela and J. McNeill, "Perceptions of social media on students' academic engagement in tertiary education," *Proceedings of the South African Institute of Computer Scientists and Information Technologists*, pp. 1–10, 2017.
[3] Statista Research Department. "Social media users as a percentage of the total population Malaysia 2021," Statista. https://www.statista.com/statistics/883712/malaysia-social-media-penetration/ (accessed May 10, 2023).
[4] E. Triantaphyllou, "Multi-Criteria Decision Making Methods," pp. 5–21, 2000.
[5] Y. Wind and T. L. Saaty, "Marketing Applications of the Analytic Hierarchy Process," *Source Manag. Sci.*, vol. 26, no. 7, pp. 641–658, 1980.
[6] L. G. Vargas, "An overview of the analytic hierarchy process and its applications," *Eur. J. Oper. Res.*, vol. 48, no. 1, pp. 2–8, 1990.
[7] D. Martin, "What americans do online: social media and games dominate activity," *Nielsen Online*, pp. 1–5, 2010.

[8] C. Li, J. Bernoff, C. Pflaum, and S. Glass, "How consumers use social networks," *Forrester Res. Inc.*, pp. 1–11, 2007.

[9] A. Özgün and A. Treske, "On streaming-media platforms, their audiences, and public life," *Rethink. Marx.*, vol. 33, no. 2, pp. 304–323, 2021.

[10] M. Castillo. "Mark Zuckerberg put employees on 'lockdown' for two months to launch Facebook Live: Report." CNBC. https://www.cnbc.com/2017/03/06/zuckerberg-put-employees-on-lockdown-to-launch-facebook-live-wsj.html (accessed May 10, 2023).

[11] J. Constine. "Instagram launches disappearing live video and messages." TechCrunch. https://techcrunch.com/2016/11/21/instagram-live/ (accessed May 10, 2023).

[12] E. Roth. "Twitter is finally letting everyone create Spaces." TheVerge. https://www.theverge.com/2021/10/21/22739249/twitter-finally-letting-everyone-create-spaces (accessed May 10, 2023).

[13] K. C. Chinthakayala, C. Zhao, J. Kong, and K. Zhang, "A comparative study of three social networking websites," *World Wide Web*, vol. 17, no. 6, pp. 1233–1259, 2014.

[14] N. Nazarail and Z. Kasim, "The Selection of Social Networking Sites Using Fuzzy Analytical Hierarchy Process," *ESTEEM Acad. J.*, vol. 17, pp. 1–11, 2021.

[15] N. A. Baki, N. I. Norddin, and W. A. W. Azaman, "Application of analytic hierarchy process for selecting best student," *J. Appl. Environ. Biol. Sci.*, vol. 7, no. 1, pp. 69–73, 2017.

[16] R. Anggrainingsih, M. Z. Umam, and H. Setiadi, "Determining e-learning success factor in higher education based on user perspective using Fuzzy AHP," in *MATEC Web of Conferences*, vol. 154, pp. 1–6, 2018.

[17] C. M. Tang and M. H. Ngerng, "How do students select social networking sites? an analytic hierarchy process (ahp) model," *Int. J. Cyber Soc. Educ.*, vol. 8, no. 2, pp. 81-98, 2015.

[18] B. W. Wirtz, R. Piehler, and S. Ullrich, "Determinants of social media website attractiveness," *J. Electron. Commer. Res.*, vol. 14, no. 1, pp. 11-33, 2013.

[19] V. Venkatesh, M. G. Morris, G. B. Davis, and F. D. Davis, "User acceptance of information technology: Toward a unified view," *MIS Q. Manag. Inf. Syst.*, vol. 27, no. 3, pp. 425-478, 2003.

[20] I. G. Iwan Sudipa *et al.*, "Application of MCDM using PROMETHEE II Technique in the Case of Social Media Selection for Online Businesses," in *IOP Conference Series: Materials Science and Engineering*, vol. 835, pp. 1-8, 2020.

[21] Y. A. Park and U. Gretzel, "Success factors for destination marketing websites: A qualitative meta-analysis," *J. Travel Res.*, vol. 46, no. 1, pp. 46-63, 2007.

[22] R. B. de Santis, L. Golliat, and E. P. de Aguiar, "Multi-criteria supplier selection using fuzzy analytic hierarchy process: case study from a Brazilian railway operator," *Brazilian J. Oper. Prod. Manag.*, vol. 14, no. 3, pp. 428-437, 2017.

[23] T. L. Saaty, "Theory and Applications of the Analytic Network Process." p. 352, 2005.

[24] S. W. Chou and Y. C. Chang, "The implementation factors that influence the ERP (enterprise resource planning) benefits," *Decis. Support Syst.*, vol. 46, no. 1, pp. 149-157, 2008.

[25] I. Hussain, "A study to evaluate the social media trends among university students," *Procedia - Soc. Behav. Sci.*, vol. 64, pp. 639-645, 2012.