UNIVERSITI TEKNOLOGI MARA

Nombor Sijil: 404073

Fakulti Sains Komputer Dan Matematik

TECHNICAL REPORT
FINAL YEAR PROJECT
CS249
MARCH 2022 - AUGUST 2022

APPLICATION OF FUZZY ANALYTIC NETWORK PROCESS IN EVALUATING STUDENTS' PREFERENCE FACTORS IN ONLINE LEARNING

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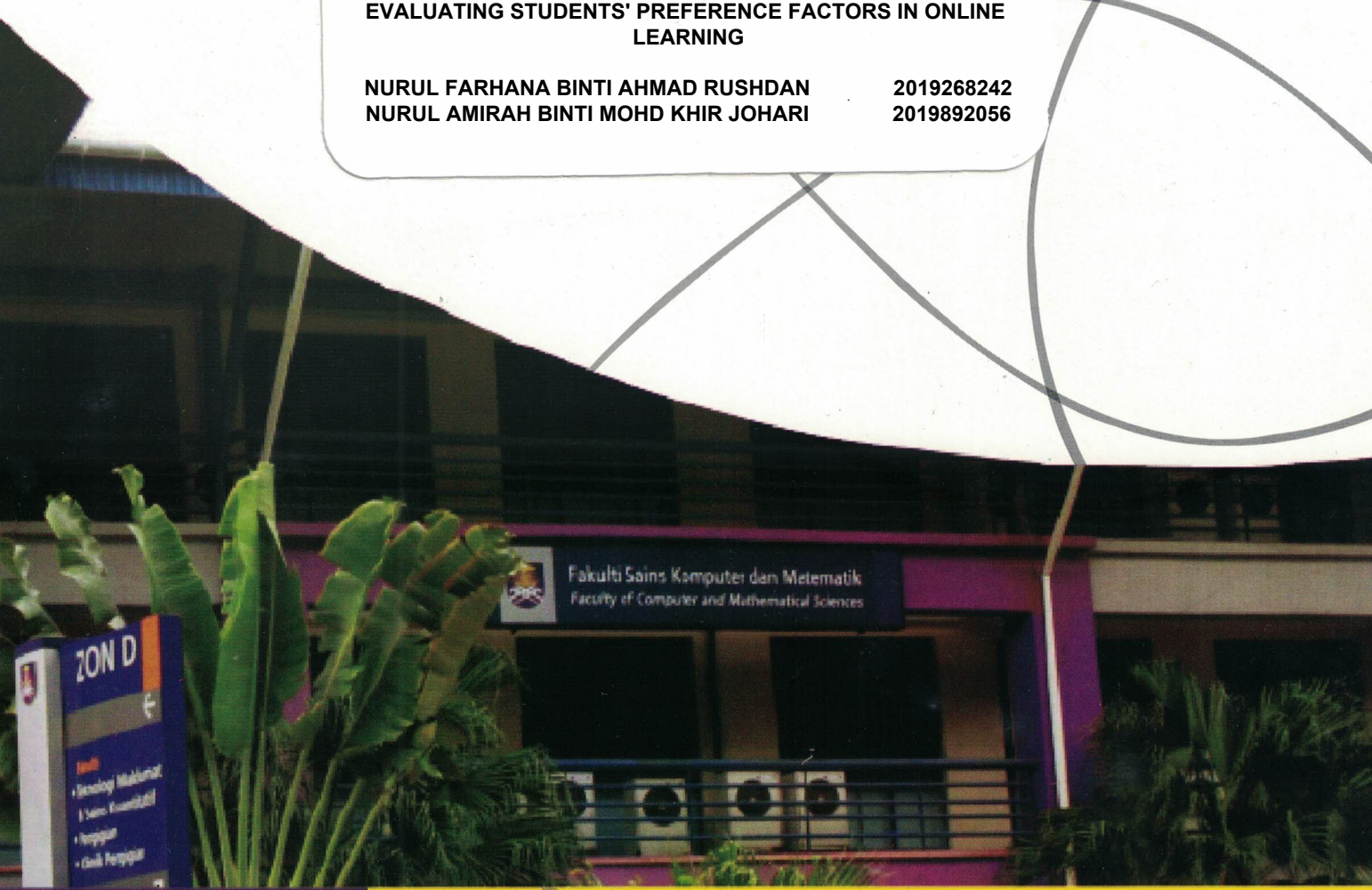

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Report submitted in partial fulfillment of the requirement
for the degree of
Bachelor of Science (Hons.) Mathematics
Center of Mathematics Studies
Faculty of Computer and Mathematical Sciences

2022

ACKNOWLEDGEMENTS

In the Name of Allah, The most Gracious, The most Merciful. Alhamdulillah, we are thankful to Allah that we finally were able to accomplish our Final Year Project (FYP). Without His blessing we would not have came this far. This project can not be completed without effort, co-operation and enthusiasm of our only partner.

Besides that, a big thank and appreciation we address to our supervisor, Puan Nurul Suhada bt Aziz because without her guide we could not have done this project properly. She is always supportive, welcoming and inspirational in guiding and supervising us in our project fulfillment to produce good output from the research studied. The topic that has been chosen by our group is regarding the effectiveness of online distance learning among students in UiTM Cawangan Kelantan (UiTMCK).

Next, we would like to express our gratitude to our panels Puan Farahanie Fauzi and Puan Nur Elini Jauhari for all the building comments and detail clarification regarding our proposal. Their previous suggestion for our proposal has been benefited wisely in completing our project.

Nobody has been more important and supportive than the member of our family. We are deeply grateful for our parents for the love and support for the entire journey of our study. They are the ultimate role model and motivation for us.

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ABSTRACT

Recently, the world has been affected by the Coronavirus disease (COVID-19), which caused major disruptions in every sector including the education sector. Most of the education systems in the world has to shift to fully online learning. In line with this, University Teknologi Mara (UiTM) has decided to execute online learning during the pandemic outbreak. However, numerous challenges occurred during online learning. Therefore, the purposed of this study is to evaluate students' preference factors in online learning system among students in UiTMCK by using the Fuzzy Analytic Network Process (FANP). The criteria involved were easy to use, easy to interact with educators, interesting content, and proper navigation. For sub-criteria which are the factors, it involved system quality, content, learner community, and learner interface. Ten decision-makers from UiTMCK have been requested to complete this fuzzy questionnaire for data collection purposes. According to the findings of this study, content has the highest weight compared to the other factors. The result obtained by using the Fuzzy ANP suits to reduce biases and is fairer to all factors because the method provides systematic calculation by generating the total score for each factor. Hence, the qualifying factor will be selected based on rank.

1 INTRODUCTION

1.1 Research Background

The education sector in Malaysia was particularly affected by the pandemic Covid-19. Traditional face-to-face learning has been replaced by online learning to ensure educational continuity. All categories of students have to adapt to the new method of studying including preschool, primary students, secondary students, and all levels of university students. Many prestigious universities around the world have fully adopted online learning as a way to ensure continuity of education by Chung et al. (2020).

In Malaysia, our government has announced a Movement Control Order (MCO) in 2020 to control the spreading of this deadly virus. Unfortunately, some universities do not well-prepared to confront this online learning according to Chakraborty et al. (2021). But in this situation, nobody can choose the solution, and all students have to adapt to online learning from time to time. According to Chakraborty et al. (2021), there are a lot of advances in educational technology in the last few decades and are very useful for online education. All students and educators have to learn to use some applications and university online education systems that ease the way for online learning. For example, the most favorable application is WhatsApp, while U-future is designed specifically for UiTM as an educational portal. This platform is designed for an easier medium to interact with each other. Other than that, there are many more applications that most university students and educators use such as Google Classroom, Telegram, Tiktok, and Instagram. Since Covid-19 emerged in the world in early 2020, online learning has become significant. Therefore, all educators and students need to help each other to make online learning become effective.

Accordingly, this research paper is written to determine students' preference factors in online learning during this pandemic among the students of the UiTMCK. This research applies the Fuzzy Analytic Network Process (FANP) by applying Triangular Fuzzy Number (TFN).

Analytic Network Process (ANP) is a multi-criteria decision-making (MCDM) method to support complex and uncertain environments of decision-making and recommends a fuzzy analytic network process (FANP) approach to prioritize decision elements. This research is conducted to find out the most preferable criteria for online learning and to observe the main factors that influence our online education nowadays. Through this research, education in Malaysia can be enhanced in all aspects for educators and students to give and gain knowledge.

1.2 Problem Statement

Since the pandemic of Covid-19, there are restrictions including standard operating procedures for everyone in controlling the spread of the virus. In correlation with minimizing the spread of the deadly virus, the academician has to be remotely undergoing their activities from home. Online learning requires efficient elements in its implementation especially in terms of the system whether by institution management. UiTMCK's students were the target for this study to evaluate the students' preference factors of the UiTM online learning. Online learning was a challenge for the students as there are many problems due to its immediate implementation and lack of preparation, especially in terms of the university's learning system itself, learners' and educators' familiarity with the online learning platform and network availability.

Therefore, it is important to evaluate the factor of online learning in order to improve the available online learning system provided by the university. There are criteria discussed in previous research studies mainly personalization, content, learners community and learners' interface (Sadi-Nezhad et al., 2010). These criteria were evaluated by applying Fuzzy Analytics Network Process (FANP) with Fuzzy Set Theory. This method will make the evaluation process more effective and this study will help the academician as well as the university's management to improvise the current online learning system.

1.3 Research Objective

The purpose of this research is to study the Fuzzy set in evaluating the effectiveness of the online learning system that has been implemented in teaching and learning activities from different faculties at the Mara University of Technology. The objectives of this study are as below:

1. To apply Triangular Fuzzy Number (TFN) in the Analytic Network Process (ANP) approach.

2. To identify for each criterion using Fuzzy AHP.

3. To rank the students' preference factors in online learning.

1.4 Significant Of Project

This research will benefit some groups of individuals in several ways. The educators and learners of online education can identify what is the best factor in online learning. On the other hand, this research can help universities to improve their services. The university will get to know the advantages and disadvantages of online learning. Learners and also educators can fix and improve the actions to maintain the progress of education in Malaysia.

1.5 Scope Of Project

This research will be focusing on degree students in the UiTMCK in sharing their perspectives on the effectiveness of online learning. The respondents will compare the situation of education during and before the pandemic. 10 students were selected to be decision-makers in this research and they were given a questionnaire to be answered. The data collected will be analysed and concluded to complete the research.

2 LITERATURE REVIEW

2.1 Fuzzy Set Theory

Fuzzy are sets containing elements that have degrees of membership. In 1965 L. A. Zadeh formulated the initial statement of fuzzy set theory. Since then this mathematical sub discipline has gone through substantial theoretical development. There has been incandescence of applications of this fundamental of a mathematical framework to a massive field respectively according to Maiers & Sherif (1985). Fuzzy has been focused on some researched papers that help in decision making. Based on research papers, many applications of this theory can be found, for example, in artificial intelligence, robotics, computer science and technology, medicine, engineering, decision theory, expert systems, operations research, pattern recognition, logic and management science. Mathematical developments have advanced to a very high standard and are still forthcoming today (Zimmermann, 2010). The same goes for Sadi-Nezhad et al. (2010), fuzzy help them assume dependencies between criteria in evaluating e-learning platforms. Meanwhile, the research paper of Tseng et al. (2011) used a fuzzy set to generalized quantitative evaluation model that considers both the interdependence among measures and the fuzziness of subjective perception is currently lacking in the literature. The results indicated that the fuzzy analytical network process is a straightforward, relevant, and practical method of identifying the primary measures that give impact the strength of e-learning.

Besides, to quantify imprecise input data, researchers use fuzzy numbers. Fuzzy numbers are quantities whose t of numbers are in contrast to an ordinary crisp number. Fuzzy numbers are used as they help the decision making process handle the data. (Kumar et al., 2021). Other than that, fuzzy set theory is a theory of classes with not sharp boundaries. Fuzzy set theory is much larger than fuzzy logic in its narrow sense and consists of the latter as one of its branches. Among the other subdivision of fuzzy set theory are fuzzy arithmetic, fuzzy data analysis. fuzzy

mathematical programming, fuzzy topology and fuzzy graph theory. What is important to know is that any crisp theory can be fuzziest by conclude the concept of a set within that theory to the concept of a fuzzy set. Indeed, it is very likely that sometimes most theories will be fuzzed in this idea. ((Zimmermann, 2010))

As we noted before, the basis of fuzzy set theory has been developed mathematically. The theory of this field has substantially matured. Importantly there has been numerous developments of the applications of fuzzy set theory to a broad range of difficulties. (Maiers & Sherif, 1985). According to (Tseng et al., 2011), Fuzzy set theory was also used to evaluate the uncertainty which can be represented by a fuzzy number. A TFN is a special type of fuzzy number whose membership function is defined by three real numbers (l, m, u), where l, m, and u are real numbers and $l \leq m \leq u$.

In addition, fuzzy may be assumed as an attachment of multi-valued logic. Its uses and objectives. Thus, the fact that fuzzy logic deals with approximate rather than precise modes of reasoning imply that, in general, the chains of reasoning in fuzzy logic are concise in length, and do not play as effective a role as it does in classical logical systems. The conclusion is, in fuzzy logic, everything, including truth is a matter of degree, (Zadeh, 1988).

2.2 Fuzzy Analytic Network Process (FANP)

Evaluating students' preference factors on online learning platforms is very significant for those who are engaging this method in their academic activities. Through criteria gathered from many research studies for this problem, accessibility and learner feedback can be expected to be dependent and it is expected that traditional statistical approach is not suitable for evaluating dependent relations. Fuzzy ANP was introduced by Saaty in 1996, generalized from the

analytic hierarchy process (AHP). The ANP approach is a qualitative multi-attribute decision making approach presenting structured communication to identify problems (Bhattacharya et al., 2014). ANP technique is formed through a network structure and the relationship between criteria of the modeling process and feedback between criteria clusters is analyzed. Each element in a network is called a cluster.

ANP allows more complex interrelationships among the decision criteria and elements thus, does not require a strictly hierarchical structure (used in AHP) where the hierarchy of elements derives from a general to a more specific attribute to reach the desirable level of decision criteria (Tseng et al., 2011). The problem of evaluating online learning effectiveness becomes very complex due to the existence of several criteria and these criteria have interactions that give effects over each other and it has been discussed appropriately to apply Analytic Process Network. Fuzzy set theory is used to eliminate ambiguity and eliminate the uncertainty.

In terms of the degree of interdependence and relationship, the ANP is applied to investigate the criteria to comparative ranking (Galankashi et al., 2016). It is recommended to use ANP for dependencies of criteria as this framing needs decision makers to make pairwise comparisons to evaluate the suggested criteria realistically. However, both ANP and AHP can not reflect human thinking clearly even though practical and academic capabilities can be employed to undergo the decision making. Thus, to deal with ambiguity and linguistic terms, decision makers applied fuzzy sets as mentioned before (Hemmati et al., 2018). According to Saaty, similar to the AHP technique, this approach is based on the Markov Chain as the final weight of the ranking of suggested criteria is computed using a ratio scale. Explicit interactions between criteria in the ANP process produce high accuracy of decision making (Shyur & Shih, 2006).

2.3 Online Learning , E-Learning System

Online learning can be conducted both online or offline learning engagement which has taken place over the internet or else it can be defined as a medium of obtaining knowledge via a range of electronic media. The parameters to measure the effectiveness of online learning were proposed to be stability, security, reliability and responsiveness, ease of use, user friendliness, organization and personalization, provision of interactivity, and multimedia interaction including learning outcomes and achievement, online learning familiarity and critically affected the effectiveness but not related for interaction (Muhammad et al., 2020).

The flexibility of the learning schedule in online learning including the costs for learners to travel from their institutions is lower and a comprehensive e-learning system manages to satisfy students and learners which leads to a profitable commercial model. (Lee et al., 2019). Positive relationship between information quality which concerned the existence of 'bugs' in the system, user interface consistency, ease of use, the response rate in an interactive system, quality documentation, and sometimes maintainability of the program code and user satisfaction was found to be strong support (Wang & Chiu, 2011).

Another previous research appealed that, to assess students' perspective on online learning system, these factors need to be considered; course content (material in course, module components offered), lecturer concern to students (personal attachment, two-way discussion after class), social activities (aggregation in club, events and societies), communication with university related to management, assessments (exams, quizzes, assessments, and feedbacks), counseling services (the range of help provided by an advisor, etc.), instruction medium (language and channel, etc.) and people (peer interest, etc.). The other factors such as encouraging level of student interaction, personalization and e-learning provision should be focused on more

(Uppal et al., 2021).

Three measurements were taken by Uppal et al. (2020) which are service quality (SERVQUAL) reliability, assurance, tangibility, empathy and responsiveness), information quality from learning content dimension (presentation, structure, interactivity, language and delivery modes) and system quality (in term of course website for its interface design, navigation, attractiveness and ease of use). Chopra et al. (2019) measured system quality, net benefits service quality, user satisfaction and information quality from the students perspective. Thorough research had been done from this research that strengthened and supported their decision in selecting the mentioned factors. Firstly, systems quality is defined as the quality of an e-learning portal in terms of its ease of use, friendly user interface and easy access without troubleshooting. A. N. Islam (2013) stressed that access, ease of use, navigation and reliable are four characteristics that have to be considered while Azlan et al. (2020) added flexibility, functionality, compatibility and well-designed for measurement of system quality in e-learning platform.

Information quality or quality of content is one of the main factors that have to be considered in evaluating significant factors for online learning as a dimension including instructional materials (for example pdf, ppts, audio and video). Besides, content quality varies with the proper arrangement of assignments and quizzes to ensure learning information, learned principles, skills and knowledge can be delivered well by learners as well as providing exact, sufficient and up-to-date information (Wang & Chiu, 2011). Service quality is one of the most important factors for online learning. Service quality can maximize the delivery of learning input by providing proper explanation and assistance via online while frequent consultation and periodical feedback to evaluate user's and learners' satisfaction through the customer support system adding extra attributes to customer delight (Chopra et al., 2019).

Table 2.1: Summary of previous research on E-learning quality service

Author	**Factors**
Cidral et al. (2018)	Usability, understanbility, interesting,, reliable
Uppal (2017)	Empathy, reliablity, tangibility, responsiveness, learning content, assurance
Ragab et al. (2018)	Society support, student, course, technology, instructor
Al-Samarraie et al. (2017)	Utility value of course, usefulness of system, quality of information
Raspopovic & Jankulovic (2017)	Flexibility, user friendly, stability, security, response time, reliablity
Lin & Wang (2012)	Ease of use, proper navigation, friendliness, acceptability, stabilty
M. Islam et al. (2011)	integration and accessibility, reliability, ease of use
Machado-Da-Silva et al. (2014)	Interactive content, usability, interesting, understandibility
Sadi-Nezhad et al. (2010)	personalization, content, learner community, learner interface

3 METHODOLOGY

The methodology is designed based on surveys from different research and studies about management performance on online learning in many academic institution systems. The proposed methodology in this study process which consists 7 steps according to the main principles of designing an evaluation of students' preference for online learning systems by Fuzzy Analytic Network Process are as follows:

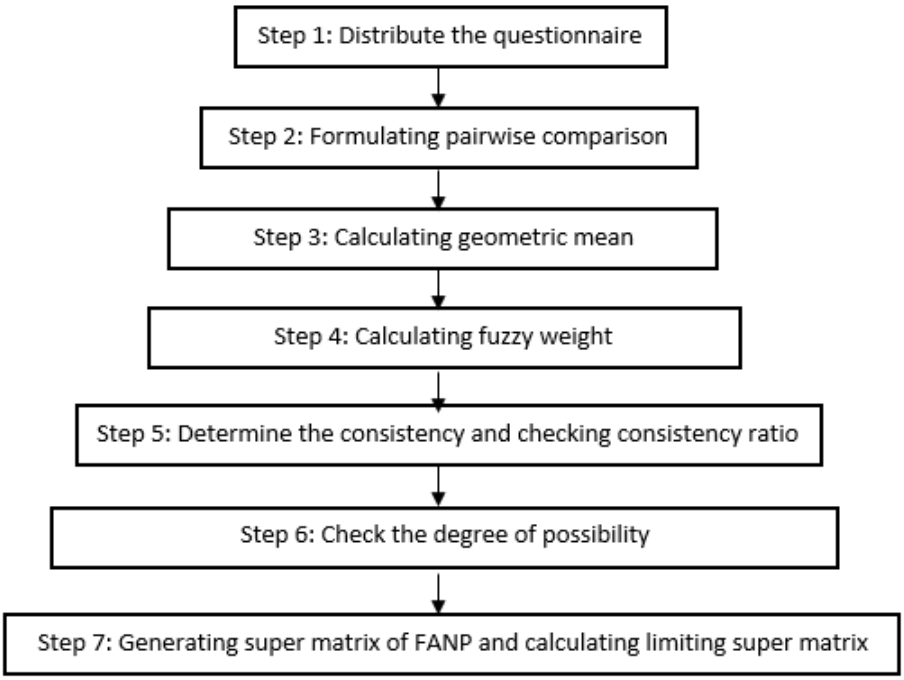

Figure 3.1: Methodology Flow Chart

Criteria and sub-criteria are identified from surveys conducted on the different matrix for measuring online learning effectiveness. A model is built and the problem is converted to a network structure and the problem is transformed into a logical network system for all elements interact to with each other. Figure 3.2 below shows the diagram of the network structure.

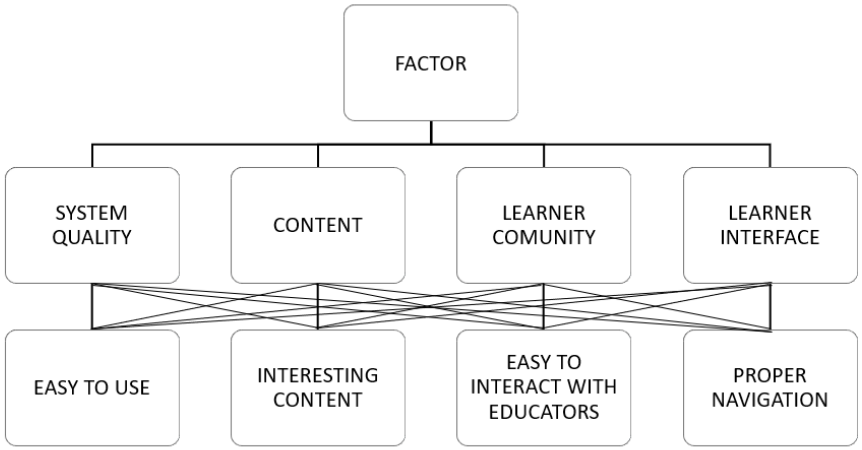

Figure 3.2: Network Structure

According to the above network structure, the criteria are easy to use, interesting content, easy to interact with educators and proper navigation. Meanwhile, the factors are system quality, content, learner community and learner interface. System quality is one of the factors chosen where every institution manages a comprehensive e-learning system for instance, U-Future for UiTM. The quality of the system includes the existence of 'bugs', response rate, quality of documentation and many more. Another factor is content which consists of course material, module components, educators' personal attachment and so on. For example, the quality of subjects content by educators in U-Future or Google Classroom. Learner community is also important in order to engage in society. Learner community also involves a medium for communication with the university related to management, giving feedback on learning medium and services. Lastly, learner interface includes a medium or channel for learners and educators for two-way communication and discussion like WhatsApp and Telegram. Thus, these factors are evaluated its dependent relationship with criteria is calculated.

STEP 1 : Distribute the survey questionnaire

Required data is obtained from a survey where 10 decision makers will answer a questionnaire using Google Form.

STEP 2: Formulate pairwise comparison matrix

Data obtained will be converted into TFN numbers to compare relative importance. Similar to AHP, a pairwise comparison matrix is formed by comparing decision elements in each cluster. Clusters themselves are also compared based on the goals, criteria and interdependencies. According to Saaty the relative importance of the elements is measured with nine-point scales as below:

Table 3.1: Linguistic value look-up table

Fuzzy language	**TFN**	**Reciprocal TFNs**
Absolute important	(9,9,9)	(1/9, 1/9 ,1/9)
Demonstrate important	(6,7,8)	(1/8, 1/7,/1/6)
strong importance	(4,5,6)	(1/6, 1/5, 1/4)
Weak important	(2,3,4)	(1/4, 1/3, 1/2)
Equal important	(1,1,1)	(1,1,1)
Intermediate	(7,8,9), (5,6,7), (3,4,5), (1,2,3)	(1/9, 1/8 ,1/7), (1/7, 1/6, 1/5), (1/5, 1/4, 1/3), (1/3, 1/2, 1)

STEP 3: Calculate geometric mean

Geometric mean is calculated by the formula below. Value of r_i represents as geometric mean,

$$r_i = A_1 \times A_2 = (l_1, m_1, u_1) \times (l_2, m_2, u_2) \tag{1}$$

STEP 4: Calculate fuzzy weight, w_i

Weighted criteria is calculated using the formula,

$$w_i = r_i \times (r_1 + r_2 \cdots + r_n)^{-1} \tag{2}$$

After that, the weighted sum value is formed thus, λ_{max} which is the largest eigenvalue will be calculated.

STEP 5: Determine the consistency and check consistency ratio

The weight consistency is calculated by this equation:

$$CI = (\lambda_{max} - n)/(n-1) \tag{3}$$

Thus, the consistency ratio must be less than 0.1 is formulated by the equation below:

$$CR = (CI)/(RI) \tag{4}$$

where n is the number of items being compared and random index (RI) is generated by Saaty as below:

Table 3.2: Random Index

n	0	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.40	1.45	1.49

STEP 6: Calculate the degree of possibility

Degree of possibility is calculated by mean to determine how likely it is to have a larger fuzzy number than another one.

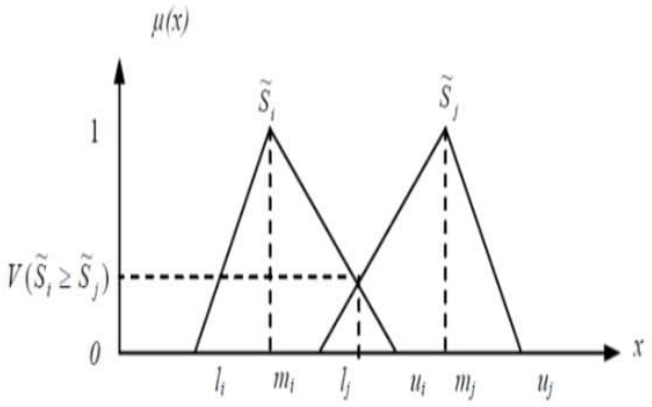

Figure 3.3: Probability of being larger of two fuzzy numbers to each other

Figure above is mathematically represented by the formula below:

$$V = (S_i \geq S_j) = \begin{cases} 1 & if m_i \geq m_j \\ 0 & if u_i \geq l_j \\ \frac{u_i - l_j}{(u_i - m_i) - (m_j - l_j)} & else \end{cases}$$

The function of V is the matrix of X corresponding to equation (5).

$$X = (V(S_i S_i) | i, j = 1, 2, \ldots n \quad \text{where} \quad i \neq j) \tag{5}$$

Then, the minimum amount of every row is calculated to form a new matrix of D as the formula (6).

$$D = min(v_i j) \quad i, j = 1, 2, \ldots, n \text{where} \quad i \neq j) \tag{6}$$

The matrix of D above will be normalized and lastly the normal weight will be calculated with the formula (7).

$$W = \frac{D_{i1}}{sum \quad of \quad D_{i1}} \quad \text{where} \quad i = 1, 2, \ldots n \tag{7}$$

Step 2 or 6 should be done for each block of super matrix.

STEP 7: Generate super-matrix and calculate limited super- matrix

Unweighted super-matrix is formed in which the elements are greater than 1 and the matrix needs to be normalized to a weighted super-matrix. The weighted super-matrix is formed to limited super-matrix and then it must be normalised. The pairwise comparison will be 0 if there is no interdependency among the criteria.

$$W_{ANP} = \lim_{k \to +\infty} W^{2k+1} \quad \text{where} \quad k = 1, 2, \ldots \tag{8}$$

Limited super-matrix allows bringing all the weighted super-matrix elements. The operation will continue to work if the elements are identical. The ultimate factor with the highest weight is ranked the best.

4 IMPLEMENTATION

STEP 1: Distribute questionnaire

A set of questionnaires was distributed to ten decision makers in UiTMCK. The decision makers selected were needed to answer the fuzzy questionnaire to generate a pairwise-comparison matrix where it is prepared based on factors and criteria.

The set of questionnaires was transformed into a Triangular Fuzzy Number (TFN) based on Table 3.1 in the Methodology section where the decision makers ticked on the column on the questions. the factors and criteria were defined as below:

Table 4.1: Factors and criteria

Factors	**Criteria**
F1: System quality	C1: Easy to use
F2: Content	C2:Easy to interact with educators
F3: Learner community	C3: Interesting content
F4: Learner interface	C4: Proper navigation

STEP 2: Formulate pairwise comparison matrix

Pairwise Comparison Matrix for Criteria

$$\begin{array}{c} \\ C1 \\ C2 \\ C3 \\ C4 \end{array} \begin{array}{c} \begin{array}{cccc} C1 & C2 & C3 & C4 \end{array} \\ \begin{pmatrix} (1,1,1) & (\frac{11}{6},\frac{11}{4},\frac{11}{3}) & (\frac{33}{7},\frac{29}{5},\frac{13}{2}) & (\frac{39}{5},\frac{41}{5},\frac{43}{5}) \\ (\frac{3}{7},\frac{3}{5},\frac{6}{7}) & (1,1,1) & (\frac{14}{5},\frac{18}{5},\frac{24}{5}) & (\frac{9}{2},\frac{26}{5},\frac{44}{7}) \\ (\frac{1}{6},\frac{1}{5},\frac{1}{4}) & (\frac{2}{9},\frac{1}{3},\frac{2}{5}) & (1,1,1) & (\frac{17}{9},\frac{14}{5},\frac{26}{7}) \\ (\frac{1}{8},\frac{1}{8},\frac{1}{6}) & (\frac{1}{6},\frac{1}{5},\frac{1}{4}) & (\frac{1}{3},\frac{2}{5},\frac{5}{9}) & (1,1,1) \end{pmatrix} \end{array}$$

Pairwise Comparison Matrix of criteria with respect to "easy to use", (C1)

$$\begin{array}{c} \\ F1 \\ F2 \\ F3 \\ F4 \end{array} \begin{array}{c} \begin{array}{cccc} F1 & F2 & F3 & F4 \end{array} \\ \begin{pmatrix} (1,1,1) & (\frac{1}{4},\frac{1}{3},\frac{1}{2}) & (\frac{23}{5},\frac{28}{5},\frac{33}{5}) & (\frac{17}{7},\frac{18}{5},\frac{38}{9}) \\ (2,3,4) & (1,1,1) & (\frac{44}{7},\frac{36}{5},8) & (\frac{23}{6},\frac{26}{5},\frac{17}{3}) \\ (\frac{1}{6},\frac{1}{5},\frac{1}{4}) & (\frac{1}{8},\frac{1}{7},\frac{1}{6}) & (1,1,1) & (\frac{1}{4},\frac{2}{7},\frac{1}{2}) \\ (\frac{3}{5},\frac{2}{7},1) & (\frac{1}{3},\frac{1}{5},\frac{5}{8}) & (3,\frac{18}{5},5) & (1,1,1) \end{pmatrix} \end{array}$$

Pairwise Comparison Matrix of criteria with respect to "easy to interact with educators", (C2)

$$\begin{array}{c} \\ F1 \\ F2 \\ F3 \\ F4 \end{array} \begin{array}{c} \begin{array}{cccc} F1 & F2 & F3 & F4 \end{array} \\ \begin{pmatrix} (1,1,1) & (\frac{1}{8},\frac{1}{6},\frac{1}{6}) & (\frac{1}{9},\frac{1}{9},\frac{1}{9}) & (\frac{1}{4},\frac{1}{3},\frac{1}{2}) \\ (6,\frac{31}{5},8) & (1,1,1) & (\frac{1}{4},\frac{1}{3},\frac{1}{2}) & (\frac{24}{5},\frac{29}{5},\frac{34}{5}) \\ (9,9,9) & (2,3,4) & (1,1,1) & (\frac{22}{5},\frac{27}{5},\frac{32}{5}) \\ (2,3,4) & (\frac{1}{7},\frac{1}{6},\frac{2}{9}) & (\frac{1}{6}3,\frac{2}{9},\frac{2}{7}) & (1,1,1) \end{pmatrix} \end{array}$$

Pairwise Comparison Matrix of criteria with respect to "interesting content",(C3).

$$\begin{array}{c} \\ F1 \\ F2 \\ F3 \\ F4 \end{array} \begin{array}{c} \begin{array}{cccc} F1 & F2 & F3 & F4 \end{array} \\ \begin{pmatrix} (1,1,1) & (\frac{1}{4},\frac{1}{3},\frac{1}{2}) & (2,3,4) & (5,6,7) \\ (2,3,4) & (1,1,1) & (5,6,7) & (\frac{15}{2},8,\frac{17}{2}) \\ (\frac{1}{4},\frac{1}{3},\frac{1}{2}) & (\frac{1}{7},\frac{1}{6},\frac{1}{5}) & (1,1,1) & (2,3,4) \\ (\frac{1}{6},\frac{1}{6},\frac{1}{5}) & (\frac{1}{8},\frac{1}{8},\frac{1}{7}) & (\frac{1}{4},\frac{1}{3},\frac{1}{2}) & (1,1,1) \end{pmatrix} \end{array}$$

Pairwise Comparison Matrix of criteria with respect to "proper navigation", (C4).

$$\begin{array}{c} \\ F1 \\ F2 \\ F3 \\ F4 \end{array} \begin{array}{c} \begin{array}{cccc} F1 & F2 & F3 & F4 \end{array} \\ \begin{pmatrix} (1,1,1) & (2,3,4) & (5,6,7) & (\frac{15}{2},8,\frac{17}{2}) \\ (\frac{1}{4},\frac{1}{3},\frac{1}{2}) & (1,1,1) & (\frac{14}{5},3,\frac{24}{5}) & (4,5,6) \\ (\frac{1}{7},\frac{1}{6},\frac{1}{5}) & (\frac{1}{4},\frac{1}{3},\frac{1}{2}) & (1,1,1) & (2,3,4) \\ (\frac{1}{8},\frac{1}{8},\frac{1}{7}) & (\frac{1}{6},\frac{1}{5},\frac{1}{4}) & (\frac{1}{2},\frac{1}{3},\frac{1}{2}) & (1,1,1) \end{pmatrix} \end{array}$$

STEP 3: Calculate geometric mean

From Equation (1) in the Methodology section, we get an extended equation as below:

$$r_i = ((l_1 + l_2 + l_3 + l_4)^{\frac{1}{4}}, (m_1 + m_2 + m_3 + m_4)^{\frac{1}{4}}, (u_1 + u_2 + u_3 + u_4)^{\frac{1}{4}}) \tag{9}$$

By using the above formula, geometric mean (r_i) of lower(l_i), middle(m_i) and upper(u_i) elements of pairwise comparison matrix in Step 2 are produced.

Therefore, the fuzzy evaluation matrix for criteria, C1, C2, C3 and C4 is;

$$\begin{array}{c} \\ C1 \\ C2 \\ C3 \\ C4 \end{array} \begin{array}{c} \begin{array}{ccc} l & m & u \end{array} \\ \begin{pmatrix} 2.8600 & 3.3766 & 3.7794 \\ 1.5212 & 1.8307 & 2.2516 \\ 0.5132 & 0.6303 & 0.7901 \\ 0.2847 & 0.3172 & 0.3835 \end{pmatrix} \end{array}$$

Table 4.2: Fuzzy evaluation matrix for factors with respect to criteria.

Fuzzy weight	C1			C2			C3			C4		
	l	m	u	l	m	u	l	m	u	l	m	u
F1	1.2912	1.6101	1.9323	0.2427	0.2799	0.3102	1.2574	1.5651	1.9343	2.9428	3.4641	3.9278
F2	2.6348	3.2555	3.6783	1.6381	1.8607	2.2837	2.9428	3.4641	3.9278	1.2936	1.4953	1.9480
F3	0.2645	0.2942	0.3646	2.9832	3.4749	3.8960	0.5196	0.6435	0.8034	0.5196	0.6435	0.8034
F4	0.8882	0.6730	1.3168	0.4787	0.5841	0.7141	0.2561	0.2919	0.3468	0.2648	0.3033	0.3630

Table 4.2 shows the fuzzy evaluation matrices for each factor with respect to criteria obtained from equation (1).

STEP 4: Calculate fuzzy weight and weight/priority vector

Inverse of row summation for the matrix below (obtained from the geometric mean) is calculated.

$$\begin{array}{c} \\ C1 \\ C2 \\ C3 \\ C4 \\ Sum \\ Inverse \end{array} \begin{array}{c} \begin{array}{ccc} l & m & u \end{array} \\ \begin{pmatrix} 2.8600 & 3.3766 & 3.7794 \\ 1.5212 & 1.8307 & 2.2516 \\ 0.5132 & 0.6303 & 0.7901 \\ 0.2847 & 0.3172 & 0.3835 \\ 5.1790 & 6.1548 & 7.2047 \\ 0.1931 & 0.1625 & 0.1388 \end{pmatrix} \end{array}$$

Then each lower, middle and upper value of each criteria is multiplied with the inverse to get fuzzy weight matrix.

$$\begin{array}{c} \\ C1 \\ C2 \\ C3 \\ C4 \end{array} \begin{array}{c} \begin{array}{ccc} l & m & u \end{array} \\ \begin{pmatrix} 0.5522 & 0.5486 & 0.5246 \\ 0.2937 & 0.2974 & 0.3125 \\ 0.0991 & 0.1024 & 0.1097 \\ 0.055 & 0.0515 & 0.0532 \end{pmatrix} \end{array}$$

To get the weight or priority vector, the average of lower, middle and upper values is calculated.

$$Weight = \frac{0.5522 + 0.5486 + 0.5246}{3}$$

Table 4.4: Fuzzy weight for factors with respect to each criterion Table 4.3: Weight of criteria

Criteria	Weight
C1	0.5418
C2	0.3012
C3	0.1037
C4	0.0532

Table 4.4: Fuzzy weight for factors with respect to each criteria

	C1			C2			C3			C4		
	l	m	u	l	m	u	l	m	u	l	m	u
F1	0.2542	0.2760	0.2650	0.0454	0.0451	0.0431	0.2527	0.2624	0.2758	0.5861	0.5865	0.5577
F2	0.5188	0.5581	0.5044	0.3066	0.3001	0.3170	0.5914	0.5808	0.5601	0.2576	0.2532	0.2766
F3	0.0521	0.0504	0.0500	0.5584	0.5605	0.5408	0.1044	0.1079	0.1146	0.1035	0.1089	0.1141
F4	0.1749	0.1154	0.1806	0.0896	0.0942	0.0991	0.0515	0.0489	0.0495	0.0527	0.0514	0.0515

Table 4.5: Weight of factors with respect to criteria

Weight/ Priority vector				
	C1	C2	C3	C4
F1	0.2651	0.5271	0.0508	0.1570
F2	0.0445	0.3079	0.5532	0.0943
F3	0.2636	0.5774	0.1090	0.0500
F4	0.5768	0.2625	0.1088	0.0519

STEP 5: Determine the consistency and check consistency ratio

Consistency is checked by using the equation (3):

$$CI = (\lambda_{max} - n)/(n-1)$$

Firstly the λ_{max} is calculated. The pairwise comparison matrix should be normalised.

$$\mathrm{P} = \begin{bmatrix} 1 & 2.7333 & 5.8 & 8.2 \\ 0.6 & 1 & 3.6 & 5.2 \\ 0.1873 & 0.3010 & 1 & 2.8 \\ 0.1238 & 0.2044 & 0.4 & 1 \end{bmatrix}$$

The elements in the column of the pairwise comparison matrix are added to get the sum of the column matrix.

$$Sum_c = \begin{bmatrix} 1.9111 & 4.2387 & 10.8 & 17.2 \end{bmatrix}$$

Each element of the pairwise comparison matrix is divided to the sum of the matrix to form a normalized comparison matrix.

$$\mathrm{P}_N = \begin{bmatrix} 0.5233 & 0.6448 & 0.5370 & 0.4767 \\ 0.314 & 0.2359 & 0.3333 & 0.3023 \\ 0.098 & 0.071 & 0.0926 & 0.1628 \\ 0.0648 & 0.0482 & 0.037 & 0.0581 \end{bmatrix}$$

Criteria weight (C_w) is calculated by adding the P_N by its row and dividing by the number of criteria.

$$C_w = \begin{bmatrix} 0.5455 \\ 0.2964 \\ 0.1061 \\ 0.052 \end{bmatrix}$$

Criteria weight (C_w) is then multiplied by the pairwise comparison matrix (P_N). Calculate the weighted sum value by adding the elements of the row for the new matrix formed.

$$P_N \times C_w = \begin{bmatrix} 1 & 2.7333 & 5.8 & 8.2 \\ 0.6 & 1 & 3.6 & 5.2 \\ 0.1873 & 0.3010 & 1 & 2.8 \\ 0.1238 & 0.2044 & 0.4 & 1 \end{bmatrix} \times \begin{bmatrix} 0.5455 \\ 0.2964 \\ 0.1061 \\ 0.052 \end{bmatrix} = \begin{bmatrix} 0.5455 & 0.8101 & 0.6154 & 0.4268 \\ 0.3273 & 0.2964 & 0.382 & 0.2707 \\ 0.1022 & 0.0892 & 0.1061 & 0.1457 \\ 0.0675 & 0.0606 & 0.0424 & 0.052 \end{bmatrix}$$

$$\text{Weighted sum value} = \begin{bmatrix} 2.3977 \\ 1.2763 \\ 0.4432 \\ 0.2226 \end{bmatrix}$$

Each element of the weighted sum value matrix is divided by each element of C_w.

$$\text{Weighted sum value} = \begin{bmatrix} 4.3957 \\ 4.3061 \\ 4.1773 \\ 4.2771 \end{bmatrix}$$

Each element of the matrix below is summed up to get λ_max which is 4.2891.

Consistency Index (CI) = $\frac{4.2891-4}{4-1}$ = 0.0964. Consistency Ratio (CR) =$\frac{CI}{4.2891}$= 0.10 so, when the CR is lesser or equal to 0.1 then it is said to be consistent.

Table 4.6: Consistency Ratio for Factors

	C1	C2	C3	C4
Consistency Ratio	0.08	0.1	0.0483	0.0416

STEP 6: Calculate degree of possibility

The degree of possibility where $V(S_i \geq S_j)$, the probability of being larger of two fuzzy number (S_i and S_j) to each other is calculated using the equation below. The detailed calculation and comparison are shown below.

$$V = (S_i \geq S_j) = \begin{cases} 1 & if m_i \geq m_j \\ 0 & if u_i \geq l_j \\ \frac{u_i - l_j}{(u_i - m_i) - (m_j - l_j)} & else \end{cases}$$

Row comparison for criteria C1

$V(S1 \geq S2) = 1$

V(S1$\geq$ S3) = 1

V(S1$\geq$ S4) = 1

Take the minimum value for $V(S1 \geq S2, S3, S4)$ which is 1.

Row comparison for criteria C2

$V(S2 \geq S1) = 0$

V(S2$\geq$ S3) = 1

V(S2$\geq$ S4) = 1

Take the minimum value for $V(S2 \geq S1, S3, S4)$ which is 0.

Row comparison for criteria C3

$V(S3 \geq S1) = 0$

V(S3$\geq$ S2) = 0

V(S3$\geq$ S4) = 1

Take the minimum value for $V(S3 \geq S1, S2, S4)$ which is 0.

Row comparison for criteria C4

$V(S4 \geq S1) = 0$

V(S4$\geq$ S2) = 0

V(S4$\geq S3$) $= 0$

We take the minimum value for $V(S4 \geq S1, S2, S3)$ which is 0.

Table 4.7: Degree of Possibility for Criteria

Row comparison	C1	C2	C3	C4
Minimum Value	1	0	0	0

Table 4.8: Degree of Possibility for Factor

with respect to	C1	C2	C3	C4
F1	1	0	0	1
F2	1	0	1	0
F3	0	1	0	0
F4	0	0	0	0

Here, we can see the degree of possibility by extent analysis method has assigned the zero value for the weight leading to criterion or factor not to be considered in decision analysis so, we rather utilized the geometric mean by Buckley to calculate the fuzzy weight.

STEP 7: Generating super matrix and limiting super matrix

The next step is to construct super matrix of FANP. To do so, the obtained priority vectors of the previous step are positioned in the proper columns to form super matrix. Thus limiting super matrix is generated by using stochastic in octave or by calculating the square of super matrix, $L = S^2$.

$$\mathbf{S} = \begin{array}{c} \\ Goal \\ C1 \\ C2 \\ C3 \\ C4 \\ F1 \\ F2 \\ F3 \\ F4 \end{array} \begin{array}{c} \begin{array}{ccccccccc} Goal & C1 & C2 & C3 & C4 & F1 & F2 & F3 & F4 \end{array} \\ \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0.5455 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0.2964 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0.1061 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0.0520 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0.2651 & 0.0445 & 0.2639 & 0.5768 & 1 & 0 & 0 & 0 \\ 0 & 0.5271 & 0.3079 & 0.5774 & 0.2625 & 0 & 1 & 0 & 0 \\ 0 & 0.0508 & 0.5532 & 0.1090 & 0.1088 & 0 & 0 & 1 & 0 \\ 0 & 0.1570 & 0.0943 & 0.0500 & 0.0519 & 0 & 0 & 0 & 1 \end{pmatrix} \end{array}$$

$$
\mathbf{L} = \begin{array}{c} \\ Goal \\ C1 \\ C2 \\ C3 \\ C4 \\ F1 \\ F2 \\ F3 \\ F4 \end{array}
\begin{array}{c}
\begin{array}{ccccccccc} Goal & C1 & C2 & C3 & C4 & F1 & F2 & F3 & F4 \end{array} \\
\left(\begin{array}{ccccccccc}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0.2158 & 0.2651 & 0.0445 & 0.2639 & 0.5768 & 1 & 0 & 0 & 0 \\
0.4537 & 0.5271 & 0.3079 & 0.5774 & 0.2625 & 0 & 1 & 0 & 0 \\
0.2089 & 0.0508 & 0.5532 & 0.1090 & 0.1088 & 0 & 0 & 1 & 0 \\
0.1216 & 0.1570 & 0.0943 & 0.0500 & 0.0519 & 0 & 0 & 0 & 1
\end{array}\right)
\end{array}
$$

5 RESULTS AND DISCUSSION

This section discusses the results of the FANP model to rank the students' preference factorsfactors on online learning effectiveness for all the criteria by using Microsoft Excel. The capability of these factors to maximize their functions which imply every proposed criteria is considered. Therefore, four factors of online learning which are system quality, content, learner community and learner interface are investigated to rank the factors that contribute to the effectiveness of online learning in terms of the criteria, easy to use, interesting content, easy to interact with educators and proper navigation.

According to what included in the research methodology section, to analyse the fuzzy decision matrices and deal with fuzzy data, Chang's extended analysis is used. The input of FANP model are pairwise comparison matrices shown in Tables 5.1 to 5.5. The data used in the pairwise comparison matrix in TFN number are separately gathered for each criteria.

Table 5.1: Pairwise comparison of the criteria

Criteria	Easy to use	Easy to interact with educators	Interesting content	Proper navigation	Weight
Easy to use	(1,1,1)	(11/6,11/4,11/3)	(9/2,29/5,13/2)	(33/5,41/5,43/5)	0.5418
Easy to interact with educators	(3/7,3/5,6/7)	(1,1,1)	(14/5,18/5,24/5)	(9/2,26/5,44/7)	0.3012
Interesting content	(1/6,1/5,1/4)	(2/9,1/3,2/5)	(1,1,1)	(17/9,14/5,26/7)	0.1037
Proper navigation	(1/8,1/8,1/6)	(1/6,1/5,1/4)	(1/3,2/5,5/9)	(1,1,1)	0.0532

The research is conducted for four criteria. the Table 5.1 shows the data used in pairwise comparison matrices are uniquely assembled for "easy to use", "easy to interact with educators", proper navigation" and "proper navigation". The weight for "easy to use" has the highest value which it can be hypothesized that students prefer factors that are easy to use in online learning.

Table 5.2: Pairwise comparison with respect to easy to use.

	System quality	Content	Learner community	Learner interface	Weight
System quality	(1,1,1)	(1/4,1/3,1/2)	(23/5,28/5,33/5)	(17/7,18/5,38/9)	0.2651
Content	(2,3, 4)	(1,1,1)	(44/7,36/5,8)	(23/6,26/5,17/3)	0.5271
Learner community	(1/6,1/5,1/4)	(1/8,1/7,1/6)	(1,1,1)	(1/4,2/7,1/2)	0.0508
Learner interface	(3/5,2/7,1)	(1/3,1/5,5/8)	(3,18/5,5)	(1,1,1)	0.1570

Table 5.3: Pairwise comparison with respect to easy to interact with educators.

	System quality	Content	Learner community	Learner interface	Weight
System quality	(1,1,1)	(1/8,1/6,1/6)	(1/9,1/9,1/9)	(1/4,1/3,1/2)	0.0445
Content	(6,31/5,8)	(1,1,1)	(1/4,1/3,1/2)	(24/5,29/5,34/5)	0.3079
Learner community	(9,9,9)	(2,3,4)	(1,1,1)	(22/5,27/5,32/5)	0.5532
Learner interface	(2,3,4)	(1/7,1/6,2/9)	(1/6,2/9,2/7)	(1,1,1)	0.0943

Table 5.4: Pairwise comparison with respect to interesting content.

	System quality	Content	Learner community	Learner interface	Weight
System quality	(1,1,1)	(1/4,1/3,1/2)	(2,3,4)	(5,6,7)	0.2636
Content	(2,3,4)	(1,1,1)	(5,6,7)	(15/2,8,17/2)	0.5774
Learner community	(1/4,1/3,1/2)	(1/7,1/6,1/5)	(1,1,1)	(2,3,4)	0.1090
Learner interface	(1/7,1/6,1/5)	(1/8,1/8,1/7)	(1/4,1/3,1/2)	(1,1,1)	0.0500

Table 5.5: Pairwise comparison with respect to proper navigation.

	System quality	Content	Learner community	Learner interface	Weight
System quality	(1,1,1)	(2,3,4)	(5,6,7)	(15/2,8,17/2)	0.5768
Content	(1/4,1/3,1/2)	(1,1,1)	(14/5,3,24/5)	(4,5,6)	0.2625
Learner community	(1/7,1/6,1/5)	(1/4,1/3,1/2)	(1,1,1)	(2,3,4)	0.1088
Learner interface	(1/8,1/8,1/7)	(1/6,1/5,1/4)	(1/4,1/3,1/2)	(1,1,1)	0.0519

The data collection are from ten guided students in UiTM Kelantan Branch. The ratings of all the ten students are combined using the average of pairwise comparison values. According to prior step of FANP, priority weights is obtained. Tables 5.1 until 5.5 shows the pairwise comparison matrix of the criteria where each criterion is compared with others to find the relative

weight as shown in the last column of Tables 5.1 to 5.5. Therefore, comparable to above tables, Chang's priority weights and fuzzy intervals of factors are calculated for all criteria.

Table 5.6: Limiting super matrix

	Goal	C1	C2	C3	C4	F1	F2	F3	F4
Goal	0	0	0	0	0	0	0	0	0
C1	0	0	0	0	0	0	0	0	0
C2	0	0	0	0	0	0	0	0	0
C3	0	0	0	0	0	0	0	0	0
C4	0	0	0	0	0	0	0	0	0
F1	0.2158	0.2651	0.0445	0.2639	0.5768	1	0	0	0
F2	0.4537	0.5271	0.3079	0.5774	0.2625	0	1	0	0
F3	0.2089	0.0508	0.5532	0.1090	0.1088	0	0	1	0
F4	0.1216	0.1570	0.0943	0.0500	0.0519	0	0	0	1

Super matrix of FANP is obtained where the rankings for online learning factors for all criteria are displayed in Table 5.6. According to FANP results, the factors with the highest rank is content factor (F2) where the second highest is system quality (F1) follows by learner community (F3) and learner interface (F4). Thus, content which involves course material, module components and attachments, and its medium has to be the priority embraced to make up an effective learning. According to the result, content factor (F2) has high value for each criterion where content is required to be efficient especially in term of ease to use and its attractiveness (interesting criterion).

6 CONCLUSIONS AND RECOMMENDATIONS

In this study, a model was developed by using Fuzzy ANP. Ten decision makers are requested to answer the fuzzy questionnaire to express their opinions. The fuzzy questionnaire is developed based on main four criteria which are easy to use (C1), easy to interact with educators (C2), interesting content (C3), and proper navigation (C4) and four factors which are system quality (F1), content (F2), learner community (F3) and learner interface (F4). The decision makers' answers from the questionnaires were transformed into a Triangular Fuzzy Number (TFN) to generate a pairwise comparison matrix. The selection score model was developed based on the fuzzy weight obtained for each criteria and factor.

ANP has been successfully conducted in the selection of the students' preference factors in online learning. According to the findings of this study, easy to use (C1) has the highest fuzzy weight among the other criteria. The rank continues with easy to interact with educators (C2), interesting content (C3) and proper navigation (C4). For factor, content (F2) recorded the highest fuzzy weight among others. Therefore, content factor should be prioritized in online learning for maximum effectiveness in the education process. Next, the ranks of factors continue with system quality (F1), learner community (F3) and learner interface (F4) which is the least important in online learning. As a direction for future studies, one may investigate with more suitable criteria and factors to fit in the online learning system. In other words, many factors including the condition of educators, students, study equipment, and decision makers' comments can affect the online learning function. This study has only utilized ANP by geometric mean method for the decision making, hence next study is recommended to apply the least square priority method by Xu, or the fuzzy preference programming method developed by Mikhailov.

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APPENDIX A

Questionnaire Manual

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Survey Questionnaire for:

APPLICATION OF FUZZY ANALYTIC NETWORK PROCESS (FANP) FOR STUDENT CONSIDERATION OF ONLINE DISTANCE LEARNING EFFECTIVENESS

Dear Madam/Sir/Ms,

This is academic research (Final Year Project) about choosing a comprehensive university in Malaysia for a medicine course. In this study, we are using the Fuzzy Analytical Network Process (FANP) in overall aspects which are content, design, technical, and presentation. Furthermore, we would like to compare this method with another method which is a manual system.

All the information will be used for academic purposes only. Please be comfortable filling out the answer. Your support will help us in completing this research. Thank you and have a great day.

INSTRUCTION: Questionnaire used to facilities comparison of main and sub-criterion:

Read the following question and put check on the pairwise comparison matrices. If a criterion on the left is more important than the on matching on the right, put your check mark to the left importance "Equal" under the importance level you prefer. If a criterion on the left is less important than the one on the right, put your check mark to the right side of the importance "Equal" under the importance level you prefer.

The importance of a criteria to another criteria is determined by fuzzy

1 Equally importance
3 Weakly importance
5 Fairly importance
7 Strongly importance
9 Absolutely importance

The questionnaire is divided into two (2) parts.

(i) Comparison of four (4) main criteria
(ii) Comparison of four (4) factors

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QUESTIONS

1. **Comparison of four (4) main criteria**

With respect to the overall goal factor contributing to effectiveness of ODL

Question 1: How important is ease to use (C_1) compared to content (c_2)?
Question 2: How important is ease to use (C_1) compared to ease to interact with educators (C_3)?
Question 3: How important is ease to use (C_1) compared to proper navigation (C_4)?
Question 4: How important is interesting content (C_2) compared to ease to interact with educators (C_3)?
Question 5: How important is interesting content (C_2) compared to proper navigation (C_4)?
Question 6: How important is ease to interact with educators (C_3) compared to proper navigation (C_4)?

With respect to: The overall goal		Importance of one main- factor over another									
Question	Criteria	9	7	5	3	1	3	5	7	9	Criteria
Q1	Easy to use										interesting content
Q2	Easy to use										easy to interact with educators
Q3	Easy to use										proper navigation
Q4	interesting content										easy to interact with educators
Q5	interesting content										proper navigation
Q6	easy to interact with educators										proper navigation

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2. **Comparison of four (4) factors**

With respect to the criteria "*ease to use* (C_1)"

Question 1: How important is system quality (F_1) compared to content (F_2)?

Question 2: How important is system quality (F_1) compared to learner community (F_3)?

Question 3: How important is system quality (F_1) compared to learner interface (F_4)?

Question 4: How important is content (F_2) compared to learner community (F_3)?

Question 5: How important is content (F_2) compared to learner community (F_4)?

Question 6: How important is learner community (F_3) compared to learner interface (F_4)?

With respect to: Suitability for the purpose		Importance of one factor over another									
Question	Criteria	9	7	5	3	1	3	5	7	9	Criteria
Q1	System quality										Content
Q2	System quality										Learner community
Q3	System quality										Learner interface
Q4	Content										Learner community
Q5	Content										Learner interface
Q6	Learner community										Learner interface

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With respect to the criteria "interesting content (C_2)"

Question 1: How important is system quality (F_1) compared to content (F_2)?

Question 2: How important is system quality (F_1) compared to learner community (F_3)?

Question 3: How important is system quality (F_1) compared to learner interface (F_4)?

Question 4: How important is content (F_2) compared to learner community (F_3)?

Question 5: How important is content (F_2) compared to learner community (F_4)?

Question 6: How important is learner community (F_3) compared to learner interface (F_4)?

With respect to: Suitability for the purpose		Importance of one factor over another									
Question	Criteria	9	7	5	3	1	3	5	7	9	Criteria
Q10	System quality										Content
Q11	System quality										Learner community
Q12	System quality										Learner interface
Q13	Content										Learner community
Q14	Content										Learner interface
Q15	Learner community										Learner interface

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With respect to the criteria "*ease to interact with educators* (C_3)"

Question 1: How important is system quality (F_1) compared to content (F_2)?

Question 2: How important is system quality (F_1) compared to learner community (F_3)?

Question 3: How important is system quality (F_1) compared to learner interface (F_4)?

Question 4: How important is content (F_2) compared to learner community (F_3)?

Question 5: How important is content (F_2) compared to learner community (F_4)?

Question 6: How important is learner community (F_3) compared to learner interface (F_4)?

With respect to: Suitability for the purpose		Importance of one factor over another									
Question	Criteria	9	7	5	3	1	3	5	7	9	Criteria
Q16	System quality										Content
Q17	System quality										Learner community
Q18	System quality										Learner interface
Q19	Content										Learner community
Q20	Content										Learner interface
Q21	Learner community										Learner interface

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With respect to the criteria "*proper navigation* (C_4)"

Question 1: How important is system quality (F_1) compared to content (F_2)?
Question 2: How important is system quality (F_1) compared to learner community (F_3)?
Question 3: How important is system quality (F_1) compared to learner interface (F_4)?
Question 4: How important is content (F_2) compared to learner community (F_3)?
Question 5: How important is content (F_2) compared to learner community (F_4)?
Question 6: How important is learner community (F_3) compared to learner interface (F_4)?

With respect to: Suitability for the purpose		Importance of one factor over another									
Question	Criteria	9	7	5	3	1	3	5	7	9	Criteria
Q16	System quality										Content
Q17	System quality										Learner community
Q18	System quality										Learner interface
Q19	Content										Learner community
Q20	Content										Learner interface
Q21	Learner community										Learner interface

APPENDIX B

SECTION A - CRITERIA

	Decision Maker 1	Easy to use			sy to interact with educato			Interesting content			Proper navigation		
2	Easy to use	1	1	1	2	3	4	4	5	6	6	7	8
3	Easy to interact with educator	1/4	1/3	1/2	1	1	1	2	3	4	4	5	6
4	Interesting content	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1	2	3	4
	Proper navigation	1/8	1/7	1/6	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

1.00	Decision Maker 2	Easy to use			Easy to interact with educato			Interesting content			Proper navigation		
2	Easy to use	1	1	1	2	3	4	4	5	6	6	7	8
3	Easy to interact with educator	1/4	1/3	1/2	1	1	1	2	3	4	4	5	6
4	Interesting content	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1	2	3	4
	Proper navigation	1/8	1/7	1/6	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

	Decision Maker 3	Easy to use			Easy to interact with educato			Interesting content			Proper navigation		
2	Easy to use	1	1	1	1/4	1/3	1/2	2	3	4	6	7	8
1	Easy to interact with educator	2	3	4	1	1	1	6	7	8	9	9	9
3	Interesting content	1/4	1/3	1/2	1/8	1/7	1/6	1	1	1	2	3	4
4	Proper navigation	1/8	1/7	1/6	1/9	1/9	1/9	1/4	1/3	1/2	1	1	1

Decision Maker 4	Easy to use			sy to interact with educat			Interesting content			Proper Navigation		
Easy to use	1	1	1	2	3	4	4	7	6	9	9	9
Easy to interact with educator	1/4	1/3	1/2	1	1	1	2	3	4	4	5	6
Interesting content	1/6	1/7	1/4	1/4	1/3	1/2	1	1	1	2	3	4
Proper navigation	1/8	1/9	1/6	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

Decision Maker 5	Easy to use			sy to interact with educat			Interesting content			Proper navigation		
Easy to use	1	1	1	2	3	4	6	7	8	9	9	9
Easy to interact with educator	1/4	1/3	1/2	1	1	1	4	3	6	2	5	4
Interesting content	1/8	1/7	1/6	1/6	1/3	1/4	1	1	1	2	3	4
Proper navigation	1/9	1/9	1/9	1/4	1/5	1/2	1/4	1/3	1/2	1	1	1

Decision Maker 6	Easy to use			sy to interact with educat			Interesting content			Proper navigation		
Easy to use	1	1	1	2	3	4	9	9	9	6	7	8
Easy to interact with educator	1/4	1/3	1/2	1	1	1	4	5	6	6	3	8
Interesting content	1/9	1/9	1/9	1/6	1/5	1/4	1	1	1	1	1	1
Proper navigation	1/8	1/7	1/6	1/8	1/3	1/6	1	1	1	1	1	1

Decision Maker 7	Easy to use			Easy to interact with educat			Interesting content			Proper navigation		
Easy to use	1	1	1	2	3	4	4	5	6	9	9	9
Easy to interact with educator	1/4	1/3	1/2	1	1	1	2	3	4	4	5	6
Interesting content	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1	2	3	4
Proper navigation	1/8	1/9	1/6	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

Decision Maker 8	Easy to use			Easy to interact with educat			Interesting content			Proper navigation		
Easy to use	1	1	1	2	3	4	4	5	6	9	9	9
Easy to interact with educator	1/4	1/3	1/2	1	1	1	2	3	4	4	5	6
Interesting content	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1	2	3	4
Proper navigation	1/8	1/9	1/6	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

Decision Maker 9	Easy to use			Easy to interact with educat			Interesting content			Proper navigation		
Easy to use	1	1	1	2	3	4	6	7	8	9	9	9
Easy to interact with educator	1/4	1/3	1/2	1	1	1	2	3	4	4	5	6
Interesting content	1/6	1/7	1/4	1/4	1/3	1/2	1	1	1	2	3	4
Proper navigation	1/8	1/9	1/6	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

Decision Maker 10	Easy to use			Easy to interact with educat			Interesting content			Proper navigation		
Easy to use	1	1	1	2	3	4	4	5	6	9	9	9
Easy to interact with educator	1/4	1/3	1/2	1	1	1	2	3	4	4	5	6
Interesting content	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1	2	3	4
Proper navigation	1/9	1/9	1/9	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

Calculating fuzzy geometric mean value

	l	m	u
Easy to use	2.8600	3.3766	3.7794
Easy to interact with educator	1.5212	1.8307	2.2516
Interesting content	0.5132	0.6303	0.7901
Proper navigation	0.2847	0.3172	0.3835
TOTAL	5.1790	6.1548	7.2047
INVERSE	0.1931	0.1625	0.1388

Calculating fuzzy weight

	Fuzzy weight			weight
Easy to use	0.55223	0.54861	0.52458	0.5418
Easy to interact with educator	0.29373	0.29744	0.31253	0.3012
Interesting content	0.09909	0.10241	0.10967	0.1037
Proper navigation	0.05496	0.05154	0.05323	0.0532

Easy to use C1
Easy to interact with educator, C2
Interesting content, C3
Proper navigation, C4

	C1	C2	C3	C4
C1	1.0000	2.7333	5.8000	8.2000
C2	0.6000	1.0000	3.6000	5.2000
C3	0.1873	0.3010	1.0000	2.8000
C4	0.1238	0.2044	0.4000	1.0000
SUM	1.9111	4.2387	10.8000	17.2000

	C1	C2	C3	C4	Criteria weights
C1	0.5233	0.6448	0.5370	0.4767	0.5455
C2	0.3140	0.2359	0.3333	0.3023	0.2964
C3	0.0980	0.0710	0.0926	0.1628	0.1061
C4	0.0648	0.0482	0.0370	0.0581	0.0520

Fuzzy evaluation matrix of factor with respect to easy to use (C1):

$$\begin{array}{c} \\ F1 \\ F2 \\ F3 \\ F4 \end{array} \begin{array}{c} \begin{array}{ccc} l & m & u \end{array} \\ \begin{pmatrix} \frac{9}{7} & \frac{8}{5} & 2 \\ \frac{21}{8} & \frac{13}{4} & \frac{11}{9} \\ \frac{1}{4} & \frac{2}{7} & \frac{3}{8} \\ \frac{8}{9} & \frac{2}{3} & \frac{4}{3} \end{pmatrix} \end{array}$$

Fuzzy evaluation matrix of Factor with respect to easy to interact with educators (C2):

$$\begin{array}{c} \\ F1 \\ F2 \\ F3 \\ f4 \end{array} \begin{array}{c} \begin{array}{ccc} l & m & u \end{array} \\ \begin{pmatrix} \frac{1}{4} & \frac{2}{7} & \frac{1}{3} \\ \frac{5}{3} & \frac{13}{7} & \frac{16}{7} \\ 3 & \frac{7}{2} & \frac{35}{9} \\ \frac{1}{2} & \frac{3}{5} & \frac{5}{7} \end{pmatrix} \end{array}$$

Fuzzy evaluation matrix of factor with respect to easy to interesting content (C3):

$$\begin{array}{c} \\ F1 \\ F2 \\ F3 \\ F4 \end{array} \begin{array}{c} \begin{array}{ccc} l & m & u \end{array} \\ \begin{pmatrix} \frac{5}{4} & \frac{11}{7} & 2 \\ 3 & \frac{7}{2} & 4 \\ \frac{1}{2} & \frac{2}{3} & \frac{4}{5} \\ \frac{1}{4} & \frac{2}{7} & \frac{1}{3} \end{pmatrix} \end{array}$$

Fuzzy evaluation matrix of criteria with respect to proper navigation (C4):

$$\begin{array}{c} \\ F1 \\ F2 \\ F3 \\ F4 \end{array} \begin{array}{c} \begin{array}{ccc} l & m & u \end{array} \\ \begin{pmatrix} 3 & \frac{7}{2} & 4 \\ \frac{11}{7} & \frac{3}{2} & \frac{11}{5} \\ \frac{1}{2} & \frac{2}{3} & \frac{4}{5} \\ \frac{1}{4} & \frac{1}{3} & \frac{1}{3} \end{pmatrix} \end{array}$$

Fuzzy weight of factors with respect to easy to use (C1):

$$\begin{array}{c} \\ F1 \\ F2 \\ F3 \\ F4 \end{array} \begin{array}{c} \begin{array}{ccc} l & m & u \end{array} \\ \begin{pmatrix} 0.2542 & 0.2760 & 0.2651 \\ 0.5188 & 0.5581 & 0.5044 \\ 0.0521 & 0.0504 & 0.0500 \\ 0.1749 & 0.1154 & 0.1806 \end{pmatrix} \end{array}$$

Fuzzy weight of factors with respect to easy to interact with educators (C2) :

$$\begin{array}{c} \\ F1 \\ F2 \\ F3 \\ F4 \end{array} \begin{array}{c} \begin{array}{ccc} l & m & u \end{array} \\ \begin{pmatrix} 0.0454 & 0.0451 & 0.0431 \\ 0.3066 & 0.3001 & 0.3170 \\ 0.5584 & 0.5605 & 0.5408 \\ 0.0896 & 0.0942 & 0.091 \end{pmatrix} \end{array}$$

Fuzzy weight of factors with respect to interesting content (C3) :

$$\begin{array}{c} \\ F1 \\ F2 \\ F3 \\ F4 \end{array} \begin{array}{c} \begin{array}{ccc} l & m & u \end{array} \\ \begin{pmatrix} 0.2527 & 0.2624 & 0.2758 \\ 0.5914 & 0.5808 & 0.5601 \\ 0.1044 & 0.1079 & 0.1146 \\ 0.0515 & 0.0489 & 0.0495 \end{pmatrix} \end{array}$$

Fuzzy weight of factors with respect to proper navigation (C4):

$$\begin{array}{c} \\ F1 \\ F2 \\ F3 \\ F4 \end{array} \begin{array}{c} \begin{array}{ccc} l & m & u \end{array} \\ \begin{pmatrix} 0.5861 & 0.5865 & 0.5577 \\ 0.2576 & 0.2532 & 0.2766 \\ 0.1035 & 0.1089 & 0.1141 \\ 0.0527 & 0.0514 & 0.0515 \end{pmatrix} \end{array}$$

DEGREE OF POSSIBILITY FOR FACTORS

- With respect to C1

Row comparison for F1

$V(S1 \geq S2) = 1$

$V(S1 \geq S3) = 6.645$

$V(S1 \geq S4) = 9.757$

Take the minimum value for $V(S1 \geq S2, S3, S4)$ which is 1.

Row comparison for F2

$V(S2 \geq S1) = 1$

$V(S2 \geq S3) = 1$

$V(S2 \geq S4) = 1$

Take the minimum value for $V(S2 \geq S1, S3, S4)$ which is 1.

Row comparison for F3

$V(S3 \geq S1) = 0$

$V(S3 \geq S2) = 0$

$V(S3 \geq S4) = 0$

Take the minimum value for $V(S3 \geq S1, S2, S4)$ which is 0. Row comparison for F4

$V(S4 \geq S1) = \frac{1}{4}$

$V(S4 \geq S2) = 0$

$V(S4 \geq S3) = \frac{14}{9}$

We take the minimum value for $V(S4 \geq S1, S2, S3)$ which is 0.

- With respect to C2

Row comparison for F1

$V(S1 \geq S2) = 0$

$V(S1 \geq S3) = 0$

$V(S1 \geq S4) = 1$

Take the minimum value for $V(S1 \geq S2, S3, S4)$ which is 0.

Row comparison for F2

$V(S2 \geq S1) = 4.4347$

$V(S2 \geq S3) = 0$

$V(S2 \geq S4) = 1$

Take the minimum value for $V(S2 \geq S1, S3, S4)$ which is 0.

Row comparison for F3

$V(S3 \geq S1) = 1$

$V(S3 \geq S2) = 1$

$V(S3 \geq S4) = 1$

Take the minimum value for $V(S3 \geq S1, S2, S4)$ which is 1.

Row comparison for F4

$V(S4 \geq S1) = 0$

$V(S4 \geq S2) = 0$

$V(S4 \geq S3) = 0$

We take the minimum value for $V(S4 \geq S1, S2, S3)$ which is 0.

- With respect to C3

Row comparison for F1

$V(S1 \geq S2) = 0$

$V(S1 \geq S3) = 1$

$V(S1 \geq S4) = 1$

Take the minimum value for $V(S1 \geq S2, S3, S4)$ which is 0.

Row comparison for F2

$V(S2 \geq S1) = 1$

$V(S2 \geq S3) = 1$

$V(S2 \geq S4) = 1$

Take the minimum value for $V(S2 \geq S1, S3, S4)$ which is 1.

Row comparison for F3

$V(S3 \geq S1) = 0$

$V(S3 \geq S2) = 0$

$V(S3 \geq S4) = 1$

Take the minimum value for $V(S3 \geq S1, S2, S4)$ which is 0.

Row comparison for F4

$V(S4 \geq S1) = 0$

$V(S4 \geq S2) = 0$

$V(S4 \geq S3) = 0$

We take the minimum value for $V(S4 \geq S1, S2, S3)$ which is 0.

- With respect to C4

Row comparison for F1

$V(S1 \geq S2) = 1$

$V(S1 \geq S3) = 1$

$V(S1 \geq S4) = 1$

Take the minimum value for $V(S1 \geq S2, S3, S4)$ which is 1.

Row comparison for F2

$V(S2 \geq S1) = 0$

$V(S2 \geq S3) = 1$

$V(S2 \geq S4) = 1$

Take the minimum value for $V(S2 \geq S1, S3, S4)$ which is 0.

Row comparison for F3

$V(S3 \geq S1) = 0$

$V(S3 \geq S2) = 0$

$V(S3 \geq S4) = 2.7$

Take the minimum value for $V(S3 \geq S1, S2, S4)$ which is 0.

Row comparison for F4

$V(S4 \geq S1) = 0$

$V(S4 \geq S2) = 0$

$V(S4 \geq S3) = 0$

We take the minimum value for $V(S4 \geq S1, S2, S3)$ which is 0.

Factor

Decision maker 1

FACTORS

w.r.t easy to use	system quality			content			learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	6	7	8	4	5	6
content	2	3	4	1	1	1	6	7	8	4	5	6
learner comunity	1/6	1/7	1/5	1/8	1/7	1/6	1	1	1	1/4	1/5	1/2
learner interface	1/6	1/5	1/4	1/6	1/5	1/4	4	5	6	1	1	1

w.r.t easy to interact with educator	system quality			content			learner comunity			learner interface		
system quality	1	1	1	1/8	1/7	1/6	1/9	1/9	1/9	1/4	1/3	1/2
content	6	7	8	1	1	1	1/4	1/3	1/2	4	5	6
learner comunity	9	9	9	2	3	4	1	1	1	6	7	8
learner interface	2	3	4	1/6	1/5	1/4	1/8	1/7	1/6	1	1	1

w.r.t interesting content	system quality			content			learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	2	3	4	4	5	6
content	2	3	4	1	1	1	6	7	8	9	9	9
learner comunity	1/4	1/3	1/2	1/8	1/7	1/6	1	1	1	2	3	4
learner interface	1/6	1/5	1/4	1/9	1/9	1/9	1/4	1/3	1/2	1	1	1

w.r.t proper navigation	system quality			content			learner comunity			learner interface		
system quality	1	1	1	2	3	4	4	5	6	6	7	8
content	1/4	1/3	1/2	1	1	1	6	3	8	4	5	6
learner comunity	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1	2	3	4
learner interface	1/8	1/7	1/6	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

Decision maker 2

w.r.t easy to use	system quality			content			learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	4	5	6	2	3	4
content	2	3	4	1	1	1	9	9	9	6	7	8
learner comunity	1/6	1/5	1/4	1/9	1/9	1/9	1	1	1	1/4	1/3	1/2
learner interface	1/4	1/3	1/2	1/8	1/7	1/6	2	3	4	1	1	1

w.r.t easy to interact with educator	system quality			content			learner comunity			learner interface		
system quality	1	1	1	1/8	1/5	1/6	1/9	1/9	1/9	1/4	1/3	1/2
content	6	5	8	1	1	1	1/4	1/3	1/2	6	7	8
learner comunity	9	9	9	2	3	4	1	1	1	2	3	4
learner interface	2	3	4	1/8	1/7	1/6	1/4	1/3	1/2	1	1	1

w.r.t interesting content	system quality			content			learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	2	3	4	6	7	8
content	2	3	4	1	1	1	4	5	6	6	7	8
learner comunity	1/4	1/3	1/2	1/6	1/5	1/4	1	1	1	2	3	4
learner interface	1/8	1/7	1/6	1/8	1/7	1/6	1/4	1/3	1/2	1	1	1

w.r.t proper navigation	system quality			content			learner comunity			learner interface		
system quality	1	1	1	2	3	4	6	7	8	9	9	9
content	1/4	1/3	1/2	1	1	1	6	3	8	4	5	6
learner comunity	1/8	1/7	1/6	1/4	1/3	1/2	1	1	1	2	3	4
learner interface	1/9	1/9	1/9	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

Decision maker 3

w.r.t easy to use	system quality			content			learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	4	5	6	2	3	4
content	2	3	4	1	1	1	6	7	8	4	5	6
learner comunity	1/6	1/5	1/4	1/8	1/7	1/6	1	1	1	1/4	1/3	1/2
learner interface	1/4	1/3	1/2	1/6	1/5	1/4	2	3	4	1	1	1

w.r.t easy to interact with educator	system quality			content			learner comunity			learner interface		
system quality	1	1	1	1/8	1/7	1/6	1/9	1/9	1/9	1/4	1/3	1/2
content	6	7	8	1	1	1	1/4	1/3	1/2	4	5	6
learner comunity	9	9	9	2	3	4	1	1	1	6	7	8
learner interface	2	3	4	1/6	1/5	1/4	1/8	1/7	1/6	1	1	1

w.r.t interesting content	system quality			content			learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	2	3	4	4	5	6
content	2	3	4	1	1	1	6	7	8	9	9	9
learner comunity	1/4	1/3	1/2	1/8	1/7	1/6	1	1	1	2	3	4
learner interface	1/6	1/5	1/4	1/9	1/9	1/9	1/4	1/3	1/2	1	1	1

w.r.t proper navigation	system quality			content			learner comunity			learner interface		
system quality	1	1	1	2	3	4	4	5	6	6	7	8
content	1/4	1/3	1/2	1	1	1	2	3	4	4	5	6
learner comunity	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1	2	3	4
learner interface	1/8	1/7	1/6	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

Decision maker 4

w.r.t easy to use	system quality			content			learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	4	5	6	2	3	4
content	2	3	4	1	1	1	6	7	8	4	5	6
learner comunity	1/6	1/5	1/4	1/8	1/7	1/6	1	1	1	1/4	1/3	1/2
learner interface	1/4	1/3	1/2	1/6	1/5	1/4	2	3	4	1	1	1

w.r.t easy to interact with educator	system quality			content			learner comunity			learner interface		
system quality	1	1	1	1/8	1/7	1/6	1/9	1/9	1/9	1/4	1/3	1/2
content	6	7	8	1	1	1	1/4	1/3	1/2	4	5	6
learner comunity	9	9	9	2	3	4	1	1	1	6	7	8
learner interface	2	3	4	1/6	1/5	1/4	1/8	1/7	1/6	1	1	1

w.r.t interesting content	system quality			content			learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	2	3	4	4	5	6
content	2	3	4	1	1	1	6	7	8	9	9	9
learner comunity	1/4	1/3	1/2	1/8	1/7	1/6	1	1	1	2	3	4
learner interface	1/6	1/5	1/4	1/9	1/9	1/9	1/4	1/3	1/2	1	1	1

w.r.t proper navigation	system quality			content			learner comunity			learner interface		
system quality	1	1	1	2	3	4	4	5	6	6	7	8
content	1/4	1/3	1/2	1	1	1	2	3	4	4	5	6
learner comunity	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1	2	3	4
learner interface	1/8	1/7	1/6	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

Decision maker 5

w.r.t easy to use	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	4	5	6	1/6	3	1/4
content	2	3	4	1	1	1	6	7	8	1/4	5	1/2
learner comunity	1/6	1/5	1/4	1/8	1/7	1/6	1	1	1	1/8	1/3	1/6
learner interface	4	1/3	6	2	1/5	4	6	3	8	1	1	1

w.r.t easy to interact with educator	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/8	1/5	1/6	1/9	1/9	1/9	1/4	1/3	1/2
content	6	5	8	1	1	1	1/4	1/3	1/2	6	7	8
learner comunity	9	9	9	2	3	4	1	1	1	2	3	4
learner interface	2	3	4	1/8	1/7	1/6	1/4	1/3	1/2	1	1	1

w.r.t interesting content	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	2	3	4	6	7	8
content	2	3	4	1	1	1	4	5	6	6	7	8
learner comunity	1/4	1/3	1/2	1/6	1/5	1/4	1	1	1	2	3	4
learner interface	1/8	1/7	1/6	1/8	1/7	1/6	1/4	1/3	1/2	1	1	1

w.r.t proper navigation	system quality			content			learner comunity			learner interface		
system quality	1	1	1	2	3	4	6	7	8	9	9	9
content	1/4	1/3	1/2	1	1	1	2	3	4	4	5	6
learner comunity	1/8	1/7	1/6	1/4	1/3	1/2	1	1	1	2	3	4
learner interface	1/9	1/9	1/9	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

Decision maker 6

w.r.t easy to use	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	6	7	8	4	5	6
content	2	3	4	1	1	1	6	7	8	4	5	6
learner comunity	1/6	1/7	1/5	1/8	1/7	1/6	1	1	1	1/4	1/5	1/2
learner interface	1/6	1/5	1/4	1/6	1/5	1/4	4	5	6	1	1	1

w.r.t easy to interact with educator	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/8	1/7	1/6	1/9	1/9	1/9	1/4	1/3	1/2
content	6	7	8	1	1	1	1/4	1/3	1/2	4	5	6
learner comunity	9	9	9	2	3	4	1	1	1	6	7	8
learner interface	2	3	4	1/6	1/5	1/4	1/8	1/7	1/6	1	1	1

w.r.t interesting content	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	2	3	4	6	7	8
content	2	3	4	1	1	1	4	5	6	6	7	8
learner comunity	1/4	1/3	1/2	1/6	1/5	1/4	1	1	1	2	3	4
learner interface	1/8	1/7	1/6	1/8	1/7	1/6	1/4	1/3	1/2	1	1	1

w.r.t proper navigation	system quality			content			learner comunity			learner interface		
system quality	1	1	1	2	3	4	6	7	8	9	9	9
content	1/4	1/3	1/2	1	1	1	2	3	4	4	5	6
learner comunity	1/8	1/7	1/6	1/4	1/3	1/2	1	1	1	2	3	4
learner interface	1/9	1/9	1/9	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

Decision maker 7

w.r.t easy to use	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	4	5	6	2	3	4
content	2	3	4	1	1	1	6	7	8	4	5	6
learner comunity	1/6	1/5	1/4	1/8	1/7	1/6	1	1	1	1/4	1/3	1/2
learner interface	1/4	1/3	1/2	1/6	1/5	1/4	2	3	4	1	1	1

w.r.t easy to interact with educator	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/8	1/7	1/6	1/9	1/9	1/9	1/4	1/3	1/2
content	6	7	8	1	1	1	1/4	1/3	1/2	4	5	6
learner comunity	9	9	9	2	3	4	1	1	1	6	7	8
learner interface	2	3	4	1/6	1/5	1/4	1/8	1/7	1/6	1	1	1

w.r.t interesting content	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	2	3	4	4	5	6
content	2	3	4	1	1	1	6	7	8	9	9	9
learner comunity	1/4	1/3	1/2	1/8	1/7	1/6	1	1	1	2	3	4
learner interface	1/6	1/5	1/4	1/9	1/9	1/9	1/4	1/3	1/2	1	1	1

w.r.t proper navigation	system quality				content		learner comunity			learner interface		
system quality	1	1	1	2	3	4	4	5	6	6	7	8
content	1/4	1/3	1/2	1	1	1	2	3	4	4	5	6
learner comunity	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1	2	3	4
learner interface	1/8	1/7	1/6	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

Decision maker 8

w.r.t easy to use	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	4	5	6	2	3	4
content	2	3	4	1	1	1	6	7	8	4	5	6
learner comunity	1/6	1/5	1/4	1/8	1/7	1/6	1	1	1	1/4	1/3	1/2
learner interface	1/4	1/3	1/2	1/6	1/5	1/4	2	3	4	1	1	1

w.r.t easy to interact with educator	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/8	1/7	1/6	1/9	1/9	1/9	1/4	1/3	1/2
content	6	7	8	1	1	1	1/4	1/3	1/2	4	5	6
learner comunity	9	9	9	2	3	4	1	1	1	6	7	8
learner interface	2	3	4	1/6	1/5	1/4	1/8	1/7	1/6	1	1	1

w.r.t interesting content	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	2	3	4	4	5	6
content	2	3	4	1	1	1	6	7	8	9	9	9
learner comunity	1/4	1/3	1/2	1/8	1/7	1/6	1	1	1	2	3	4
learner interface	1/6	1/5	1/4	1/9	1/9	1/9	1/4	1/3	1/2	1	1	1

w.r.t proper navigation	system quality				content		learner comunity			learner interface		
system quality	1	1	1	2	3	4	4	5	6	6	7	8
content	1/4	1/3	1/2	1	1	1	2	3	4	4	5	6
learner comunity	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1	2	3	4
learner interface	1/8	1/7	1/6	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

Decision maker 9

w.r.t easy to use	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	4	5	6	2	3	4
content	2	3	4	1	1	1	6	7	8	4	5	6
learner comunity	1/6	1/5	1/4	1/8	1/7	1/6	1	1	1	1/4	1/3	1/2
learner interface	1/4	1/3	1/2	1/6	1/5	1/4	2	3	4	1	1	1

w.r.t easy to interact with educator	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/8	1/5	1/6	1/9	1/9	1/9	1/4	1/3	1/2
content	6	5	8	1	1	1	1/4	1/3	1/2	6	7	8
learner comunity	9	9	9	2	3	4	1	1	1	2	3	4
learner interface	2	3	4	1/8	1/7	1/6	1/4	1/3	1/2	1	1	1

w.r.t interesting content	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	2	3	4	6	7	8
content	2	3	4	1	1	1	4	5	6	6	7	8
learner comunity	1/4	1/3	1/2	1/6	1/5	1/4	1	1	1	2	3	4
learner interface	1/8	1/7	1/6	1/8	1/7	1/6	1/4	1/3	1/2	1	1	1

w.r.t proper navigation	system quality				content		learner comunity			learner interface		
system quality	1	1	1	2	3	4	6	7	8	9	9	9
content	1/4	1/3	1/2	1	1	1	2	3	4	4	5	6
learner comunity	1/8	1/7	1/6	1/4	1/3	1/2	1	1	1	2	3	4
learner interface	1/9	1/9	1/9	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

Decision maker 10

w.r.t easy to use	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	6	7	8	4	5	6
content	2	3	4	1	1	1	6	7	8	4	5	6
learner comunity	1/6	1/7	1/5	1/8	1/7	1/6	1	1	1	1/4	1/5	1/2
learner interface	1/6	1/5	1/4	1/6	1/5	1/4	4	5	6	1	1	1

w.r.t easy to interact with educator	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/8	1/5	1/6	1/9	1/9	1/9	1/4	1/3	1/2
content	6	5	8	1	1	1	1/4	1/3	1/2	6	7	8
learner comunity	9	9	9	2	3	4	1	1	1	2	3	4
learner interface	2	3	4	1/8	1/7	1/6	1/4	1/3	1/2	1	1	1

w.r.t interesting content	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	2	3	4	6	7	8
content	2	3	4	1	1	1	4	5	6	6	7	8
learner comunity	1/4	1/3	1/2	1/6	1/5	1/4	1	1	1	2	3	4
learner interface	1/8	1/7	1/6	1/8	1/7	1/6	1/4	1/3	1/2	1	1	1

w.r.t proper navigation	system quality				content		learner comunity			learner interface		
system quality	1	1	1	2	3	4	6	7	8	9	9	9
content	1/4	1/3	1/2	1	1	1	2	3	4	4	5	6
learner comunity	1/8	1/7	1/6	1/4	1/3	1/2	1	1	1	2	3	4
learner interface	1/9	1/9	1/9	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

Pairwise comparison matrix

w.r.t easy to use	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	4 3/5	5 3/5	6 3/5	2 3/7	3 3/5	4 2/9
content	2	3	4	1	1	1	6 2/7	7 1/5	8	3 5/6	5 1/5	5 2/3
learner comunity	1/6	1/5	1/4	1/8	1/7	1/6	1	1	1	1/4	2/7	1/2
learner interface	3/5	2/7	1	1/3	1/5	5/8	3	3 3/5	5	1	1	1

w.r.t easy to interact with educator	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/8	1/6	1/6	1/9	1/9	1/9	1/4	1/3	1/2
content	6	6 1/5	8	1	1	1	1/4	1/3	1/2	4 4/5	5 4/5	6 4/5
learner comunity	9	9	9	2	3	4	1	1	1	4 2/5	5 2/5	6 2/5
learner interface	2	3	4	1/7	1/6	2/9	1/6	2/9	2/7	1	1	1

w.r.t interesting content	system quality				content		learner comunity			learner interface		
system quality	1	1	1	1/4	1/3	1/2	2	3	4	5	6	7
content	2	3	4	1	1	1	5	6	7	7 1/2	8	8 1/2
learner comunity	1/4	1/3	1/2	1/7	1/6	1/5	1	1	1	2	3	4
learner interface	1/7	1/6	1/5	1/8	1/8	1/7	1/4	1/3	1/2	1	1	1

w.r.t proper navigation	system quality				content		learner comunity			learner interface		
system quality	1	1	1	2	3	4	5	6	7	7 1/2	8	8 1/2
content	1/4	1/3	1/2	1	1	1	2 4/5	3	4 4/5	4	5	6
learner comunity	1/7	1/6	1/5	1/4	1/3	1/2	1	1	1	2	3	4
learner interface	1/8	1/8	1/7	1/6	1/5	1/4	1/4	1/3	1/2	1	1	1

Calculate fuzzy geometric mean value

w.r.t easy to use	l	m	u
system quality	1.2912	1.6101	1.9323
content	2.6348	3.2555	3.6783
learner comunity	0.2645	0.2942	0.3646
learner interface	0.8882	0.6730	1.3168
total	5.0787	5.8328	7.2920
inverse	0.1969	0.1714	0.1371

w.r.t easy to interact with educator	l	m	u
system quality	0.2427	0.2799	0.3102
content	1.6381	1.8607	2.2837
learner comunity	2.9832	3.4749	3.8960
learner interface	0.4787	0.5841	0.7141
total	5.3427	6.1996	7.2040
inverse	0.1872	0.1613	0.1388

w.r.t interesting content	l	m	u
system quality	1.2574	1.5651	1.9343
content	2.9428	3.4641	3.9278
learner comunity	0.5196	0.6435	0.8034
learner interface	0.2561	0.2919	0.3468
total	4.9760	5.9645	7.0123
inverse	0.2010	0.1677	0.1426

w.r.t proper navigation	l	m	u
system quality	2.9428	3.4641	3.9278
content	1.2936	1.4953	1.9480
learner comunity	0.5196	0.6435	0.8034
learner interface	0.2648	0.3033	0.3630
total	5.0209	5.9062	7.0422
inverse	0.1992	0.1693	0.1420

Calculate fuzzy weight

w.r.t easy to use	Fuzzy weight			weight
system quality	0.2542	0.2760	0.2650	0.2651
content	0.5188	0.5581	0.5044	0.5271
learner comunity	0.0521	0.0504	0.0500	0.0508
learner interface	0.1749	0.1154	0.1806	0.1570

w.r.t easy to interact with educators	Fuzzy weight			weight
system quality	0.0454	0.0451	0.0431	0.0445
content	0.3066	0.3001	0.3170	0.3079
learner comunity	0.5584	0.5605	0.5408	0.5532
learner interface	0.0896	0.0942	0.0991	0.0943

w.r.t interesting content	Fuzzy weight			weight
system quality	0.2527	0.2624	0.2758	0.2636
content	0.5914	0.5808	0.5601	0.5774
learner comunity	0.1044	0.1079	0.1146	0.1090
learner interface	0.0515	0.0489	0.0495	0.0500

w.r.t proper navigation	Fuzzy weight			weight
system quality	0.5861	0.5865	0.5577	0.5768
content	0.2576	0.2532	0.2766	0.2625
learner comunity	0.1035	0.1089	0.1141	0.1088
learner interface	0.0527	0.0514	0.0515	0.0519