Journal of Science and Mathematics Letters, Vol 10, Issue 1, 2022 (10-21)
ISSN 2462-2052, eISSN 2600-8718

RESEARCH PAPER

Achievement Goals Analysis in the Learning of Calculus Based on Fuzzy Number Conjoint Method

Roselah Osman[1], Nazirah Ramli[2*], Nur Azlina Mohd Noor[3], Nur'Izzati Najihah Mohamed Thoriq[4], Zuraidar Badaruddin[5], Nur Aziean Mohd Idris[6]

[1,3,4,6]Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, MALAYSIA
[2]Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA Pahang, 26400 Bandar Jengka, Pahang, MALAYSIA
[5]Akademi Pengajian Bahasa, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, MALAYSIA

*Corresponding author: nazirahr@uitm.edu.my

Received: 10 March 2021; **Accepted:** 12 January 2022; **Published:** 27 May 2022

To cite this article (APA): Osman, R., Ramli, N., Mohd Noor, N. A., Mohamed Thoriq, N. N., Badaruddin, Z., & Mohd Idris, N. A. (2022). Achievement Goals Analysis in the Learning of Calculus Based on Fuzzy Number Conjoint Method. *Journal of Science and Mathematics Letters*, *10*(1), 10-21. https://doi.org/10.37134/jsml.vol10.1.2.2022

To link to this article: https://doi.org/10.37134/jsml.vol10.1.2.2022

Abstract

The conjoint method, which is based on fuzzy sets of numbers, is widely used to describe linguistic values for human preference in an uncertain environment. However, the fuzzy sets used to describe the membership function of linguistic value do not realistically represent the physical world, so the conjoint method can fill the gap and produce more meaningful results. The fuzzy numbers conjoint method is used in this paper to analyze the achievement goals of undergraduates in the learning of calculus. One hundred and seven selected Bachelor of Science (Hons) Mathematics and Bachelor of Science (Hons) Actuarial Science students from one public university in Klang Valley, Selangor, participated in this study. The data for this study, which was distributed via Google form, was based on a previous study's Achievement Goals Questionnaire. The fuzzy number conjoint method with similarity measure based on geometric distance, ambiguity, value, area, left and right height were used to calculate and analyze the data gathered from respondents' opinions of attributes for each linguistic value. The priority of the degree of agreement among undergraduates on the achievement goals in the learning of calculus is worrying as they may not learn all that they possibly could in this subject (A_{11}), getting better grades than most other students (A_1), followed by avoiding performing poorly compared to other students in this subject (A_2), and doing better than other students (A_{12}) with an overall ranking as follows $A_{11} \approx A_1 \succ A_2 \approx A_{12} \succ A_5 \succ A_8 \succ A_{14} \succ A_{13} \succ A_9 \succ A_6 \succ A_3 \succ A_{15} \succ A_7 \succ A_{10} \succ A_4$. The findings of this study can be used to assist and guide academicians and mathematics educators in enhancing students' achievement goals for calculus learning.

Keywords: achievement, fuzzy number conjoint method, goals, undergraduates

INTRODUCTION

Calculus is a fundamental subject for students pursuing degrees in mathematics, physics, chemistry, economics, finance, and actuarial science, among other fields. The fact that calculus is so important is due to the fact that it has applications in numerous fields. Students struggle with calculus because they lack the ability to think logically in order to comprehend its concepts. The majority of the attention is focused on the factors that influence success in calculus. Educators faced a number of challenges, the most significant of which is improving students understanding. Students' learning in calculus is influenced by their ability to achieve their objectives. Learning about one's own goals is one of the most important factors influencing one's own academic achievement patterns (Ames, 1990). As a result, many studies have been carried out by mathematics education researchers to investigate the attitudes, beliefs, and perceptions of students toward the learning of calculus. A number of studies have discovered that students' perceptions of the utility of what they have learned in calculus have had an impact on their motivation to learn, their interest in learning, and their achievement (Liang, 2009; Osman, Hilmi, Ramli, & Abdullah, 2020).

Human preference is ambiguous, imprecise, and subjective. As a result of the ability of fuzzy theory to deal with data in linguistic values, the fuzzy conjoint method (FCM) can effectively define human preferences. As a result, in 1965, Zadeh developed fuzzy logic based on fuzzy set theory. Since then, FCM has been used in a variety of fields, including finance, science, and education. Lazim and Abu Osman (2009) used FCM to assess teachers' beliefs in mathematics, and they discovered that drills and practices were one of the best ways to learn mathematics. FCM had also been used to describe students' perceptions of the computer algebra system (CAS) learning environment in a study conducted by Abdullah and Osman (2011). They discovered that students had different perceptions of teachers in terms of the general outlook on teaching and the role of teachers in the CAS learning environment. Sarala and Kavitha (2017) used the fuzzy conjoint model to assess students' and teachers' beliefs in mathematics learning. Their research discovered that students required a conceptual understanding of mathematics to learn it, whereas teachers believed that doing more exercises was one of the best ways to learn mathematics. Then, Gopal, Salim, and Ayub (2019) used fuzzy conjoint to examine lower secondary students' perceptions of learning mathematics. They discovered that students' overall perceptions of learning mathematics were mostly positive due to their interest in mathematics. Finally, Suparlan et al. (2019) used fuzzy conjoint to examine students' perceptions of game-based mathematics classrooms, and the study revealed that the majority of students had positive perceptions of game-based learning classrooms. The aforementioned studies, however, used the FCM based on a fuzzy set, which does not represent the physical world (Gao, Zhang, & Cao, 2009). To overcome the limitations of previous studies, Osman et al. (2019) proposed the use of FCM based on fuzzy numbers. Fuzzy numbers depict the physical world more realistically and can produce attribute weights at different levels of confidence (Dom, Hasan, Shahidin, & Apandi, 2019; Sulaiman et al., 2017; Ramli & Mohamad, 2009). Nonetheless, Osman et al. (2019) used Patra and Mondal (2015)'s similarity measure based on area, height, and distance, which cannot differentiate the degree of similarity for some different pairs of fuzzy numbers. In other research, Khorshidi and Nikfalazar (2017) proposed a modified degree of similarity technique based on the geometric distance, areas, perimeter, height, and centre of gravity of fuzzy numbers. The method, on the other hand, is incapable of distinguishing the similarity of two pairs of non-identical crisp-valued fuzzy numbers. In this paper, the FCM based on fuzzy numbers is used to analyze students' achievement goals in the learning of calculus.

The similarity measure based on geometric distance, ambiguity, value, area, left and right height by Chutia and Gogoi (2018) is used to calculate the degree of similarity of the fuzzy numbers. The similarity measure by Chutia and Gogoi (2018) outperforms some of the previous similarity measures such as Patra and Mondal (2015), Xu, Shang, Qian and Shu (2010), and Khorshidi and Nikfalazar (2017), which cannot differentiate the degree of similarity for some different fuzzy numbers.

METHODOLOGY

The basic definitions fuzzy number, linguistic variable, and similarity measures are presented in this section. These fundamental definitions are essential for analyzing data based on the FNCM.

Fuzzy Number

Definition 1: (Chen, Lin, & Huang, 2006)

A normal fuzzy number $\tilde{A}$ denoted as $\tilde{A} = (a_1, a_2, a_3, a_4)$ has membership function defined as

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

and shown in Figure 1.

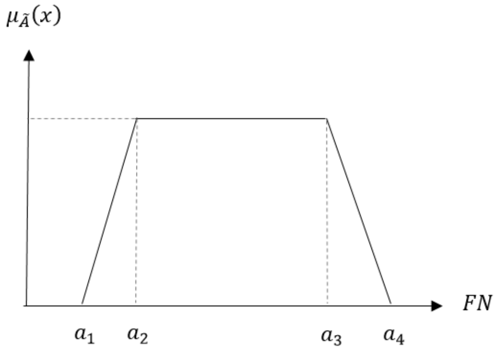

Figure 1. Fuzzy numbers, (a_1, a_2, a_3, a_4)

Linguistic Variable

Definition 2: (Wang, 1997)

A linguistic variable is characterised by (*X, T, U, M*), whereby *X* is the name of the linguistic variable, *T* is the set of linguistic values that *X* can take, *U* is the actual physical domain in which the linguistic variable *X* takes its quantitative values, and *M* is a semantic rule that relates each linguistic value in *T* with a fuzzy set in *U*. There are five linguistic values involved which are ‘strongly disagree,' 'disagree,' 'undecided,' 'agree,' and ‘strongly agree.' The domain's value is mapped to a degree between 0 and 1. The conjoint method represents linguistic values as fuzzy numbers.

Similarity Measure

The measure of similarity is a term used to describe the degree of resemblance between two objects or group comparison (Cross & Sudkamp, 2002).

Definition 3: (Chutia and Gogoi, 2018)

If $A=\left(a_1,a_2,a_3,a_3;\omega_1,\omega_2\right)$ and $B=\left(b_1,b_2,b_3,b_3;\omega_1',\omega_2'\right)$ are two non-empty GFNs with different left heights and right heights. Then, the degree of similarity between these two GFNs, denoted as $S\left(A,B\right)$ is defined as

$$\begin{aligned} S\left(A,B\right) &= \left(1-\frac{1}{4}\sum_{i=1}^{4}\left|a_i-b_i\right|\right) \\ &\times\left(1-\frac{1}{2}\left[\left|\mathrm{Amb}\left(A\right)-\mathrm{Amb}\left(B\right)\right|+\left|\mathrm{Val}\left(\mathrm{A}\right)\right|-\mathrm{Val}\left(B\right)\right]\right) \\ &\times\left(1-\frac{1}{2}\left[\left|\omega_1-\omega_1'\right|+\left|\omega_2-\omega_2'\right|\right]\right) \\ &\times\frac{\min\left(r_x^A,r_x^B\right)+\min\left(r_y^A,r_y^B\right)}{\max\left(r_x^A,r_x^B\right)+\max\left(r_y^A,r_y^B\right)} \end{aligned} \tag{1}$$

where,

$$\mathrm{Amb}\left(A\right)=\frac{1}{6}\left[\left(a_3-a_1\right)\omega_1^{\,2}+\left(a_4-a_2\right)\omega_2^{\,2}+\left(a_3-a_2\right)\omega_1\,\omega_2\right] \tag{2}$$

$$\mathrm{Amb}\left(B\right)=\frac{1}{6}\left[\left(b_3-b_1\right)\omega_1^{\,2}+\left(b_4-b_2\right)\omega_2^{\,2}+\left(b_3-b_2\right)\omega_1'\,\omega_2'\right] \tag{3}$$

$$\mathrm{Val}\left(A\right)=\frac{1}{6}\left[\left(a_1-a_3\right)\omega_1^{\,2}+\left(a_2+a_4+4a_3\right)\omega_2^{\,2}+\left(a_2-a_3\right)\omega_1\,\omega_2\right] \tag{4}$$

$$\mathrm{Val}\left(B\right)=\frac{1}{6}\left[\left(b_1-b_3\right)\omega_1'^{\,2}+\left(b_2+b_4+4b_3\right)\omega_2'^{\,2}+\left(b_2-b_3\right)\omega_1'\,\omega_2'\right] \tag{5}$$

$$\left(I_x\right)_{R_1}=\frac{\omega_1^{\,3}}{12}\left(b-a\right) \tag{6}$$

$$\left(I_y\right)_{R_1}=\frac{\omega_1}{12}\left(3b^3-a^3-a^2b-ab^2\right) \tag{7}$$

$$\left(I_x\right)_{R_2}=\begin{cases}\dfrac{\left(c-b\right)\omega_1^{\,3}}{3}, & if\ \ \omega_1\le\omega_2; \\ \dfrac{\left(c-b\right)\omega_2^{\,3}}{3}, & if\ \ \omega_1\ge\omega_2;\end{cases} \tag{8}$$

$$\left(I_x\right)_{R_3}=\begin{cases}\dfrac{c-b}{12}\left(\omega_2^{\,3}-3\omega_1^{\,3}+\omega_1^{\,2}\omega_2+\omega_1\,\omega_2^{\,2}\right), & if\ \ \omega_1\le\omega_2; \\ \dfrac{c-b}{12}\left(\omega_1^{\,3}-3\omega_2^{\,3}+\omega_1^{\,2}\omega_2+\omega_1\,\omega_2^{\,2}\right), & if\ \ \omega_1\ge\omega_2;\end{cases} \tag{9}$$

$$\left(I_x\right)_{R_4}=\frac{\left(d-c\right)\omega_2^{\,3}}{12} \tag{10}$$

$$\left(I_y\right)_{\left(R_2+R_4\right)}=\frac{\omega_1}{3}\left(c^3-b^3\right)+\frac{\left(\omega_2-\omega_1\right)}{12}\left(3c^3-b^3-c^2b-cb^2\right) \tag{11}$$

$$\left(I_y\right)_{R_3} = \frac{\omega_2}{12}\left(d^3 - 3c^3 + c^2 d + cd^2\right) \tag{12}$$

$$r_x^A = \sqrt{\frac{\left(I_x\right)_{R_1} + \left(I_x\right)_{R_2} + \left(I_x\right)_{R_3} + \left(I_x\right)_{R_4}}{ar\left(A\right)}} \tag{13}$$

$$r_y^A = \sqrt{\frac{\left(I_y\right)_{R_1} + \left(I_y\right)_{(R_2+R_4)} + \left(I_y\right)_{R_3}}{ar\left(A\right)}} \tag{14}$$

Fuzzy Number Conjoint Method (FNCM)

This section presents the procedure of the fuzzy number conjoint method (FNCM). The FNCM considers a questionnaire with N attributes, s linguistic values of preferences and V_j ($j = 1, 2, 3, ..s$) denotes as the *j*-th linguistic values of preferences. For $s = 5$, the linguistic values are denoted as V_1, V_2, V_3, V_4 and V_5 which represent values of preferences such as strongly disagree, disagree, undecided, agree and strongly agree respectively.

The procedure of FNCM consists of several steps as follows:

Step 1: Collect respondents' opinion based on *p* linguistic values.

Step 2: Calculate the number of respondents' opinion denotes as f_{ij} whereby f_{ij} represents the number of respondents' opinion for attribute *i* with linguistic values V_j

Step 3: Calculate the weight w_{ij} of attribute *i* with linguistic values V_j as

$$w_{ij} = \frac{f_{ij}}{\sum_j^s f_{ij}} \tag{15}$$

Step 4: Calculate the overall membership function of attribute R_i as

$$R_i = \sum_{j=1}^{s} w_{ij} V_j \quad for \ i = 1, 2, 3...15 \tag{16}$$

Whereby V_j is the *j-th* linguistic value and is R_i in fuzzy numbers conjoint method form.

Step 5: Calculate the degree of similarity between R_i and V_j using the similarity measure from Chutia and Gogoi (2018).

Step 6: Compare the degree of similarity for attribute A_i and select the maximum degree of similarity of attribute A_i.

Step 7: State the linguistic values related to the maximum degree of similarity of attribute A_i

Step 8: Rank the maximum degree of similarity in Step 5 from the most preferred (highest maximum degree of similarity) to the least preferred (lowest maximum degree of similarity).

Fuzzy Number Conjoint Method (FNCM) for Analyzing Students' Achievement Goals

This section describes how the fuzzy number conjoint method was used to analyze students' calculus achievement goals. The method's performance is compared to different similarity measures from Khorshidi and Nikfalazar (2017), Patra and Mondal (2015), and Xu et al. (2010). The students in the Bachelor of Science (Hons) Mathematics and Bachelor of Science (Hons) Actuarial Science programmes at one public university in Klang Valley, Selangor, who participated in this research were given the Achievement Goal Questionnaire, which was adapted from Sundre, Barry, Gynnild, and Ostgard, (2012). The following are the steps in the implementation procedure:

Step 1: The data involves fifteen attributes ($A_1, A_2, A_3..., A_{15}$) with five linguistic values in fuzzy number form (as shown in Table 1 and Table 2 respectively).

Table 1. Students' Attributes and Achievement Goals

Attributes	Achievement goals in calculus
A_1	My goal in this subject is to get better grades than most of the other students.
A_2	I just want to avoid doing poorly compared to other students in this subject.
A_3	Completely mastering the material in this subject is important to me.
A_4	I really want to work hard in this subject.
A_5	I am afraid that I may not understand the content of this subject as thoroughly as I'd like.
A_6	It is important for me to do well compared to other students.
A_7	I want to learn as much as possible in this subject.
A_8	The fear of performing poorly in this subject is what motivating me.
A_9	I want to do as much work as possible in this subject.
A_{10}	The most important thing for me in this subject is to understand the content as thoroughly as possible.
A_{11}	I am worry that I may not learn all that I possible could in this subject.
A_{12}	I want to do better than other students in this subject.
A_{13}	I want to get through this subject by doing at most amount of work possible.
A_{14}	I am definitely concerned that I may not learn all that I can in this subject.
A_{15}	I look forward to working really hard in this subject.

Table 2. Linguistic values and related fuzzy numbers

Linguistic Values, V_j	Fuzzy Numbers
Strongly disagree, V_1	(0,1,2,3)
Disagree, V_2	(1,2,3,4)
Undecided, V_3	(3,4,5,6)
Agree, V_4	(5,6,7,8)
Strongly Agree, V_5	(7,8,9,10)

Step 2: The data of respondents' opinion are given in Table 3, with A_i represents the *i*-th attribute.

Table 3. Frequencies on students' opinion

Attributes	V_1	V_2	V_3	V_4	V_5	Total
A_1	5	5	18	40	39	107
A_2	4	8	10	52	33	107
A_3	2	1	7	59	38	107
A_4	4	1	4	46	52	107
A_5	4	4	17	52	30	107
A_6	5	2	17	59	24	107
A_7	3	2	4	52	46	107
A_8	3	4	14	51	35	107
A_9	3	5	13	64	22	107

A_{10}	2	2	3	57	43	107
A_{11}	3	3	15	59	27	107
A_{12}	4	3	18	51	31	107
A_{13}	2	6	19	52	28	107
A_{14}	1	6	17	57	26	107
A_{15}	1	2	4	61	39	107

Step 3: Based on Eq.15, the weight, w_{ij} of attribute i with linguistic values V_j is given in Table 4.

Table 4. Weight of linguistic values of students' expectation with related attributes

w_{ij}	V_1	V_2	V_3	V_4	V_5
A_1	0.04673	0.04673	0.16822	0.37383	0.36449
A_2	0.03738	0.07477	0.09346	0.48598	0.30841
A_3	0.01869	0.00935	0.06542	0.55140	0.35514
A_4	0.03738	0.00935	0.03738	0.42991	0.48598
A_5	0.03738	0.03738	0.15888	0.48598	0.28037
A_6	0.04673	0.01869	0.15888	0.55140	0.22430
A_7	0.02804	0.01869	0.03738	0.48598	0.42991
A_8	0.02804	0.03738	0.13084	0.47664	0.32710
A_9	0.02804	0.04673	0.12150	0.59813	0.20561
A_{10}	0.01869	0.01869	0.02804	0.53271	0.40187
A_{11}	0.02804	0.02804	0.14019	0.55140	0.25234
A_{12}	0.03738	0.02804	0.16822	0.47664	0.28972
A_{13}	0.01869	0.05607	0.17757	0.48598	0.26168
A_{14}	0.00935	0.05607	0.15888	0.53271	0.24299
A_{15}	0.00935	0.01869	0.03738	0.57009	0.36449

Step 4: Based on Eq. 16, the overall membership function of attribute i, R_i is presented in Table 5.

Table 5. Overall membership for attribute *i*

FN, R_i	Overall membership R_i
R_1	(4.97196,5.97196,6. 97196,7. 97196)
R_2	(4.94393,5.94393,6.94393,7.94393)
R_3	(5.44860,6.44860,7.44860,8.44860)
R_4	(5.67290,6.67290,7.67290,8.67290)
R_5	(4.90654,5.90654,6.90654,7.90654)
R_6	(4.82243,5.82243,6.82243,7.82243)
R_7	(5.57009,6.57009,7.57009,8.57009)
R_8	(5.10280,6.10280,7.10280,8.10280)
R_9	(4.84112,5.84112,6.84112,7.84112)
R_{10}	(5.57944,6.57944,7.57944,8.57944)

R_{11}	(4.97196,5.97196,6.97196,7.97196)
R_{12}	(4.94393,5.94393,6.94393,7.94393)
R_{13}	(4.85047,5.85047,6.85047,7.85047)
R_{14}	(4.89720,5.89720,6.89720,7.89720)
R_{15}	(5.53271,6.53271,7.53271,8.53271)

Step 5 & Step 6: The degree of similarity R_i and V_j using the similarity measure from Chutia and Gogoi (2018) based on Eq. (1) is presented in Table 6. The maximum degree of similarity for each R_i is denoted with " * " in Table 6.

Table 6. Similarity degree between R_i and V_j for students' expectation

	V_1	V_2	V_1	V_2	V_3	V_4	V_5
R_1	0.5291	0.6238	0.2178	0.3184	0.6005	0.9934*	0.6093
R_2	0.5317	0.6264	0.2200	0.3212	0.6050	0.9868*	0.6048
R_3	0.4839	0.5786	0.1834	0.2732	0.5281	0.8989*	0.6902
R_4	0.4627	0.5574	0.1685	0.2537	0.4966	0.8518*	0.7306
R_5	0.5353	0.6300	0.2229	0.3250	0.6110	0.9781*	0.5987
R_6	0.5432	0.6379	0.2295	0.3337	0.6248	0.9586*	0.5853
R_7	0.4724	0.5671	0.1752	0.2625	0.5109	0.8731*	0.7119
R_8	0.5167	0.6114	0.2080	0.3055	0.57989	0.9760*	0.6309
R_9	0.5414	0.6361	0.2280	0.3317	0.6217	0.9629*	0.5883
R_{10}	0.4715	0.5662	0.1746	0.2617	0.5096	0.8712*	0.7136
R_{11}	0.5291	0.6238	0.2178	0.3184	0.6005	0.9934*	0.6093
R_{12}	0.5317	0.6264	0.2200	0.3212	0.6050	0.9868*	0.6048
R_{13}	0.5406	0.6353	0.2273	0.3307	0.6202	0.9651*	0.5897
R_{14}	0.5361	0.6309	0.2236	0.3260	0.6126	0.9759*	0.5972
R_{15}	0.4759	0.5707	0.1777	0.2658	0.5161	0.8810*	0.7052

*denotes highest similarity degree

Step 7 & Step 8: The highest degree of similarity of each attribute *i* and its linguistic value is shown in Table 7.

Table 7. The highest degree of similarity and ranking for each attribute

Attributes, A_i	**Highest similarity degree**	**Linguistic value**	**Ranking**
A_1	0.9934	Agree, V_4	1
A_2	0.9868	Agree, V_4	3
A_3	0.8989	Agree, V_4	11
A_4	0.8518	Agree, V_4	15
A_5	0.9781	Agree, V_4	5
A_6	0.9586	Agree, V_4	10
A_7	0.8731	Agree, V_4	13
A_8	0.9760	Agree, V_4	6
A_9	0.9629	Agree, V_4	9

A_{10}	0.8712	Agree, V_4	14
A_{11}	0.9934	Agree, V_4	1
A_{12}	0.9868	Agree, V_4	3
A_{13}	0.9651	Agree, V_4	8
A_{14}	0.9759	Agree, V_4	7
A_{15}	0.8810	Agree, V_4	12

RESULTS AND DISCUSSION

Results of Undergraduates' Achievement Goals in Calculus

From Table 7, the result obtained shows the ranking of the undergraduates of mathematics and actuarial science achievement goals in calculus. The undergraduates worry that they may not learn all that they possibly could in this subject (A_{11}) with 0.9934 degree of agreement, undergraduates' goal in this subject is to get better grades than most of the other students (A_1) at 0.9934 degree of agreement, undergraduates want to do better than other students in this subject (A_{12}) with 0.9868 degree of agreement, undergraduates want to avoid doing poorly compared to other students in this subject (A_2) at 0.9868 degree of agreement, undergraduates are afraid that they may not understand the content of this subject as thoroughly as they would (A_5) with 0.9781 degree of agreement, the fear of performing poorly in this subject is what motivating them (A_8) with 0.9760 degree of agreement, undergraduates are definitely concerned that they may not learn all that they can in this subject (A_{14}) with 0.9759 degree of agreement, undergraduates want to get through this subject by doing at most amount of work possible (A_{13}) with 0.9651 degree of agreement, undergraduates want to do as much work as possible in this subject (A_{19}) with 0.9629 degree of agreement, it is important for undergraduates to do well compared to other students (A_6) with 0.9586 degree of agreement, undergraduates completely mastering the material in this subject is important to them (A_3) at 0.8989 degree of agreement, undergraduates look forward to working really hard in this subject (A_{15}) with 0.8810 degree of agreement, undergraduates want to learn as much as possible in this subject (A_7) with 0.8731 degree of agreement, the most important thing for undergraduates in this subject is to understand the content as thoroughly as possible (A_{10}) with 0.8712 degree of agreement, and undergraduates really want to work hard in this subject (A_4) with 0.8518 degree of agreement. Thus, undergraduates agreed with the attributes with ranking

$$A_{11} \approx A_1 \succ A_2 \approx A_{12} \succ A_5 \succ A_8 \succ A_{14} \succ A_{13} \succ A_9 \succ A_6 \succ A_3 \succ A_{15} \succ A_7 \succ A_{10} \succ A_4 .$$

From the ranking, it shows that undergraduates are worried that they might not be able to learn all they could in this subject. In other words, they are afraid that they do not have much time to learn calculus. Their achievement goals are to get better results and better performance in calculus. Since the question about comparing to other students ranks at the top, it can be concluded that most mathematics and actuarial science students are competitive to achieve their goals as they want to get better results.

Comparison of Results with Different Similarity Measures

This section compares the findings with Khorshidi and Nikfalazar (2017), and Patra and Mondal (2015). Table 8 compares the maximum similarity degree and ranking for undergraduates' achievement goals level for each similarity degree.

Table 8. Comparison of preference level and ranking with other similarity measures

Attributes, A_i	**Patra & Mondal (2015)**			**Khorshidi & Nikfalazar (2017)**			**Chutia & Gogoi (2018)**		
	Highest SD	**Linguistic terms**	**Rank**	**Highest SD**	**Linguistic terms**	**Rank**	**Highest SD**	**Linguistic terms**	**Rank**
A_1	0.9972	Agree	1	0.9973	Agree	1	2	Agree	1
A_2	0.9944	Agree	3	0.9947	Agree	3	0.9868	Agree	3
A_3	0.9551	Agree	11	0.9575	Agree	11	0.8989	Agree	11
A_4	0.9327	Agree	15	0.9363	Agree	15	0.8518	Agree	15
A_5	0.9907	Agree	5	0.9912	Agree	5	0.9781	Agree	5
A_6	0.9822	Agree	10	0.9832	Agree	10	0.9586	Agree	10
A_7	0.9430	Agree	13	0.9460	Agree	13	0.8731	Agree	13
A_8	0.9897	Agree	6	0.9903	Agree	6	0.9760	Agree	6
A_9	0.9841	Agree	9	0.9850	Agree	9	0.9629	Agree	9
A_{10}	0.9421	Agree	14	0.9451	Agree	14	0.8712	Agree	14
A_{11}	0.9972	Agree	1	0.9973	Agree	1	0.9934	Agree	1
A_{12}	0.9944	Agree	3	0.9947	Agree	3	0.9868	Agree	3
A_{13}	0.9851	Agree	8	0.9858	Agree	8	0.9651	Agree	8
A_{14}	0.98972	Agree	6	0.99026	Agree	6	0.97590	Agree	7
A_{15}	0.94673	Agree	12	0.94954	Agree	12	0.88100	Agree	12

The degree of similarity based on studies from Patra and Mondal (2015) and Khorshidi and Nikfalazar (2017) give almost the same category of ranking with the proposed FNCM except for attributes A_8 and A_{14}. Both methods produce the ranking as $A_{11} \approx A_1 \succ A_2 \approx A_{12} \succ A_5 \succ A_8 \approx A_{14} \succ A_{13} \succ A_9 \succ A_6 \succ A_3 \succ A_{15} \succ A_7 \succ A_{10} \succ A_4$. A_8 and A_{14} are ranked equally ($A_8 \approx A_{14}$) although their related fuzzy numbers are not the same. However, the proposed FNCM ranked A_8 higher than A_{14} ($A_8 \succ A_{14}$) with ranking as $A_{11} \approx A_1 \succ A_2 \approx A_{12} \succ A_5 \succ A_8 \succ A_{14} \succ A_{13} \succ A_9 \succ A_6 \succ A_3 \succ A_{15} \succ A_7 \succ A_{10} \succ A_4$. According to the proposed FNCM, undergraduates ranked their fear of performing poorly in this subject (ranked A_8) higher than not learning everything possible in this subject (ranked A_{14}). While the degree of similarity between Patra and Mondal (2015) and Khorshidi and Nikfalazar (2017) is insufficient to distinguish them, their fear of performing poorly in this subject (ranked A_8), and they are certain that they will not learn everything possible in this subject (ranked A_{14}).

CONCLUSION

A fuzzy numbers conjoint method (FNCM) was used in this paper to identify undergraduates' achievement goals. Fuzzy conjoint analysis, which is based on fuzzy numbers, has demonstrated its benefits in identifying factors that are strongly agreed to strongly disagreed in the form of level of agreement based on the highest similarity value. Based on the results, the ranking for FNCM is $A_{11} \approx A_1 \succ A_2 \approx A_{12} \succ A_5 \succ A_8 \succ A_{14} \succ A_{13} \succ A_9 \succ A_6 \succ A_3 \succ A_{15} \succ A_7 \succ A_{10} \succ A_4$. The findings can be used by educators to improve their teaching methods for mathematics and actuarial science students. The importance of incorporating course and programme level goals should not be overlooked. The results of using a fuzzy numbers conjoint method in calculus studies could be investigated, and the results could be more useful and meaningful. Future researchers should consider using interval-valued fuzzy numbers to represent the level of undergraduates' calculus achievement goals. From an educator's perspective, the results can be used to improve their teaching methods for mathematics and actuarial science students. The involvement of course and programme level goals should not be neglected. The results with the application of a fuzzy numbers conjoint method in the calculus studies could be explored and perhaps be more useful and give a more meaningful result.

Acknowledgement
We would like to give our gratitude and thanks to Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA (UiTM) for funding grant.

REFERENCES

Abdullah, L., & Osman, A. (2011). Fuzzy Set Conjoint Model in describing students' perceptions on Computer Algebra System learning environment. *International Journal of Computer Science Issues*, *8*(2), 92–97.

Ames, C. A. (1990). Motivation: What teachers need to know. *Teachers College Record*, *91*(3), 409–421.

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.

Cross, V. V., & Sudkamp, T. A. (2002). *Similarity and compatibility in Fuzzy Set Theory* (Vol. 93). Springer.

Chutia, R., & Gogoi, M. K. (2018). Fuzzy risk analysis in poultry farming using a new similarity measure on generalized fuzzy numbers. *Computers & Industrial Engineering*, *115*, 543-558.

Dom, R. M., Hasan, H., Shahidin, A. M., & Apandi, N. A. (2019). Fuzzy TOPSIS ranking of academic programs' competitiveness. *International Journal of Academic Research in Business and Social Sciences, 9*(13), 319–328.

Gao, S., Zhang, Z., & Cao, C. (2009). Multiplication operation on fuzzy numbers. *Journal of Software, 4*(4), 331-338.

Gopal, K., Salim, N., & Ayub, A.F, M. (2019). Perceptions of learning Mathematics among Lower Secondary Students in Malaysia: Study on students' engagement using Fuzzy Conjoint Analysis. *Malaysian Journal of Mathematical Sciences*, *13*(2), 165.

Khorshidi, H. A., & Nikfalazar, S. (2017). An improved similarity measure for generalized fuzzy numbers and its application to fuzzy risk analysis. *Applied Soft Computing Journal*, *52*, 478–486.

Lazim, M. A., & Abu Osman, M. T. (2009). Measuring teachers' beliefs about mathematics: A fuzzy set approach. *World Academy of Science, Engineering and Technology 33*, 1098–1102.

Liang, Su. (2009). Validating the instrument: Students' perceptions on learning Calculus. *NERA Conference Proceedings,* 21.

Osman, R., Hilmi, Z.A.G., Ramli,N., & Abdullah, N.H.M.(2020). Metaphors and images of mathematics among secondary school students. *Academic Science Journal, 13,*1-7.

Sarala, N., & Kavitha, R. (2017). Fuzzy conjoint model in measuring students' expectation and teachers' belief on learning mathematics. *International Journal of Advanced Trends in Engineering, Science and Technology*, *2*(2), 6–10.

Sulaiman, N. S., Mohammad, D., Mohd Shariff, J., Sayed Ahmad, S. A.& Abdullah, K. (2017). Extended FTOPSIS with Distance and set Theoretic–Based Similarity Measure. *Indonesian Journal of Electrical Engineering and Computer Science, 9*(2), 387-394.

Sundre, D., Barry, C., Gynnild, V., & Ostgard, E. T. (2012). Motivation for achievement and attitudes toward mathematics instruction in a required Calculus Course at the Norwegian University of Science and Technology. *Numeracy, 5*(1), 1-18.

Suparlan, A., Shohaimay, F., Haron, N, Zainal Abidin, S., Dasman, A., & Mokhtar@Mother, M. (2019). Evaluation of students' perceptions of game-based mathematics classroom using fuzzy conjoint analysis. *Gading Journal of Science and Technology*, *2*(2), 54–63.

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: Conference Series, 1366*, 012117.

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 Journal*, *28*, 276–284.

Ramli, N., & Mohamad, D. (2009). A centroid-based performance evaluation using aggregated fuzzy numbers. *Applied Mathematical Sciences*, *3*(48), 2369-2381.

Wang, W. (1997). New similarity measures on fuzzy sets and on elements. *Fuzzy Sets and Systems, 85*(3), 305-309.

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.