Fuzzy number conjoint method to measure students’ expectation on the learning of mathematics

R Osman¹, N Ramli², Z Badaruddin³, H Ayub⁴ and S N A Syed Abdul Karim⁵

¹Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA Shah Alam, Selangor, Malaysia
²Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA Pahang, Bandar Jengka, Pahang, Malaysia
³Akademi Pengajian Bahasa, Universiti Teknologi MARA Shah Alam, Selangor, Malaysia
⁴Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA Shah Alam, Selangor, Malaysia
⁵Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA Shah Alam, Selangor, Malaysia

1 E-mail: roselah@tmsk.uitm.edu.my
2 E-mail: nazirahr@uitm.edu.my
3 E-mail: zuraidar@uitm.edu.my
4 E-mail: hamidaha@tmsk.uitm.edu.my
5 E-mail: sharifahunurain@gmail.com

Abstract:
The issues related to students’ expectation on the learning of mathematics is considered crucial because one can never decide the appropriate educational path that suits the students according to what they are supposed to study and should engage in the learning process. This study performed analysis on the secondary data of a previous research conducted on students’ expectation on the learning of mathematics. Due to the vague and imprecise human judgment and preference, fuzzy approach is used in this study. The fuzzy conjoint method based on fuzzy set is being widely used to analyse human preference. However, the method cannot produce the weight of attribution in various degrees of confidence. The aim of this study is to improve fuzzy conjoint method based on trapezoidal fuzzy number and investigate the students’ level of preferences on the learning of Mathematics and to compare the result with the secondary data. Hence, by incorporating fuzzy number in continuous form, it will enable the respondents to express their opinion in a more detailed interpretation. This study improvised the existing procedure by employing trapezoidal fuzzy number in representing the predefined linguistic terms and the aggregation of preference level of the respondents based on each criterion. The highest priorities of degree of agreement for students’ expectation is lecturers should focus more on developing and understanding the concept of learning mathematics, followed by student-lecturer interaction and lecturers and lecturers should have sufficient time to complete all the syllabus.

Keywords: Conjoint Method; Expectation; Learning Mathematics; Trapezoidal Fuzzy Number

1. Introduction
Students’ expectations are the perceptions of human observation which is subjective, uncertain and indefinite in nature. Due to the ability of fuzzy theory that can deal with data in linguistic values, the human preference and subjective perceptions can be effectively defined by fuzzy set theory. By incorporating the fuzzy set theory (FST), the human preference is defined in a subjective manner. Fuzzy set theory has frequently appeared in many fields such as management, production and psychology (Abiyev et al., 2016; Ahmad et al., 2018; Ramli et al., 2010; Ramli et al., 2018; Sulaiman et al., 2018, Osman et al., 2019).

Conjoint analysis is a procedure to measure preferences given to various attributes of a product. The analysis was first developed by Luce and Tukey (1964) who are mathematical psychologists (Caruso et al., 2009). The ability to quantify the relative importance of the real world preference issues has led conjoint analysis to be widely used to measure and predict consumer preference. Wilson and Turksen (1994) proposed the fuzzy conjoint model (FCM) to measure preference under fuzzy
environment which incorporates the fuzzy set theory into the conjoint analysis method. The FCM analysis provides attribute with degrees of similarity to reflect the level of agreement (Abdullah et al., 2011). Due to the effectiveness of FCM in representing the preferences in uncertain environment, it has been applied in many areas such as in management, education, and business.

Osman and Lazim (2009) applied the FCM to measure teachers’ beliefs in mathematics. In the study, they found that the attribute ‘drills and practice is one of the best way in the learning of mathematics’ has the highest degree of similarity with level of strongly agree. Abdullah et al. (2011) has applied the FCM in analysing students’ perceptions in the learning of algebra using computer algebra system. The study found that the students agreed to a certain level of agreement that in order to provide greater opportunities in learning algebra, is by integrating technology environment in classroom learning.

In 2011, Tawil et al. conducted a study using FCM to analyse the perceptions of residents on service charge of Malaysian high-rise residential management. The results showed that the residents highly agreed for a payment counter to be opened on weekends. On the other hand, Abiyev et al. (2016) used the FCM to analyse the job satisfaction of hotel staff. The study ranked the feeling of accomplishment of the job as the highest agreement. Kavitha and Sarala (2017) have also applied the FCM in measuring students’ expectation and teachers’ belief in the learning of mathematics. They found that students ranked the conceptual understanding as the first priority in the learning of mathematics compared to teachers ranked drills and practice. The teachers’ beliefs in the learning of mathematics are consistent with Kavitha and Sarala’s (2017) and Osman and Lazim’s (2009) studies. In a similar study, Yaakub et al. (2018) also used the FCM in measuring consumers’ opinion on cycling transport. The study showed that consumers preferred the bicycle routes are situated near their schools, recreational areas, workplace, and colleges. However, the above-mentioned FCM used fuzzy sets to define the membership function of the linguistic values, in which the α-cut of the fuzzy numbers for all values of $\alpha \in [0,1]$ cannot be obtained. In addition, the fuzzy set which is in discrete form does not represent good human judgement and preference.

In this study, an improvised trapezoidal fuzzy number conjoint method (TrFNFCM) will be presented. Based on the previous research by Kavitha and Sarala (2017), the TrFNFCM for examining students’ expectation is proposed. By using the trapezoidal fuzzy number, the membership function will be presented in continuous form in which the weight of attributes can be determined for each degree of confidence, $\alpha$. The remaining part of the paper is arranged accordingly: preliminaries on trapezoidal fuzzy numbers are presented in Section 2 and followed by the procedure of TrFNFCM in Section 3. Section 4 presents the application of TrFNFCM in determining students’ expectation. Section 5 compares the findings with the previous studies and Section 6 concludes the paper.

2. Preliminaries

This section presents some basic definitions of trapezoidal fuzzy numbers (TrFNs) and similarity measure by Patra and Mondal (2015).

A generalized trapezoidal fuzzy number $\tilde{A}$ denoted as $\tilde{A} = (a_1, a_2, a_3, a_4: 1)$ has membership function, $\mu_{\tilde{A}}(x)$ defined as

$$
\mu_{\tilde{A}}(x) = \begin{cases} 
0, & x < a_1 \\
\frac{x-a_1}{a_2-a_1}, & a_1 \leq x \leq a_2 \\
1, & a_2 \leq x \leq a_3 \\
\frac{a_4-x}{a_4-a_3}, & a_3 \leq x \leq a_4 \\
0, & x > a_4
\end{cases}
$$

For $a_2 = a_3$, $\tilde{A}$ becomes triangular fuzzy numbers denoted as $\tilde{A} = (a_1, a_2, a_4: 1)$. 


Definition : (Patra & Mondal, 2015)

If $\tilde{T} = (t_1, t_2, t_3, t_4; w)$ is a generalized trapezoidal fuzzy number, then the area of this fuzzy number, denoted by $ar(\tilde{T})$ is given as

$$ar(\tilde{T}) = \frac{(t_4 + t_3 - t_2 - t_1) \times w}{2}$$

If $R_i = (t_{14}, t_{13}, t_{12}, t_{11}; w)$ and $L_j = (t_{24}, t_{23}, t_{22}, t_{21}; w)$ be two generalized trapezoidal fuzzy numbers, then the degree of similarity between these two fuzzy numbers, denoted by $S(R_i, L_j)$ is defined as equation below

$$S(R_i, L_j) = \left(1 - \frac{1}{4} \sum_{i=1}^{4} |t_{1i} - t_{2i}|\right) \times \left(1 - \frac{1}{2} \left(|ar(R_i) - ar(L_j)| + |w_{R_i} - w_{L_j}| \right)\right)$$

3. Trapezoidal Fuzzy Number Conjoint Method (TrFNCM)

This section illustrates the procedure of trapezoidal fuzzy number conjoint method (TrFNCM). The TrFNCM considers a questionnaire with $M$ attributes, $p$ linguistic values of preferences and $B_j (j = 1, 2, 3, \ldots, p)$ denotes as the $k$-th linguistic values of preferences. For $p = 7$, the linguistic values are denoted as $B_1$, $B_2$, $B_3$, $B_4$, $B_5$, $B_6$ and $B_7$ which represent values of preferences such as very strongly disagree, strongly disagree, disagree, undecided, agree, strongly agree and very strongly disagree respectively. Each $B_j$ is in TrFNs form.

The procedure of TrFNCM is given in the following steps:

Step 1: Collect respondents’ opinion based on $p$ linguistic values.

Step 2: Calculate the number of respondents’ opinion denotes as $t_{ij}$ whereby $t_{ij}$ represents the number of respondents’ opinion for attribute $i$ with linguistic values $B_j$.

Step 3: Calculate the weight of attribute $i$ with linguistic values $B_j$ as

$$w_{ij} = \frac{t_{ij}}{\sum_{j=1}^{p} t_{ij}}.$$

(1)

Step 4: Calculate the overall membership function of attribute $i$ as

$$F_i = \sum_{j=1}^{p} w_{ij} B_j \text{ for } i = 1, 2, 3, \ldots, M.$$

(2)

Step 5: Calculate the degree of similarity between $F_i$ and $B_j$ using the similarity measure by Patra and Mondal (2015).

Step 6: Compare the degree of similarity for attribute $F_i$. Then, choose the highest one and rank them.

4. Trapezoidal Fuzzy Number Conjoint Method (TrFNCM) for Measuring Students’ Expectation
The TrFNCM is implemented on the data of students’ expectation in learning mathematics from Sarala and Kavitha (2017). A total of 243 final year students involved in the study. The procedure of implementation is given in the following steps:

Step 1: The data involved six attributes \( A_1, A_2, A_3, \ldots, A_6 \) with seven linguistic values in TrFN form (as shown in Tables 1 and 2 respectively).

| Table 1. Students’ expectation in learning mathematics |
|------------------------------------------------------|
| Attribute | Students’ expectation |
| \( A_1 \) | Smooth relationship between lecturers and students so that students can voice out their ideas freely |
| \( A_2 \) | Lecturers should be more focused in developing and understanding the concept and procedure in problem solving |
| \( A_3 \) | Lecturers’ motivation and support are important to encourage students in learning mathematics |
| \( A_4 \) | Explaining the mathematical modelling is very important so that students can apply mathematics in real world problem |
| \( A_5 \) | Lecturers have enough time to finish all the syllabus |
| \( A_6 \) | The interaction between students and lecturers |

| Table 2. Linguistic values in TrFN form |
|----------------------------------------|
| Linguistic values, \( B_j \) | TrFN |
| Very strongly disagree, \( B_1 \) | \((0, 0, 1, 2)\) |
| Strongly disagree, \( B_2 \) | \((0, 1, 2, 3)\) |
| Disagree, \( B_3 \) | \((1, 2, 4, 5)\) |
| Undecided, \( B_4 \) | \((3, 4, 6, 7)\) |
| Agree, \( B_5 \) | \((5, 6, 8, 9)\) |
| Strongly Agree, \( B_6 \) | \((7, 8, 9, 10)\) |
| Very Strongly Agree, \( B_7 \) | \((8, 9, 10, 10)\) |

Step 2: The data of respondents’ opinion are given in Table 3 with \( A_i \) represents the \( i \)-th attribute

| Table 3. Number on students’ expectation adapted from Kavitha and Sarala (2017) |
|----------------------------------------------------------|
| Attribute \( A_i \) | \( B_1 \) | \( B_2 \) | \( B_3 \) | \( B_4 \) | \( B_5 \) | \( B_6 \) | \( B_7 \) | Total |
| \( A_1 \) | 0 | 0 | 38 | 48 | 97 | 36 | 24 | 243 |
| \( A_2 \) | 0 | 0 | 0 | 0 | 48 | 73 | 121 | 242 |
| \( A_3 \) | 0 | 0 | 19 | 40 | 61 | 49 | 74 | 243 |
| \( A_4 \) | 9 | 6 | 14 | 38 | 89 | 34 | 53 | 243 |
| \( A_5 \) | 0 | 0 | 0 | 30 | 34 | 110 | 68 | 242 |
| \( A_6 \) | 2 | 3 | 6 | 44 | 108 | 40 | 40 | 243 |

For attribute \( A_1 \), Table 3 shows none of the students chose very strongly disagree (\( B_1 \)) and strongly disagree (\( B_2 \)), 38 students chose disagree (\( B_3 \)), 48 chose undecided (\( B_4 \)), 97 chose agree (\( B_5 \)), 37 chose strongly agree (\( B_6 \)) and 24 chose very strongly agree (\( B_7 \)). One respondent did not respond on attribute \( A_2 \), thus gives the total number of opinion of attribute \( A_2 \) is 242.
Step 3: Based on Eq. (1), the weight, $w_{ij}$ of attribute $i$ with linguistic values $B_j$ is given in Table 4.

| $w_{ij}$ | $B_1$ | $B_2$ | $B_3$ | $B_4$ | $B_5$ | $B_6$ | $B_7$ |
|----------|-------|-------|-------|-------|-------|-------|-------|
| $A_1$    | 0     | 0     | 0.1564| 0.1975| 0.3992| 0.1481| 0.0988|
| $A_2$    | 0     | 0     | 0     | 0     | 0.1975| 0.3017| 0.5000|
| $A_3$    | 0     | 0     | 0.0782| 0.1646| 0.2510| 0.2016| 0.3045|
| $A_4$    | 0.0370| 0.0247| 0.0576| 0.1564| 0.3663| 0.1399| 0.2181|
| $A_5$    | 0     | 0     | 0     | 0.1240| 0.1405| 0.4545| 0.2810|
| $A_6$    | 0.0082| 0.0123| 0.0247| 0.1811| 0.4444| 0.1646| 0.1646|

Step 4: Based on Eq. (2), the overall membership function of attribute $i$, $F_i$ is presented in Table 5.

| TrFN $F_i$ | Overall membership $F_i$ |
|------------|---------------------------|
| $F_1$      | (4.5720,5.5720,7.3251,8.2263) |
| $F_2$      | (7.1033,8.1033,9.3017,9.8017) |
| $F_3$      | (5.6749,6.6749,8.1687,8.8642) |
| $F_4$      | (5.0823,6.0453,7.6255,8.4074) |
| $F_5$      | (6.5041,7.5041,8.7686,9.4876) |
| $F_6$      | (5.2593,6.2510,7.9012,8.7366) |

Step 5: The degree of similarity between $F_i$ and $B_j$ based on the similarity measure by Patra and Mondal (2015) is shown in Table 6.

| $F_i$ | $B_1$  | $B_2$  | $B_3$  | $B_4$  | $B_5$  | $B_6$  | $B_7$  |
|-------|--------|--------|--------|--------|--------|--------|--------|
| $F_1$ | 0.4066 | 0.4898 | 0.6479 | 0.8449 | 0.9284*| 0.7645 | 0.6742 |
| $F_2$ | 0.2124 | 0.2915 | 0.4190 | 0.6085 | 0.7980 | 0.9798*| 0.9118 |
| $F_3$ | 0.3261 | 0.4083 | 0.5468 | 0.7402 | 0.9271*| 0.8695 | 0.7755 |
| $F_4$ | 0.3771 | 0.4603 | 0.6040 | 0.7985 | 0.9460*| 0.8103 | 0.7181 |
| $F_5$ | 0.2600 | 0.3413 | 0.4718 | 0.6630 | 0.8543 | 0.9507*| 0.8541 |
| $F_6$ | 0.3516 | 0.4337 | 0.5833 | 0.7789 | 0.9569*| 0.8296 | 0.7373 |

* denotes highest similarity degree

Step 6: The highest similarity degree of each attribute $i$ and its linguistic value is shown in Table 7.
Table 7 shows the students agreed with all the attributes at more than 0.92 degree of similarity. Attribute $A_2$ with strongly agree at 0.9798 degree of similarity gives the first ranking. Students give the first ranking with strongly agree that lecturers should be more focused in developing the concept and process of solving problems. Attribute $A_5$ is ranked second which students agreed on the interaction between students and lecturers at 0.9569 degree of similarity. This is followed by the fifth attribute, which students’ expectation is strongly agree at 0.9507 degree of similarity that lecturers have enough time to finish all the syllabus. The fourth attribute is ranked third lowest (0.946 degree of similarity) which students agreed that explaining the mathematical modelling is very important so that students can apply mathematics in the real world problem. The first attribute is ranked second lowest (0.9271 degree of similarity) which students agreed that the smooth relationship between lecturers and students can give students opportunity to voice out their ideas freely. The least expectation is the third attribute which students agreed that lecturers’ motivation and support are important to encourage students in learning mathematics (0.9284 degree of similarity).

5. Comparison of Results
The result of the TrFNCM is compared with Kavitha and Sarala’s (2017) method, which used fuzzy set to define the linguistic values. Tables 8 and 9 compare the two methods in terms of membership function and ranking results respectively.

| Attribute | Highest similarity degree | Linguistic value | Ranking |
|-----------|---------------------------|-----------------|---------|
| $A_1$     | 0.9284                    | Agree, $B_1$    | 5       |
| $A_2$     | 0.9798                    | Strongly agree, $B_6$ | 1       |
| $A_3$     | 0.9271                    | Agree, $B_3$    | 6       |
| $A_4$     | 0.9460                    | Agree, $B_4$    | 4       |
| $A_5$     | 0.9507                    | Strongly agree, $B_6$ | 3       |
| $A_6$     | 0.9569                    | Agree, $B_1$    | 2       |

Table 7. Highest similarity degree and ranking for each attribute

| Attribute | Highest similarity degree | Linguistic value | Ranking |
|-----------|---------------------------|-----------------|---------|
| $F_i$     | Sarala & Kavitha (2017)   | TrFNCM          |         |
| $F_1$     | \{0.0998, 0.1482, 0.3992, 0.1975, 0.1564, 0, 0\} | (4.5720,5.5720,7.3251,8.2263)   |
| $F_2$     | \{0.5000, 0.3017, 0.1984, 0, 0, 0, 0\} | (7.1033,8.1033,9.3017,9.8017)   |
| $F_3$     | \{0.3045, 0.2017, 0.2513, 0.1646, 0.0782, 0, 0\} | (5.6749,6.6749,8.1687,8.8642)   |
| $F_4$     | \{0.2181, 0.1399, 0.3663, 0.1564, 0.0576, 0.0247, 0.0370\} | (5.0823,6.0453,7.6255,8.4074)   |
| $F_5$     | \{0.2810, 0.4545, 0.1405, 0.1240, 0, 0, 0\} | (6.5041,7.5041,8.7686,9.4876)   |
| $F_6$     | \{0.1646, 0.1646, 0.4444, 0.1811, 0.0247, 0.0123, 0.0082\} | (5.2593,6.2510,7.9012,8.7366)   |

Table 8. Comparison of overall membership function of attribute $i$, $F_i$
The overall membership function of attribute for Kavitha and Sarala’s (2017) method is in the form of fuzzy set, while the TrFNCM produces membership function in trapezoidal fuzzy number form. The membership in fuzzy set form can only produce results at certain degree of confidence $\alpha$ while the trapezoidal fuzzy number can produce results at all $\alpha \in [0,1]$. For example, the $\alpha$ – cut for membership function $F_1$ from Kavitha and Sarala’s (2017) can only be obtained at $\alpha = 0.0988, 0.1482, 0.3992, 0.1975$ and $0.1564$. While, for TrFNCM, the $\alpha$ – cut for membership function $F_1$ can be obtained at all $\alpha \in [0,1]$.

The ranking result by Kavitha and Sarala (2017) is $A_2 \succ A_5 \succ A_6 \succ A_3 \succ A_1 \succ A_4$, while the ranking result by TrFNCM is $A_2 \succ A_6 \succ A_5 \succ A_4 \succ A_1 \succ A_3$. The ranking of attribute for both methods is slightly different in ranking of $A_3, A_4, A_5$ and $A_6$. However, the ranking is consistent for other attributes such as ranking 1 for attribute $A_2$, and ranking 5 with attribute $A_1$. Apart from that, this study also compares the ranking results of TrFNCM using different similarity measures approaches. Table 10 shows the ranking result of TrFNCM using similarity measure by Patra and Mondal (2015), Xu et al. (2010) and Khorshidi and Nikfalazar (2017).

The similarity measure proposed by Xu et al. (2010), Patra and Mondal (2015), and Khorshidi and Nikfalazar (2017) gives different ranking but in the same category, strongly agree and agree. However, Patra and Modal (2015), and Khorshidi and Nikfalazar (2017) methods provide consistent results with strongly agreed for the first ranking for attribute $A_2$, while Xu et al. (2010) method gives the first ranking for attribute $A_6$. For other attributes, all the methods provide different ranking results.

### Table 9. Comparison of results between Kavitha and Sarala (2017) and TrFNCM

| Attribute | Kavita & Sarala (2017) | TrFNCM |
|-----------|------------------------|--------|
| $A_1$     | 0.5109 Agree           | 0.9284 Agree | 5 |
| $A_2$     | 0.5576 Very Strongly agree | 0.9798 Strongly agree | 1 |
| $A_3$     | 0.5116 Very Strongly agree | 0.9271 Agree | 6 |
| $A_4$     | 0.5009 Agree           | 0.9460 Agree, | 4 |
| $A_5$     | 0.5341 Strongly agree  | 0.9507 Strongly agree | 3 |
| $A_6$     | 0.5124 Agree           | 0.9569 Agree, | 2 |

### Table 10. Comparison ranking results using three different similarity measure

| Attribute | Patra & Mondal (2015) | Xu et al. (2010) | Khorshidi & Nikfalazar (2017) |
|-----------|------------------------|------------------|------------------------------|
| $A_1$     | 0.9284 Agree           | 0.9452 Agree     | 0.9795 Agree                 |
| $A_2$     | 0.9798 Strongly agree  | 0.9826 Strongly agree | 0.9961 Strongly agree |
| $A_3$     | 0.9271 Agree           | 0.9643 Agree     | 0.9677 Agree                 |
| $A_4$     | 0.9460 Agree           | 0.9763 Agree     | 0.9669 Agree                 |
| $A_5$     | 0.9507 Strongly agree  | 0.9572 Strongly agree | 0.9909 Strongly agree |
| $A_6$     | 0.9569 Agree           | 0.9868 Agree     | 0.9740 Agree                 |
6. Conclusion

In this study, the TrFNCM is improved based on trapezoidal fuzzy numbers and applied in measuring students’ expectation in learning mathematics. The TrFNCM does not only produce the results as ‘agree’ or ‘strongly agree’ but also provide a level of similarity to represent the strength of ‘agree’ or ‘strongly agree’. The findings showed that students strongly agreed that lecturers should focused more on developing and understanding the concept and procedure in problem solving ($A_4$) with 0.9798 degree of agreement. Students also agreed that interaction between students and lecturers are important ($A_5$) at 0.9569 degree of agreement. Students also strongly agreed that lecturers have sufficient time to complete all the syllabus ($A_6$) with 0.9507 degree of agreement. Students also agreed on the smooth relationship with lecturers is important in order for students to freely voice out their ideas ($A_1$) at 0.9284 degree of agreement, lecturers’ support and motivation are important to encourage students in learning mathematics ($A_2$) at 0.9271 degree of agreement, and explaining the mathematical modelling is very important so that students can apply mathematics in real world problem ($A_3$) with 0.9460 degree of agreement. Students are at the level of agree and strongly agree with the attributes of the following ranking $A_2 > A_6 > A_5 > A_4 > A_1 > A_3$. The results showed that lecturers need to be more supportive to motivate students in learning mathematics. The weight of attribution can be achieved at different degree of confidence $\alpha \in [0,1]$ by using TrFNCM. The membership function is defined in continuous form in which the weight of attributes can be determined at different degree of confidence, $\alpha \in [0,1]$. This indicates that the TrFNCM provides detailed results on the attributes and will give benefit to educators, researchers and decision-makers on solving issues in decision-making.

Acknowledgment

The authors would like to thank Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Malaysia and Ministry of Higher Education Malaysia for the facilities and financial support under the national grant 600-IRMI/FRGS 5/3 (022/2017), FRGS/1/2017/ICT04/UiTM/02/2.

References

[1] Abiyev, R. H., Saner, T., Eyupoglu, S., & Sadikoglu, G. (2016). Measurement of job satisfaction using fuzzy sets. Procedia - Computer Science, 102(August), 294–301.
[2] Bashiri, M., Badri, H., & Hejazi, T. H. (2010). Selecting optimum maintenance strategy by fuzzy interactive linear assignment method. Applied Mathematical Modelling, 35(1), 152-164.
[3] Chen, C. T., Lin, C. T., & Huang, S. F. (2006). A fuzzy approach for supplier evaluation and selection in supply chain management. International Journal of Production Economics, 102(2), 289-301.
[4] Cross, V. V., & Sudkamp, T. A. (2002). Similarity and compatibility in fuzzy set theory: assessment and applications. Springer Science & Business Media. (Vol. 93).
[5] Hadi-Venchehi, A., & Mohitbadian, M. (2011). A new fuzzy MCDM approach based on centroid of fuzzy numbers. Expert Syst. Appl. (Vol. 38).
[6] Ramli, N., Mohamad, D., & Sulaiman, N.H. (2010). Evaluation of teaching performance with outliers data using fuzzy approach. Procedia-Social and Behavioural Sciences, 8, pp. 190-197.
[7] Ramli,N., Mohamad, D., & Mohammed,N.(2018). Opinion Based Fuzzy Measurement Model. ESTEEM Academic Journal, Vol. 14,70-82.
[8] Osman, R., Ramli, N., Badarudin, Z., Ujang, S., Ayub, H., & Asri, S.N.F. (2019). Fuzzy number conjoint method to analyse students’ perceptions on the learning of calculus. Journal of Physics: Conf. Series, 1366, 012117.
[9] Patra, K., & Mondal, S. K. (2015). Fuzzy risk analysis using area and height based similarity measure on generalized trapezoidal fuzzy numbers and its application. Applied Soft Computing, 28, 276-284.
[10] Sarala, N., & Kavitha, R. (2017). Fuzzy conjoint model in measuring students’ expectation and teachers’ beliefs on learning mathematics. International Journal of Advanced Trends in Engineering, Science and Technology, 2(2), 6-10.
[11] Sayed Ahmad, S.A., Mohamad,D., Sulaiman, N.H., & Abdullah, K.(2018). A distance and set theoretic-based similarity measure for generalized trapezoidal fuzzy numbers. AIP Conference Proceedings 1974, 020043 (2018); https://doi.org/10.1063/1.5041574.
[12] Scozzafava, R., & Vantaggi, B. (2009). Fuzzy inclusion and similarity through coherent conditional probability. Fuzzy Sets and Systems, 160(3), 292-305.
[13] Sulaiman, N.H., Mohamad, D., Mohd Shariff, J & Sayed Ahmad, S. A., & Abdullah, K. (2018). Extended FTOPSIS with Distance and Set Theoretic-Based Similarity Measure. Indonesian Journal of Electrical Engineering and Computer Science. 9. 387-394.10.11591/ejeecs.v9.i2.pp387-394.
[14] Tawil, N.M.,Che-Ani, A. I., Ramly,A.,Daud,M.N., & Abdullah, N.A.G. (2011). International Journal of the Physical Sciences Vol. 6(3), pp. 441-447, 4 February, 2011. Available online at: http://www.academicjournals.org/IPS.
[15] Turksen, I.B., & Willson, I.A. (1994). A fuzzy preference model for consumer choice. Fuzzy Sets & Systems, 68(3), 253-266.
[16] Xiao, Z., Xia, S., Gong, K., & Li, D. (2012). The trapezoidal fuzzy soft set and its application in MCDM. *Applied Mathematical Modelling, 36*(12), 5844-5855.

[17] Xu, Z., Shang, S., Qian, W., & Shu, W. (2010). A method for fuzzy risk analysis based on the new similarity of trapezoidal fuzzy numbers. *Expert Systems with Applications, 37*(3), 1920-1927.

[18] Yaakub, N.M.I.T., Borhan, M.N., Yazid, M.R.M., & Jamaluddin, S.A. (2018). Fuzzy conjoint modelling in studying user willingness to switch to bicycle as transportation in Ipoh city. *Journal of Physics: Conf. Series, 1049*, 012045.