An Application of Fuzzy ANP in Evaluating Stress Factors Among University’s Students During Online Distance Learning

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Abstract: The outbreak of Coronavirus disease 2019 (COVID-19) has bring so many impacts on various aspects including education. Nearly two years into the pandemic, close to half of the world’s students, including Malaysia, are still affected by partial or full closures of educational institution. In spite of this, to ensure the continuity of learning, one of the initiatives taken by our government is introducing online distance learning (ODL) as the new platforms of learning. However, undeniably, ODL is so stressful and this situation is obviously non-pleasant, especially for the long-term development of the students. Therefore, a research to find out the most influential factors, which contribute to these stresses has been conducted. In this research, a decision-making tool known as the Fuzzy Analytic Network Process (FANP) has been applied. Five main factors which are time management, environment of studies, resources, family and lecturer’s concerns, with additional of twenty-one sub-factors were studied. The percentage value of each factor was calculated using the FANP, which produced the rank for each factor. Results shows that, environment of study dominates the ranks, followed by time management, lecturer’s concern, resources and the last one is family’s concern.

Keywords: Covid-19, fuzzy ANP, online distance learning, stress factors

1. Introduction
The Coronavirus disease 2019 (COVID-19) pandemic, has drastically changed people's lives and lifestyles. Educational institutions, schools, and universities all over the world have to be closed in order to preserve social isolation and prevent the disease from spreading [1]. Being aware of the importance of education, especially for the young generation, Malaysia's education sector has adopted an online distance learning (ODL) to replace face-to-face learning. ODL is a method where teachers or educators
and students interact virtually using any online platforms such as Zoom, Google Classroom, Telegram or Microsoft Teams. This type of learning and teaching is very important for our current situations, since it allows continuity of learning despite of the educational institution’s closure, and it is available at any time, from any places [2]. However, abrupt transition from physical classrooms to virtual environment is not easy for the students. Most of them are still coping and adapting to this new way of learning. The shift to virtual communication reduces much-needed personal contact, as well as the stress of learning new skills. This situation leads to confusion, anxiety and may cause depression among students. It is well known that, students, especially college or university students, have many existing problems to be handled including life shifts, personal matters, assessments/assignments, and career exploration [3]. Student’s performances are strongly influenced by their ability to manage these matters. Since learning through ODL require the students to be independent, it is indeed adding up their pressure [4]. There are many factors which may trigger the stress during ODL. The most significant issues are lack of accessibility to internet and digital devices, which prohibits the students from joining the live classes, hindering the proper learning process, and enabling them from completing their assessments, which may later affect their final semester grade. Definitely, the final semester results are the major concern of most students [1]. Hence the frustration, which may lead to stress arises. Apart from internet connectivity and availability of digital devices, other factors which may distract and inhibits online classes are time managements, environment of studies, resources, family and lecturer’s concerns.

This research therefore seeks to investigate the problems faced by the students during online learning, consequently determine the most influential factors of stress, and finally figure out the solutions. The fuzzy mathematics was applied in the development of methods of decision making. In 1965, Zadeh [5] introduced the concept of fuzzy sets that referring to the sets with imprecise and ambiguous nature. The concept of fuzzy information could be of special interest in the applications where fuzzy sets must be converted into crisp sets to avoid uncertainty. There are few types of Multi-Criteria Decision Making models that can be used in decision making process, such as Analytic Hierarchy Process (AHP), Analytical Network Process (ANP), Decision Making Trial and Evaluation Laboratory (DEMATEL), VIKOR and Fuzzy Technique for Order Preference by Similarities to Ideal Solution (TOPSIS). Specifically, ANP is used in this research for its ability to solve complex problems. AHP was developed by Saaty [6] to solve the multi criteria decision making. However, decision making is a cognitive and mental process derived from the most possible adequate selection based on tangible and intangible criteria which are arbitrarily chosen by those who make the decisions [6]. Later in 1996, Saaty [7] developed an ANP that is a more general form of the AHP used in multi criteria decision making analysis. ANP is represented, instead of a hierarchy, by a network [6]. The applications involve ANP are now quite common in many fields such as insurance [8], supplier selection market [9] and software performance [10]. Both AHP and ANP use a system of pairwise comparisons to measure the weights of the components of the structure, and finally to rank the alternatives in the decision. In AHP the criteria are considered to be independent of one another and the alternatives are considered to be independent of the decision criteria of each other [5]. ANP does not require independence among elements, so it can be used as an effective tool in these researches because the alternatives not been considered.

2. Methodology
The Analytic Hierarchy Process (AHP) and the Analytic Network Process (ANP) are two traditional Multi Criteria Decision Making (MCDM) methods developed by Saaty. ANP is a powerful tool to solve the decision problem if interdependent relationships have substantial impacts in the decision model. In this current study, the method of ANP has been utilized. The steps and concept of fuzzy numbers are shown below.
2.1 Basic Concept Fuzzy Set Theory

A fuzzy set \( A \) in the universe of discourse \( X \) is defined by [11]

\[
\tilde{A} = \{ <x, \mu_A(X) > | x \epsilon X \} \tag{1}
\]

where \( \mu_A(X) \) is called the membership function for the fuzzy set \( \tilde{A} \), which is characterized by membership function in the interval [0,1]. If the value of the membership function is restricted either to 0 or 1, then \( \tilde{A} \) is reduced to crisp set.

2.2 Triangular Fuzzy Number

A triangular fuzzy number, \( \tilde{A} \) can be denoted as \( \tilde{A} = (a, b, c) \) and the membership function is given by [7]

\[
\mu_{\tilde{A}} = (x) \begin{cases} 
\frac{x-a}{b-a} & a \leq x \leq b \\
\frac{c-x}{c-b} & b \leq x \leq c \\
0 & \text{otherwise} 
\end{cases} \tag{2}
\]

The significance of factors and sub-factors shall be assessed with linguistic variables. Linguistic variables at five different levels, namely "equally important", "weakly important", "strongly important", "very important" and "absolutely important" at five fuzzy scales. A linguistic variable is given a linguistic value. Normally, the scales used to measure the importance of factors and sub-factors range from 0 to 1. The conversion of linguistic variables into numbers is shown in table 1 based on Chang’s extent analysis [12].

| Linguistic scale of importance | Triangular Fuzzy Scale | Triangular Fuzzy Reciprocal Scale | Scale in survey |
|--------------------------------|-----------------------|----------------------------------|----------------|
| Equally important             | (1,1,1)               | (1,1,1)                          | 1              |
| Weakly important              | (2/3,1,3/2)           | (2/3,1,3/2)                      | 2              |
| Strongly important            | (3/2,2,5/2)           | (2/5,1/2,2/3)                    | 3              |
| Very strongly important       | (5/2,3,7/2)           | (2/7,1/3,2/5)                    | 4              |
| Absolutely important          | (7/2,4,9/2)           | (2/9,1/4,2/7)                    | 5              |

2.3 Evaluation of Factors and Sub-Factors

These five factors and twenty-one sub-factors were used, based on previous research of stress factors during online distance learning (ODL), the appropriateness of the variables on the current chosen respondents. The list and code of the factors and sub-factors are shown in table 2.
| Factors                  | Sub-Factors                                                                 |
|-------------------------|------------------------------------------------------------------------------|
| C1 - Time Management    | S11 - Tight schedule                                                        |
|                         | S12 – Long time spent on completing the assignments                          |
|                         | S13 – Unable to meet the dateline                                            |
| C2 - Environment of Study| S21 - Study space                                                           |
|                         | S22 - Distractions                                                          |
|                         | S23 - Losing focus                                                          |
|                         | S24 - Peer support                                                          |
| C3 - Resources          | S31 - Limited learning materials                                            |
|                         | S32 - Corrupted files                                                       |
|                         | S33 - Lack of facilities                                                    |
|                         | S34 - Limited software accessibility                                        |
|                         | S35 - Limited data/ Internet accessibility                                   |
|                         | S36 - Poor internet connectivity                                           |
| C4 - Family Concern     | S41 - Lack of understanding from family members                             |
|                         | S42 - Lack of parent’s cooperation (students were asked to do house-chores) |
|                         | S43 – Sibling’s distractions                                                |
| C5 - Lecturer Concern   | S51 – Heavy workloads (too much tasks/assignments/assessments are assigned) |
|                         | S52 – Syllabus cannot be fully covered/completed                             |
|                         | S53 - Different teaching methods (Different lecturers with different approaches of teachings) |
|                         | S54 - No proper guidance from lecturers                                     |
|                         | S55 - Lack of interactions/communications between students and lecturers     |
2.4 Construction of Hierarchical Structure of the Problems

The Fuzzy ANP method was structured into three stages: objectives, factors and sub-factors. These three stages are interactively linked as shown by figure 1.

![Diagram of Hierarchical Structure of Factors and Sub-factors]

Figure 1. Hierarchical structure of the factors and sub-factor.
2.5 Computation Local Weight of Factors

Local weights of factors and sub-factors were computed using pairwise comparison matrix based on linguistic scale evaluations, which was calculated by using pairwise comparison techniques. All linguistic scales are represented by triangular fuzzy numbers table 1. An assumption of no dependencies among the factors was made to fulfil the precondition in the Fuzzy ANP. Chang’s extended analysis [12] was applied to compute the local weight for factors and sub-factors as in the following:

Step 1: The value of fuzzy synthetic extent with respect to the \( i \) \( th \) object is defined as:

\[
S_i = \sum_{j=1}^{m} M^j \bigotimes \left[ \sum_{i=1}^{n} \sum_{j=1}^{m} M^j \right]^{-1}
\]

where \( M \) is the value in the pairwise comparison matrix of factors.

Step 2: The degree of possibility of \( M_2 = (a_2, b_2, c_2) \geq M_1 = (a_1, b_1, c_1) \) is defined as

\[
V(M_2 \geq M_1) = \sup_{x \geq y} [\min(\mu_{M_1}(x), \mu_{M_2}(y))].
\]

Step 3: Compute Local Weight vectors

normalized local weight vectors, \( Lw = \frac{\sum_{i=1}^{n} V(M_2 \geq M_1)}{\sum V(M_2 \geq M_1)} \)

2.6 Computation of Interdependent Weights of Each Factors

Relative impact of factors compared to other factors, \( R_{fA1} = \frac{\sum_{i=1}^{n} V(A_n \geq A_1)}{\sum V(A_n \geq A_1)} \)

where \( A_1 \) is the main factor of stress.

Interdependent weight factor, \( If = \frac{\sum_{i=1}^{n} R_{fA1} \times Lw}{\sum_{i=1}^{n} R_{fA1}} \)

2.7 Computation of the Global Weight for the Factors

Global factors weight, \( Gf = Lw \times If \)

2.8 Computation Percentage of Factors

Percentage of factors, \( Pf = Gf \times As \)

where \( As \) is an average scale for each factors based on sub-factors.

2.9 Ranking of the Preference Orders

The percentage values of each factor indicate their ranks in influencing the stress among students during ODL.

3. A Numerical Application

A survey involving the students of UiTM (Kuala Terengganu campus) as respondents were conducted. Based on this survey, the pair-wise comparison matrices of factors were constructed. The results were calculated by taking the geometric means of individual evaluations as shown in table 3.
Table 3. Pairwise comparison matrix of factors

| Factors | C1          | C2          | C3          | C4          | C5          |
|---------|-------------|-------------|-------------|-------------|-------------|
| C1      | (1.0000, 1.0000, 1.0000) | (0.9524, 0.9519, 0.9723) | (1.1079, 1.0647, 1.0600) | (1.1423, 1.0885, 1.0902) | (1.0335, 1.0118, 1.0104) |
| C2      | (1.0285, 1.0505, 1.0500) | (1.0000, 1.0000, 1.0000) | (1.1633, 1.1185, 1.0902) | (1.1994, 1.1435, 1.1116) | (1.0851, 1.0629, 1.0494) |
| C3      | (0.9434, 0.9392, 0.9026) | (0.9173, 0.8941, 0.8596) | (1.0000, 1.0000, 1.0000) | (1.0310, 1.0224, 1.0197) | (0.9328, 0.9503, 0.9626) |
| C4      | (0.9252, 0.9187, 0.8754) | (0.8996, 0.8745, 0.837) | (0.9807, 0.9781, 0.9699) | (1.0000, 1.0000, 1.0000) | (0.9047, 0.9295, 0.9440) |
| C5      | (0.9801, 0.9884, 0.9676) | (0.9529, 0.9408, 0.9215) | (1.0389, 1.0523, 1.0720) | (1.0593, 1.0759, 1.1053) | (1.0000, 1.0000, 1.0000) |

After that, the values of synthetic extent of each factor were calculated using formula in equation (3). The results are summarized as in table 4. The values for each factor was compared with other factors, to obtain their individual possibility degree using formula in equation (4). These possibility degrees are tabulated in table 5. The local weights of each factor were calculated using formula in equation (5) and displayed in table 6.

Table 4. Value of fuzzy synthetic extent for factors

| Factors | Value of Fuzzy SyntheticExtent of Factors |
|---------|-----------------------------------------|
| C1      | (0.2071, 0.2042, 0.2064)                |
| C2      | (0.2166, 0.2145, 0.2132)                |
| C3      | (0.1909, 0.1918, 0.1908)                |
| C4      | (0.1863, 0.1876, 0.1859)                |
| C5      | (0.1990, 0.2018, 0.2037)                |
Table 5. Degree of possibility for each factor

| Degree of Possibility |
|-----------------------|
| V (C1 ≥ C2)           |
| V (C1 ≥ C3)           |
| V (C1 ≥ C4)           |
| V (C1 ≥ C5)           |
| V (C2 ≥ C1)           |
| V (C2 ≥ C3)           |
| V (C2 ≥ C4)           |
| V (C2 ≥ C5)           |
| V (C3 ≥ C1)           |
| V (C3 ≥ C2)           |
| V (C3 ≥ C4)           |
| V (C3 ≥ C5)           |
| V (C4 ≥ C1)           |
| V (C4 ≥ C2)           |
| V (C4 ≥ C3)           |
| V (C4 ≥ C5)           |
| V (C5 ≥ C1)           |
| V (C5 ≥ C2)           |
| V (C5 ≥ C3)           |
| V (C5 ≥ C4)           |

Table 6. Local weight for each factor

| Factors | Local Weights |
|---------|---------------|
| C1      | 0.3000        |
| C2      | 0.4000        |
| C3      | 0.1000        |
| C4      | 0.0000        |
| C5      | 0.2000        |

The next step is to obtain the global weight of each factor. To get this, first the relative importance of each factor was calculated using formula in equation (6) and the results of each factor are shown in table 7. Based on these, the normalized interdependent weights were calculated using equation (7). The results are displayed in table 8. Finally, using the steps in 2.7, the global weights of each factor, as in table 9 were obtained.

Table 7. Relative important of factors

| Factors | C1  | C2  | C3  | C4   | C5   |
|---------|-----|-----|-----|------|------|
| C1      | 1   | 0.5 | 0.2 | 0.3333| 0.3333|
| C2      | 0.5 | 1   | 0.6 | 0.5  | 0.5  |
| C3      | 0.1667| 0.1667| 1 | 0 | 0.1667|
| C4      | 0   | 0   | 0   | 1    | 0    |
| C5      | 0.3333| 0.3333| 0.2 | 0.1667| 1    |
Table 8. Normalized interdependent weights

| Factors | Weight |
|---------|--------|
| C1      | 0.2933 |
| C2      | 0.355  |
| C3      | 0.1250 |
| C4      | 0.000  |
| C5      | 0.2267 |

Table 9. Global weight of factors

| Factors | Normalized interdependent weights | Local weights of factor | Global weights |
|---------|-----------------------------------|-------------------------|----------------|
| C1      | 0.2933                            | 0.3000                  | 0.0880         |
| C2      | 0.3550                            | 0.4000                  | 0.1420         |
| C3      | 0.1250                            | 0.1000                  | 0.0125         |
| C4      | 0.0000                            | 0.0000                  | 0.0000         |
| C5      | 0.2267                            | 0.2000                  | 0.0453         |

Percentage values of each factor were determined by multiplying their global weight with their average scale values. The scale value was then decided according to the level of preferences. Table 10 shows the percentage of each factor.

Table 10. Percentage of factors

| Factors | Global weights | Linguistic evaluation | Scale value | Percentage |
|---------|----------------|-----------------------|-------------|------------|
| C1      | 0.0880         | Medium                | 0.5         | 0.0440     |
| C2      | 0.1420         | High                  | 0.75        | 0.1065     |
| C3      | 0.0125         | Medium                | 0.5         | 0.0063     |
| C4      | 0.0000         | Medium                | 0.5         | 0.0000     |
| C5      | 0.0453         | Medium                | 0.5         | 0.0227     |

4. Result and discussion

This research was conducted to propose an effective method to evaluate the most influential factors of stress among students during ODL. The study was carried out using the data from 100 of the respondents who involved with ODL. The respondents are the diploma and bachelor degree students at UiTM Kuala Terengganu campus. Questionnaire about the factors of stress during ODL were distributed and the respondents were asked to complete the survey and rank each criterion. Each criterion was measured on five levels, and indicated as ‘lowest’ to ‘highest’ according to one’s preferences. The calculation of the results of each individual respondent was executed using the Fuzzy ANP methods. The ranking was based on the values of the percentage of factors with the greatest value placed at the top.
Table 11. Ranking the most stressful factors during ODL

| Factors                  | Percentage | Ranking order |
|--------------------------|------------|---------------|
| C1- Time Management      | 0.0440     | 2             |
| C2 -Environment of Study | 0.1065     | 1             |
| C3 - Resources           | 0.0063     | 4             |
| C4- Family Concern       | 0.0000     | 5             |
| C5- Lecturer Concern     | 0.0227     | 3             |

Table 11 shows the results of ranking orders of factors that contribute to students’ stress during ODL. The most dominating factor is C2 (environment of study, with four sub-factors which are study space (S21), distraction (S22), losing focus (S23) and peer support (S24)) with percentage value 0.1065. The main struggles of the students are to handle their environment of study. The second most influential factor is C1 (time management, with three sub-factors which are tight schedule, long time spent on completing the assignments and unable to meet the dateline) with percentage of 0.0440. The third highest is C5 (lecturer’s concerns) with percentage of 0.0227 followed by C3 (Resources) and the lowest is C4 (family’s concerns).

5. Conclusion
The environment of study is the most stressful factor affecting students’ academic performance during ODL. The least stressful factor is family’s concern. Thus, it can be concluded that, most parents are supportive with ODL, and this is a good sign for our education sectors, since this pandemic is expected to persist, maybe for another two or three years in the future. For future research, researchers are suggested to consider other Multi-Criteria Decision Making method and the result will be compared to this ANP method. Besides, a more advanced research, involving more factors and sub-factors should be conducted in the near future.

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