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# Analysing Students' Perceptions of Online Mathematics Learning Using The Fuzzy Conjoint Method

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## HIGHLIGHTS

- Fuzzy conjoint analysis is used in analysing students' perceptions of online mathematics learning among undergraduate mathematics management students at UiTM Perlis.
- Students rated neutral on all attributes except for one attribute in the student's performance in the online learning aspect.
- Students strongly disagreed that they copied each other works during online tests.
- Students viewed mathematics as a difficult subject to study online despite having flexible time for revision and detailed instruction from the lecturer on how to participate in online learning.

## ABSTRACT

*Online distance learning is increasingly popular, especially since the pandemic Covid-19. All stages of learning from elementary to university level use online learning. Because of students' various learning abilities, it takes motivation and support from their surroundings to learn new things. It is important to understand students' experiences, perspectives, and preferences toward online distance learning. This study analyzes the perceptions of online mathematics learning among 40 undergraduates who were majoring in mathematics management at the Faculty of Computer and Mathematical Sciences, UiTM Perlis. The perceptions were analyzed in 3 dimensions which are students' opinions, students' performance, and lecturers' roles in online mathematics learning using the fuzzy conjoint method. The degree of Similarity is used to rank each attribute in each dimension. According to the findings, all attributes were rated "neutral" except for one attribute which was rated "strongly disagreed". Students rated "strongly disagreed" that they sometimes copy each other works blindly during the online assessment (students' performance). Students viewed mathematics as a hard subject to learn online even though they had flexible time to study the feedback on tests/quizzes returned by the lecturers (students' opinion). The lecturers played their role well always giving feedback on student assessment and providing detailed instructions on how to participate in online learning (lecturers' role). This study helps teachers as well as the university to understand students' experiences, perspectives, and preferences. Hence, it helps find a way to improve the quality of online education.*

***Keywords:*** *online distance learning, fuzzy conjoint, perception, attribute*

## INTRODUCTION

Online learning refers to internet-based learning whereby the learning process is conducted in a virtual environment. It is also known as e-learning and was first introduced as the internet was created effect in 1990. Online learning has been used ever since in open distance learning for working adults as a way to develop equitable access to higher education for all. For the past two years the Covid - 19 pandemic has led to unprecedented challenges in all aspects of human well-being including education. Lockdown due to the pandemic had significantly disrupted the education system worldwide. Students are unable to attend classes face-to-face and interact with friends as they used to. These factors affect students emotionally and also their learning perception during the pandemic. During Movement Control Order (MCO) online distance learning was unavoidable. At all levels of education, from primary schools to universities all over the world, online learning is used to replace face-to-face or so-called traditional classroom learning.

There are many studies conducted analysing the students' perceptions towards e-learning during the ongoing COVID-19 pandemic at the high school level as well as the university level. A study by Khan et al. (2021), on university students of the National Capital Territory (NCT) of Delhi, revealed a positive perception toward e-learning and the acceptance of this new form of learning. It is because online distance learning provides them much freedom to connect with their teachers, and fellow students and engage with their study materials in the comfort and flexibility of space and time. However, a study at Liaquat College of Medicine and Dentistry, India found that during the lockdown students preferred face-to-face teaching rather than online teaching (Abbasi et al., 2021). The sudden shift from face-to-face to online learning platforms during the pandemic posed challenges to students, teachers as well and parents. The dramatic change in the education process has a big impact on the students. People's ability to process information is limited and using many learning modalities may lead to cognitive overload, which might limit the capability to learn new material effectively (Hodges et al., 2020). In addition, if students are not comfortable utilizing the technology, it might have a negative impact on their learning outcomes. Access to a device, the internet, a physical learning area, and a strong habit of learner autonomy are necessary before changing to an online learning platform. Device ownership is a recurring barrier to the successful implementation of online learning due to the digital divide. In developing nations, irregular internet access prevents successful online learning (Salac, 2016). In the case study of Western Michigan University, students reported negative experiences of distance learning such as a lack of social interaction, and time and location flexibility (Al-Mawee et al., 2021). Time management is the most important factor influencing students' academic performance in online distance learning besides the learning environment, learning method, and internet connection (Mohd Idris et al.,2022).

The student's perception of online learning in mathematics courses has become of great interest among educators. This is because students often have a negative perception of mathematics since it is often difficult for students to master (Kasmin et al., 2019). Online learning requires motivation and encouragement from the surroundings as students have different learning capabilities. The quality of the emotional life of the students affects their attitude toward mathematics learning. Therefore, a positive climate of emotions must be established by family members, teachers, and learning institutions to ensure that the students stay motivated, highly confident, and have less anxiety in learning mathematics (Colomeischi & Colomeishi, 2015). Mathematics self-concept is important to understand as it perceives students' abilities in learning mathematics. Students had positive as well as negative mathematics self-concepts in online learning (Bringula et al., 2021). Their study also identified challenges faced by the students such as technological, personal and test anxiety to name a few.

Blended learning or hybrid learning uses both face-to-face and online. This mode of learning is convenient and flexible, over more the use of technology in the online component influences the young generation to

learn. However, the study found that students preferred the face-to-face component compared to the online component in the blended learning mode of mathematics courses (Krishnan, 2016). Students were more comfortable communicating with teachers and peers face-to-face and it enabled them to better understand the mathematics concept.

Meanwhile, high school students were mostly very positive toward online learning mathematics during the time of COVID-19 (Doly & Ahmad, 2021). The result agreed with Nuril Huda et al.(2020), who found that students have a good perception of online mathematics learning using YouTube and there exists a positive relationship between students' perceptions and achievement. A study by Baya'a & Daher (2009) on students' perception of mobile phone usage in mathematics learning suggested the positivity of the student's acceptance. They were positively impressed by the capabilities of mobile phones in the process of learning mathematics. This indicates that these new technological tools have benefits in mathematics education.

Conjoint analysis is a form of statistical analysis used in market research to understand how the customers value different features of the products or services. It was initially used to understand how people make decisions based on attributes that impact users' perceived value of the product or service. The main types of conjoint analysis are Choice-Based Conjoint and Adaptive Conjoint Analysis. However, over the years there are various forms of conjoint analysis have been developed, such as the Fuzzy Conjoint Method (FCM) proposed by Burhan Turksen and Willson (1994). There are many studies on perceptions conducted using FCM. For instance, Lazim & Osman, (2009) used FCM to analysed the data from 23 mathematics teachers from 4 secondary schools in Terengganu to measure teachers' beliefs about mathematics. The study recorded 'Drills and Practice' as one of the best ways of learning mathematics' with the level of 'strongly agree'. Abdullah et al. (2011) also used FCM in their study to describe students' perceptions of the computer algebra system learning environment conducted in secondary school in Terengganu, Malaysia. FCM was used by Kasim and Muhamad Sukri (2022) in measuring students' perception of mathematics learning among undergraduate students at UiTM Perlis which found that overall students had relatively good attitudes toward mathematics learning. Abiyev et al. (2016) used FCM to measure job satisfaction among hotel employees in North Cyprus. Shahani and Rasmani (2020) used FCM with both continuous and discrete fuzzy in the evaluation of job satisfaction. The finding showed that both discrete fuzzy sets and continuous fuzzy sets produce consistent results regardless of whether the fuzzy similarity measure was used.

## METHODOLOGY

This study aims to analyse the students' perceptions of mathematics online learning from three perspectives; opinion, performance, and lecturers' roles in online mathematics learning using the Fuzzy Conjoint method.

### Data Collection

The data for this study were collected by using a questionnaire distributed to 40 degree in management mathematics students from the Faculty of Computer and Mathematical Sciences, UiTM Perlis Branch. The students were chosen due to their experience in taking online mathematics classes during the pandemic (2020 - 2022). All of them had taken at least three mathematics courses online. This study focuses on students' opinions on three perspectives of mathematics online learning namely students' opinions, students' performance, and lecturer's roles. Each factor consists of seven, five, and five attributes respectively. This study used the criteria from Kasim & Muhamad Sukri, (2022) with some adjustments to suit online learning. Table 1 below shows the list of attributes for this survey.

**Table 1:** The survey of attributes towards students' opinion, students' performance, and lecturers' role.

| Attributes | | Statement |
|---|---|---|
| Students' Opinion on Online Distance Learning | $A_1$ | Mathematics is hard to learn through online learning. |
| | $A_2$ | Mathematics causes me stress, dizziness, and headaches. |
| | $A_3$ | I received mathematics notes provided by the lecturer clearly but easily forgotten. |
| | $A_4$ | Mathematical materials are interrelated from one topic to another. |
| | $A_5$ | Mathematical knowledge is useful for problem-solving in various fields. |
| | $A_6$ | Mathematics helps me to understand other subjects more easily. |
| | $A_7$ | I do not take exams seriously as I can refer to the notes and discuss them with friends. |
| Students' Performance in Online Distance Learning | $A_8$ | I do assignments given by the lecturer independently. |
| | $A_9$ | I can achieve good grades by learning online. |
| | $A_{10}$ | During online tests, I sometimes copy my friend's answers blindly. |
| | $A_{11}$ | I managed to improve my analytical skills such as problem solving and decision making. |
| | $A_{12}$ | I have flexible time to study all the tests and quizzes returned by the lecturer. |
| Lecturers' Roles in Online Distance Learning | $A_{13}$ | The lecturer gave detailed instructions on how to participate in the course learning activities. |
| | $A_{14}$ | The lecturers always give feedback on student assessment. |
| | $A_{15}$ | The lecturers are always available when you need help. |
| | $A_{16}$ | Face-to-face contact with my lecturer is better than online. |
| | $A_{17}$ | The teaching platform (Zoom, Google Classroom, Google Meet, Microsoft Team, etc.) used is easy for you to access. |

## Likert Scale

This study applied the fuzzy sets to represent the linguistic term for the Likert Scale. It is defined as $L_i =$ {strongly disagree, disagree, neutral, agree, strongly agree}. Table 2 below shows the set of fuzzy for each $L_i$ where $i = 1,2,3,4,5$.

**Table 2:** The set of Fuzzy for each linguistic term taken by Yahaya and Mohamad (2011).

| Linguistic Term | Rating | Fuzzy Sets |
|---|---|---|
| Strongly Disagree | 1 | $L_1 =$ {1/1, 0.75/2, 0.5/3, 0/4, 0/5} |
| Disagree | 2 | $L_2 =$ {0.5/1, 1/2, 0.75/3, 0.25/4, 0/5} |
| Neutral | 3 | $L_3 =$ {0/1, 0.5/2, 1/3, 0.5/4, 0/5} |
| Agree | 4 | $L_4 =$ {0/1, 0.25/2, 0.75/3, 1/4, 0.5/5} |
| Strongly Agree | 5 | $L_5 =$ {0/1, 0/2, 0.5/3, 0.75/4, 1/5} |

## Fuzzy Conjoint Method

This study used FCM in analysing the students' perception of online mathematics learning due to the fuzziness in perception. The hierarchy of all respondents against the specific attributes was presented in fuzzy set *F*. The approximate degree of membership for each element, $y_j$ , $j = 1,2,..,l$ in fuzzy set *F* is defined as

$$\mu_F(y_j, A_m) = \sum_{i=1}^{n} W_i \bullet \mu_{L_i}(x_j, A_m) \tag{1}$$

where

- $y_j$ and $x_j$ indicates the element of the domain, with *j* referring to a number of linguistic terms which is 5. $j = 1,2,3,4,5.$
- $A_m$ is the attribute used, *m* refers to the number of the attribute; $m = 1,2,3,..,k$ where $k = 7$ in students' opinion, $k = 5$ in students' performance, and $k = 5$ lecturers' role.
- $W_i$ is the weighted for the *i*-th respondent, as $w_i$ is the linguistic value given by *i*-th respondent.

$$W_i = \frac{w_i}{\sum_{k=1}^{n} w_k} \tag{2}$$

- $\mu_{L_i}(x_j, A_m)$ is the membership degree for element $x_j$ for attribute $A_m$ according to the linguistic term for each fuzzy set $L_i$ $i.j = 1,2,3,4,5.$
- *n* is the number of respondents

## Measuring Degree of Similarity

The degree of similarity of the fuzzy set representing the whole respondents ($F$) and every fuzzy set represented by five linguistic values $(L_i)$ $i = 1,2,3,4,5.$ for each attribute $(A_m)$ was measured using the sum of a distance formula known as Euclidean distance. The formula for the similarity of two sets is given by,

$$Sim(F, L_i) = \frac{1}{1 + \sqrt{\sum_{j=1}^{5} \left[\mu_F(y_j, A_m) - \mu_{L_k}(j)\right]^2}}, \quad k = 1,2,3,4,5. \tag{3}$$

where $\mu_{L_k}(j)$ is the fuzzy set defined for linguistic rating and $\mu_F(y_j, A_m)$ is calculated from (1).

## Measurement Procedure

17 attributes need to be considered in this study and the procedure for this method is detailed as shown in Figure 1.

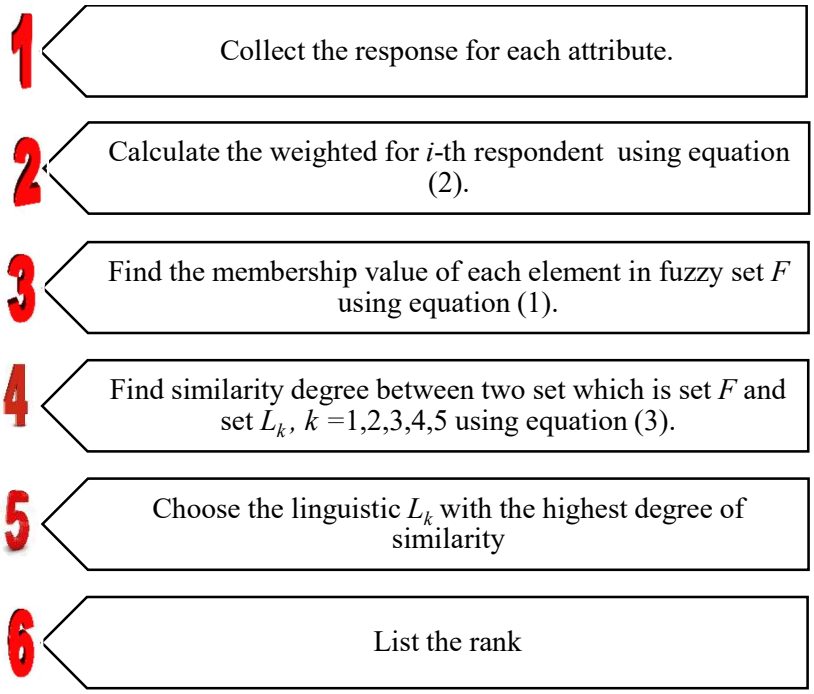


**Figure 1:** Measuring Procedure of Fuzzy Conjoint Model

The preference of attributes is described by the similarity degree S. Therefore it can be used to determine the ranking of the attributes by selecting the maximum similarity which is denoted as $S^{max}$ (Turksen & Willson, 1994).

## FINDINGS AND DISCUSSIONS

The result was obtained by running the data using Microsoft Excel and splitting it according to the categorization of attributes. Measurements and discussions for each attribute were presented in accordance with the respective category. Table 3 shows the frequency of students' perceptions of each attribute.

**Table 3:** The frequency of students' perceptions of each attribute $A_m$

| | Attribute | L1 | L2 | L3 | L4 | L5 | Total |
|---|---|---|---|---|---|---|---|
| Students' Opinion on Online Distance Learning | A1 | 4 | 9 | 16 | 7 | 4 | 40 |
| | A2 | 2 | 9 | 6 | 16 | 7 | 40 |
| | A3 | 1 | 12 | 6 | 14 | 7 | 40 |
| | A4 | 3 | 7 | 7 | 15 | 8 | 40 |
| | A5 | 0 | 2 | 8 | 16 | 14 | 40 |
| | A6 | 0 | 10 | 13 | 15 | 2 | 40 |
| | A7 | 7 | 16 | 10 | 6 | 1 | 40 |
| Students' Performance in Online Distance Learning | A8 | 0 | 4 | 13 | 18 | 5 | 40 |
| | A9 | 0 | 9 | 12 | 12 | 7 | 40 |
| | A10 | 10 | 13 | 7 | 7 | 3 | 40 |
| | A11 | 0 | 2 | 13 | 22 | 3 | 40 |
| | A12 | 4 | 7 | 14 | 9 | 6 | 40 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Lecturers' Roles in Online Distance Learning | A13 | 1 | 2 | 10 | 20 | 7 | 40 |
| | A14 | 1 | 4 | 9 | 19 | 7 | 40 |
| | A15 | 1 | 2 | 9 | 18 | 10 | 40 |
| | A16 | 1 | 2 | 6 | 14 | 17 | 40 |
| | A17 | 0 | 2 | 7 | 16 | 15 | 40 |

The weight of each attribute with respect to the linguistic value $L_k$, $k = 1,2,3,4,5$ was computed using equation (2), and the results are shown in Table 4.

**Table 4:** Weight of each attribute $A_m$ for relayed to linguistic values $L_k$

| | Attribute | L1 | L2 | L3 | L4 | L5 |
|---|---|---|---|---|---|---|
| Students' Opinion on Online Distance Learning | A1 | 0.1000 | 0.2250 | 0.4000 | 0.1750 | 0.1000 |
| | A2 | 0.0500 | 0.2250 | 0.1500 | 0.4000 | 0.1750 |
| | A3 | 0.0250 | 0.3000 | 0.1500 | 0.3500 | 0.1750 |
| | A4 | 0.0750 | 0.1750 | 0.1750 | 0.3750 | 0.2000 |
| | A5 | 0.0000 | 0.0500 | 0.2000 | 0.4000 | 0.3500 |
| | A6 | 0.0000 | 0.2500 | 0.3250 | 0.3750 | 0.0500 |
| | A7 | 0.1750 | 0.3500 | 0.2750 | 0.1750 | 0.0250 |
| Students' Performance in Online Distance Learning | A8 | 0.0000 | 0.1000 | 0.3250 | 0.4500 | 0.1250 |
| | A9 | 0.0000 | 0.2250 | 0.3000 | 0.3000 | 0.1750 |
| | A10 | 0.2250 | 0.2750 | 0.2000 | 0.1750 | 0.1250 |
| | A11 | 0.0000 | 0.0500 | 0.3250 | 0.5500 | 0.0750 |
| | A12 | 0.1000 | 0.1750 | 0.3500 | 0.2250 | 0.1500 |
| Lecturers' Roles in Online Distance Learning | A13 | 0.0250 | 0.0500 | 0.2500 | 0.5000 | 0.1750 |
| | A14 | 0.0250 | 0.1000 | 0.2250 | 0.4750 | 0.1750 |
| | A15 | 0.0250 | 0.0500 | 0.2250 | 0.4500 | 0.2500 |
| | A16 | 0.0250 | 0.0500 | 0.1500 | 0.3500 | 0.4250 |
| | A17 | 0.0000 | 0.0500 | 0.1750 | 0.4000 | 0.3750 |

The next step is to calculate the membership degree for a fuzzy set $F$ of students' opinions of each linguistic value $k$, where $k = 1,2,3,4,5$ using equation (1). The result for $L_1$ $(k = 1)$, Strongly Disagree is shown in Table 5.

**Table 5:** Membership degree of each element of fuzzy set $F$ corresponds to linguistic value $L_1$ for each attribute $A_m$.

| | Attribute | L1 | L2 | L3 | L4 | L5 |
|---|---|---|---|---|---|---|
| Students' Opinion on Online Distance Learning | A1 | 0.1000 | 0.1688 | 0.2000 | 0.0000 | 0.0000 |
| | A2 | 0.0500 | 0.1688 | 0.0750 | 0.0000 | 0.0000 |
| | A3 | 0.0250 | 0.2250 | 0.0750 | 0.0000 | 0.0000 |
| | A4 | 0.0750 | 0.1313 | 0.0875 | 0.0000 | 0.0000 |
| | A5 | 0.0000 | 0.0375 | 0.1000 | 0.0000 | 0.0000 |
| | A6 | 0.0000 | 0.1875 | 0.1625 | 0.0000 | 0.0000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | A7 | 0.1750 | 0.2625 | 0.1375 | 0.0000 | 0.0000 |
| Students' Performance in Online Distance Learning | A8 | 0.0000 | 0.0750 | 0.1625 | 0.0000 | 0.0000 |
| | A9 | 0.0000 | 0.1688 | 0.1500 | 0.0000 | 0.0000 |
| | A10 | 0.2250 | 0.2063 | 0.1000 | 0.0000 | 0.0000 |
| | A11 | 0.0000 | 0.0375 | 0.1625 | 0.0000 | 0.0000 |
| | A12 | 0.1000 | 0.1313 | 0.1750 | 0.0000 | 0.0000 |
| Lecturers' Roles in Online Distance Learning | A13 | 0.0250 | 0.0375 | 0.1250 | 0.0000 | 0.0000 |
| | A14 | 0.0250 | 0.0750 | 0.1125 | 0.0000 | 0.0000 |
| | A15 | 0.0250 | 0.0375 | 0.1125 | 0.0000 | 0.0000 |
| | A16 | 0.0250 | 0.0375 | 0.0750 | 0.0000 | 0.0000 |
| | A17 | 0.0000 | 0.0375 | 0.0875 | 0.0000 | 0.0000 |

## Students' Opinions on Online Distance Learning

The measurement outcome for students' opinions about online learning is shown in Table 6. All attributes recorded a level of agreement "neutral" with a close value of the degree of similarity. However, the top rank in students' opinion is that mathematics is hard to learn online (F1) with the maximum degree of similarity of 0.4988. Followed by the attribute that mathematics is helping them understand other subjects easier (F6) with a maximum degree of similarity of 0.4940. Unfortunately, students do not take exams seriously as they can refer to the notes and discuss with friends (F7) ranked number 3 with a score of 0.4903. Students rank numbers 4 and 5 with a maximum degree of similarity of 0.4791 and 0.4754 respectively on the attribute that received the notes clearly but easily forgotten (F3) and on the attribute that mathematics causes dizziness and headache during online learning (F2). The second lowest and the lowest degree of similarity registered "neutral" is F4 (Mathematical materials are interrelated between one topic to another) and F5 (Mathematical knowledge is useful for problem-solving in various fields) respectively. Overall, students' opinions of online distance learning towards mathematics are not positive. Contrarily, with the outcome before online learning was implemented students showed a relatively good attitude in learning mathematics (Kasim & Muhamad Sukri, 2021).

**Table 6:** Degree of similarity between the fuzzy set *F* and linguistic variables *L* for Students' Opinions.

| Fuzzy Set | L1 | L2 | L3 | L4 | L5 | S(max) | L(S(max)) | Rank |
|---|---|---|---|---|---|---|---|---|
| F1 | 0.4734 | 0.4756 | 0.4988 | 0.4439 | 0.4347 | 0.4988 | L3 | 1 |
| F2 | 0.4562 | 0.4570 | 0.4754 | 0.4330 | 0.4288 | 0.4754 | L3 | 5 |
| F3 | 0.4574 | 0.4631 | 0.4791 | 0.4336 | 0.4274 | 0.4791 | L3 | 4 |
| F4 | 0.4573 | 0.4548 | 0.4747 | 0.4334 | 0.4301 | 0.4747 | L3 | 6 |
| F5 | 0.4364 | 0.4369 | 0.4698 | 0.4328 | 0.4323 | 0.4698 | L3 | 7 |
| F6 | 0.4554 | 0.4656 | 0.4940 | 0.4416 | 0.4332 | 0.4940 | L3 | 2 |
| F7 | 0.4939 | 0.4896 | 0.4903 | 0.4373 | 0.4275 | 0.4903 | L3 | 3 |

## Students' Performance in Online Distance Learning

Table 7 shows the results of the attribute related to students' performance in online mathematics distance learning. All attributes recorded a level of agreement "neutral" except for attribute F10 which is students "strongly disagree" that they sometimes copy their friend's answers blindly during online tests. The second highest maximum degree of similarity of 0.4932 is on having flexible time to study the tests and quizzes returned by the lecturer (F12). The third highest maximum degree of similarity with a score of 0.4901 with

rated "neutral" is on the ability to get good grades through online tests (F 9). It is probably because students were confident with open book exams that they could answer the questions easily even though they admit that they did the assignment independently (F8, rank4). The lowest rank which is also rated "neutral" is on the attribute of managing to improve analytical skills such as problem-solving and decision-making (F11). This shows that students were unsure of the benefit of mathematics to them specifically in becoming a good decision maker. It is coherent with the fact that during online tests students can refer notes or googling the answers. This resulted in a lack of confidence and unable to think on their own which meant that they missed the actual opportunity to learn. The consequences can be seen in the performance of other mathematics courses in the semesters to come.

**Table 7:** Degree of similarity between the fuzzy set *F* and linguistic variables *L* for Students' Performance.

| Fuzzy Set | L1 | L2 | L3 | L4 | L5 | S(max) | L(S(max)) | Rank |
|---|---|---|---|---|---|---|---|---|
| F8 | 0.4439 | 0.4484 | 0.4845 | 0.4395 | 0.4354 | 0.4845 | L3 | 4 |
| F9 | 0.4528 | 0.4613 | 0.4901 | 0.4402 | 0.4331 | 0.4901 | L3 | 3 |
| F10 | 0.4932 | 0.4782 | 0.4775 | 0.4323 | 0.4260 | 0.4932 | L1 | 1 |
| F11 | 0.4399 | 0.4428 | 0.4809 | 0.4385 | 0.4357 | 0.4809 | L3 | 5 |
| F12 | 0.4674 | 0.4665 | 0.4908 | 0.4412 | 0.4344 | 0.4908 | L3 | 2 |

### Lecturers' Roles in Online Distance Learning

Table 8 shows the degree of similarity for lecturers' roles in online distance learning. All attributes were registered "neutral" level of agreement. Lecturers always give feedback on student assessment (F14) had the highest maximum degree of similarity value of 0.4753. The second highest degree of similarity value (0.4741) is on an attribute that the lecturers gave detailed instructions on how to participate in the course learning activities (F13). The lecturers are always available when students need help (F15) was registered at rank 3 with linguistic value in the range of "neutral". The easy access to the teaching platform used (F17) and face-to-face contact with the lecturer is better than online (F16) ranked number 4 and 5 respectively. According to the survey in this research, the most popular teaching platforms used by mathematics lecturers are Google Meet, followed by Google Classroom, WhatsApp, and Telegram.

**Table 8:** Degree of similarity between the fuzzy set *F* and linguistic variables *L* for Lecturers' Role.

| Fuzzy Set | L1 | L2 | L3 | L4 | L5 | S(max) | L(S(max)) | Rank |
|---|---|---|---|---|---|---|---|---|
| F13 | 0.4416 | 0.4411 | 0.4741 | 0.4350 | 0.4337 | 0.4741 | L3 | 2 |
| F14 | 0.4449 | 0.4454 | 0.4753 | 0.4350 | 0.4327 | 0.4753 | L3 | 1 |
| F15 | 0.4409 | 0.4399 | 0.4719 | 0.4339 | 0.4330 | 0.4719 | L3 | 3 |
| F16 | 0.4386 | 0.4362 | 0.4653 | 0.4304 | 0.4308 | 0.4653 | L3 | 5 |
| F17 | 0.4357 | 0.4357 | 0.4676 | 0.4316 | 0.4316 | 0.4676 | L3 | 4 |

## CONCLUSION AND RECOMMENDATIONS

This study used fuzzy conjoint analysis to measure the students' perceptions of learning mathematics in virtual classes. The respondents were 40 students with degrees in Mathematics Management, UiTM Perlis who experienced at least 3 mathematics courses online during the pandemic. The study focuses on 3 components of perspectives with 17 attributes. The respondents were asked to rate their level of agreement on the Likert Scale $L_1$ - $L_5$ (Strongly Disagree – Strongly Agree). The overall outcome is displayed by the similarity between fuzzy set *F* and linguistic variables.

The result shows a "neutral" level of agreement in all attributes except for one attribute with which students strongly disagree. Students admitted that they did not copy their friends' answers blindly during the online test. In students' opinion, mathematics is a difficult course to study online despite having flexible time to study the tests and quizzes returned by the lecturer. In terms of mathematics performance, students ranked third place in the ability to achieve good grades through online tests. This differs from Bringula et al. (2021) who found almost half of the students feel that they will get lower grades on the online test compared when if it is done in a face-to-face session. In the lecturers' roles, various efforts have been made to facilitate students learning activities such as giving feedback on the assignments as well as detailed instructions on how to participate in online learning. In conclusion, the result of this study shows that students do not show either positive or negative of mathematics online learning as almost all attributes were rated "neutral". The result agreed with Bringula et al. (2021) where students had positive as well as negative mathematics online learning self-concepts. It is supported by the study of Krishnan (2016) in the case of mathematics blended learning where students have preferred the face-to-face learning mode as they find the face-to-face instruction is efficient in the learning process of mathematics concepts.

Since this study is only limited to management mathematics degree students at UiTM Perlis and focuses on only 17 attributes, the finding can't be generalized to all systems of UiTM. Therefore, a larger number of respondents from various faculties are needed. Further exploration of factors influencing students' perceptions towards mathematics e-learning is needed to obtain a more accurate and relevant conclusion of overall students' perception of mathematics online learning. The same study can be done on other courses also.

## CONFLICT OF INTEREST DISCLOSURE

The authors declared that they have no conflicts of interest to disclose.

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