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Perceptions of Learning Mathematics among Lower Secondary Students in Malaysia: Study on Students' Engagement using Fuzzy Conjoint Analysis

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ABSTRACT

As Malaysia strives to embrace the Data Science & Big Data revolution, the need to produce graduates with higher mathematics competence grows accordingly. However, the nation's vision may face a threat due to the declining interest to learn mathematics among the younger generations. Although initiatives like STEM was undertaken to face this issue, the success rate was relatively low. Ultimately, the key driver of mathematics learning is students' interest; which can be described using their perceptions of learning mathematics. Accordingly, this paper evaluated the perceptions of learning mathematics among lower secondary school students in Malaysia. A descriptive survey study was conducted on 562 randomly selected students across Peninsular Malaysia. The instrument consisted of 54 attributes encompassing 3 constructs of classroom engagement. Ratings on attributes were analysed using Fuzzy Conjoint Analysis to identify the significant attributes and their influence. The most significant attribute indicated that students tried multiple times if they were unable to tackle a given problem. The least significant attribute revealed that students were always afraid of getting poor results in mathematics tests. Results attested that students had varying perceptions, however, their overall perceptions of learning mathematics were positive. Negative and neutral perceptions mainly existed for affective engagement, particularly for students' anxiety and frustration in learning mathematics. This provides important information for education stakeholders to improve the affective component of engagement. In a nutshell, this study served as an initial attempt to investigate students' perceptions of learning mathematics with respect to their classroom engagement.

Keywords: perceptions, mathematics learning, engagement, fuzzy conjoint analysis.

1. Introduction

As one of the developing countries, Malaysia continues to strive to be on par with other global nations in shaping up towards the Big Data & Data Science revolution. As grandiose as it could sound, the biggest challenge for the nation lies in the context of preparedness (or readiness) to sustain its' role in the global data-driven agenda. Thus, the country should produce more scientists especially data scientist, data analyst, data engineer and etc. in the near future. Accordingly, scientific and technical skills particularly in mathematics, statistics and computer science are utmost important for future aspiring professionals to face the challenges in the data-centric ecosystem. Hence, it is vital to instil these skills on the younger generations as early as possible, taking into account the fast rising digital age. Secondary schools can be a possible and promising platform to accomplish this requirement.

However, the local education's status quo has been facing a critical issue that could possibly pose a threat to the country's vision in this regard. Currently, majority of the upper secondary students were strongly declined in their interest to learn science, in particular mathematics (Ghagar et al., 2011, Meng et al., 2014, 2013, Mohammadpour, 2012, Nasir et al., 2017, Singh et al., 2018, Talib et al., 2009, Zakaria et al., 2010). This was evidenced by fewer numbers of students enrolling in the science stream each year (Fadzil and Saat, 2014, Ghagar et al., 2011, Meng et al., 2014, 2013, Mohammadpour, 2012, Nasir et al., 2017, Singh et al., 2018). Zakaria et al. (2010) stated that being a compulsory subject, students' interest to learn mathematics could have started to decline at the lower secondary level itself. In line with this issue, the government advocated initiatives such as Science, Engineering, Technology & Mathematics (STEM) education and Higher Order Thinking Skills (HOTS) for inducing students to excel in mathematics at the primary level and to incline towards learning mathematics at the secondary level (Jayarajah et al., 2014, Rosli, 2016, Thien and Ong, 2015). However, the success rate of these initiatives was relatively low. This was evidenced by the fairly poor achievement of Malaysia in Trends in International Mathematics and Science Study (TIMSS) assessment and Programme for International Student Assessment (PISA) (Abdullah et al., 2014, Bahrum et al., 2017, Fadzil and Saat, 2014, Jayarajah et al., 2014, Meng et al., 2014, 2013, Rosli, 2016, Thien and Ong, 2015). Moreover, Malaysia had also recorded the steepest decline in TIMSS as reported in Meisenberg and Woodley (2013). As such, the real challenge in tackling this issue inheres in instilling students' interest to learn mathematics, regardless of the education level (Ghagar et al., 2011, Meng et al., 2014, 2013, Mohammadpour, 2012, Nasir et al., 2017, Singh et al., 2018). Mutodi and Ngirande (2014) stated that perceptions are related to students' associations, beliefs, attitudes, feelings, and emotions about mathematics. Thus, it can be suggested that students' perceptions of learning mathematics can be used for deriving their interest to learn mathematics, which is vague and indeterminate directly. These perceptions are evaluated based on factors that influence students' interest to learn mathematics.

Several factors (from both cognitive and affective aspects of learning) influence students' interest to learn mathematics such as instruction method, beliefs, expectations, attitudes towards mathematics, motivation and engagement, to name a few (Bryson and Hand, 2007, Lee, 2014). Of these identified factors, students' engagement play a key role in cultivating their interest (Fredricks et al., 2004, Lee, 2014). Studying students' interest through their mathematics classroom engagement clearly indicates students' interest, as they will be more engaged in their learning if their interest is high and otherwise. Fredricks et al. (2004, 2016) asserted that one will develop interest towards a particular subject if they can appreciate what they are learning. When students do not see the value of mathematics i.e. application of mathematics in real life beyond textbook problems, they tend to feel that mathematics is irrelevant and does not lead to anywhere for their future undertakings (Bryson and Hand, 2007, Fredricks and McColskey, 2012). Eventually, students will start to develop hatred towards mathematics. Although it is not straightforward to make students to appreciate mathematics, one suggested way to achieve this is by motivating students to engage in their classroom learning (Fredricks et al., 2004, Pekrun and Linnenbrink-Garcia, 2012). Thus, being engaged provides an opportunity for students to see the values and usefulness of mathematics in a wider perspective.

Students' engagement is the quality of students' efforts involved in learning of mathematics that play an important part for obtaining desired outcomes from the learning process (Finn and Zimmer, 2012, Fredricks et al., 2016). It is a multi-faceted construct involving students' emotion, behaviour and cognition aspects pertinent to mathematics and identified through three main constructs viz. affective engagement, cognitive engagement and behavioural engagement (Eccles and Wang, 2012). As the concept of engagement is dynamic, it becomes vital to explore it in a multidimensional approach (Cirica and Jovanovicb, 2016). The most common theoretical model of engagement consists of the aforementioned constructs, in line with the multiple definitions of engagement (Wang et al., 2016). According to Veiga (2016), it is essential for engagement to be multidimensional in relevance to school settings.

Engagement holds a significant relationship with students' achievement, performance, learning outcomes, resilience, attainment and their attendance, adherence and retention in mathematics classroom (Fredricks et al., 2016, Shernoff et al., 2016). Engagement can also be referred as students' psychological approach leading to learning and understanding process, as well as in deepening knowledge, skills or capability (Eccles and Wang, 2012, Pekrun and Linnenbrink-Garcia, 2012). Lam et al. (2014), Wang and Holcombe (2010) stated that engagement is not merely commitment, involvement or participation but it entails students' feelings and emotions in the learning process. Actions without feelings are simply involvement for the sake of rules, and to feel engaged without the proper actions is not real engagement (Lam et al., 2014).

Affective engagement comprises students' favourable or unfavourable reactions towards instructors and peers (Finn and Zimmer, 2012). At the school level, it is the belief and emotions experienced through students' actions leading to interest, worries, boredom, excitement, achievement orientation, disappointment, interaction with teacher and peers, and sense of belonging among them (Dotterer and Lowe, 2011, Shernoff et al., 2016). Cognitive engagement encompasses students' willpower beyond the common level to master advanced skills in mathematics (Fredricks and McColskey, 2012). Finn and Zimmer (2012) identified cognitive competence as the benchmark of education psychology investment, the desire to accomplish something beyond normal and the yearning to face challenges and hurdles. This includes students' problem solving ability and willpower. The difference in students' cognitive engagement is their learning techniques such as memorising basic concepts using deeper strategies like integration and justification (Lee, 2014, Pekrun and Linnenbrink-Garcia, 2012). In short, cognitive engagement can be considered as the way students obtain, keep, access and to make use of information to solve mathematical problems. Behavioural engagement involves students' participation in mathematics learning tasks; and favourable conduct and positive behaviours in the learning process (Dotterer and Lowe, 2011). Fredricks et al. (2016), Lam et al. (2012) divided behavioural engagement into three aspects. The first aspect is positive attitude, where students adhere to the existing rules such as committing to attend and participate in assignments or activities without avoiding. The second is measurement on their willpower, persistence, alertness, attention and effective communication. Involvement in learning process ensures students to stay focused throughout their classroom learning. The third aspect is the school's commitment, recognised through students' participation to represent their schools in any mathematics related activities, such as mathematics quiz (Shernoff et al., 2016).

According to Azina and Halimah (2012), Ismail et al. (2014), Thien and Darmawan (2016), Thien and Ong (2015), Malaysian students' enjoyed learning mathematics and understood the importance of mathematics, however, it was reported that unfavourable dispositions (such as low mathematics self-efficacy and high levels of anxiety and stress in learning mathematics) were widespread and led to low mathematics achievement. In accordance with that, students' performance is known to be directly affected by aforementioned such dispositions, which is an obvious aftermath of their classroom engagement (Azina and Halimah, 2012, Elias et al., 2010, Ismail et al., 2014, Tarmizi and Tarmizi, 2010, Thien et al., 2015, Thien and Darmawan, 2016, Ting and Tarmizi, 2016). Nevertheless, these previous studies did not pay much attention to how students perceived their mathematics learning in classroom (*perceptions based on classroom engagement*) so as to how it would affect their interest and performance in mathematics.

In view of the above discussion and in addressing the research gap with respect to perceptions, the objective of this paper is to evaluate the perceptions of learning mathematics among lower secondary school students in Malaysia. Students' perceptions are evaluated based on their mathematics classroom engagement using Fuzzy Conjoint Analysis (FCA). As the higher level of mathematics (more real world applications of mathematics are supposed to be prevalent) is first exposed to the secondary level curriculum in Malaysia, it is apt to study the perceptions of learning mathematics among lower secondary students.

2. Methodology

2.1 Research Design and Sample

This study employed a descriptive survey design. The sample comprised 562 randomly selected lower secondary students from 17 government secondary schools across Peninsular Malaysia. This study was conducted during a mathematics summer camp attended by these students hailing from 4 school in northern, 6 in central, 4 from southern, and 3 from east coast region. There were 288 male and 274 female students. The demographic details are given in Table 1.

2.2 Instrumentation

Questionnaire of this study was adapted as it is from the validated *Student Engagement in the Mathematics Classroom* instrument developed by Kong et al. (2003). This instrument was established by identifying the possible constructs using qualitative methods of classroom observation and student interviews and was tested for validation by confirmatory factor analysis. Based on the descriptors used in the interviews, the dimensions of each construct were identified (see Table 2) Kong et al. (2003).

Table 1: Demographics

		Gender		Total
Region	Number of Schools	Male	Female	
Northern	4	80	63	143
Central	6	95	87	182
Southern	4	70	68	136
East Coast	3	56	45	101
Total	17	288	274	562

Table 2: Dimensions of engagement constructs

Affective engagement	Cognitive engagement	Behavioural engagement
Interest	Surface strategy	Attentiveness
Achievement orientation	Deep strategy	Diligence
Anxiety	Reliance	
Frustration		

The instrument consisted of 54 attributes pertaining to students' engagement in mathematics classroom, with 22 attributes corresponding to affective engagement construct, 20 attributes for cognitive engagement and 12 attributes for behavioural engagement construct. The attributes for each construct were constructed using the phrases, and wordings available in the interview transcripts; and adapted from several well established instrument (Kong et al., 2003). The final instrument resulted from series of pilot-tests, follow-up interviews and revisions; and thus, the number of attributes for each construct ended up being not similar, as they were also based on the number of dimensions within (Kong et al., 2003). Example of attributes are given in Tables 3, 4, and 5 for each construct respectively.

Students rated the attributes with a 5-point Likert scale corresponding to the linguistics variables of agreement, L. The scale represents the linguistic terms of strongly disagree (1), disagree (2), neutral (3), agree (4) and strongly agree (5). The reliability index, Cronbach's alpha evaluated by Kong et al. (2003) was 0.85 for affective engagement, 0.83 for cognitive engagement, and 0.84 for behavioural engagement, indicating a high degree of internal consistency of the items in the instrument. Collected ratings were then analysed using FCA for each constructs individually.

Table 3: Example of attributes of affective engagement (AE)

Dimension	Attribute
Interest	I feel a sense of satisfaction when I do mathematics exercises in class.
Achievement orientation	Learning mathematics is tough, but I am happy as long as I can good results.
Anxiety	I am worried in mathematics examinations.
Frustration	I dislike doing mathematics.

Table 4: Example of attributes of cognitive engagement (CE)

Dimension	Attribute
Surface strategy	I find memorising formulas is the best way to learn mathematics.
Deep strategy	I would use my spare time to study the topics we have discussed in class.
Reliance	I would learn what the teacher teaches.

Table 5: Example of attributes of behaviour engagement (BE)

Dimension	Attribute
Attentiveness	I really make an effort in the mathematics lesson.
Diligence	For difficult problems, I would study hard until I understand them.

2.3 Fuzzy Conjoint Analysis (FCA)

Fuzzy sets are able to represent the vagueness and subjective nature of human perceptions (in terms of preference or agreement) (Zimmermann, 2001). Linguistic variables are non-numerical valued variables (words or sentences in natural language) used to describe preferences (or agreement) on a particular subject of interest (Turksen and Willson, 1994). Fuzzy sets approach provides a way to deal with the unclear boundaries and uncertainty inherent in linguistic variables such as *agree* or *average*, which may not be achievable using conventional metrics (Abiyev et al., 2016). For instance, in this study, a students' rating of 2 (*disagree*) on an attribute does not clearly reflect how much does the student truly disagrees for that attribute. Such fuzziness are handled by transforming the rating of perception into degree of similarity to obtain numerical value that represent the strength of agreement on each attribute (Sarala and Kavitha, 2017).

As preference (or agreement) forms the basis of conventional conjoint analysis, it is appropriate to adapt a fuzzy set preference model to this situation (Sofian and Rambely, 2018). A fuzzy preference model was developed to represent the linguistic ratings (ratings on linguistic variables) in a vector preference model (Turksen and Willson, 1995). This preference model requires a fuzzy membership function for each of the linguistic rating on the measurement (Likert) scale. Accordingly, a fuzzified vector conjoint model known as fuzzy conjoint model (as shown in Equation 1) was developed by Turksen and Willson (1994), as an extended conjoint model based on fuzzy sets.

The hierarchical structure of respondents' ratings against the attributes are represented by the fuzzy set definition for the linguistic term applicable to each rating (e.g.: *agree* for 4), instead of the numbers corresponding to each rating (viz. 1 to 5) (Abiyev et al., 2016, Sarala and Kavitha, 2017). These fuzzy sets are essentially linear combinations of the attribute weights. The standard fuzzy sets F defined for rating on each attribute serve as the input to fuzzy conjoint model (Sofian and Rambely, 2018). The approximate degree of membership for each domain element (linguistic label), y_j in the calculated overall preference set R, $\mu_R(y_j, A_m)$ for a particular attribute A_m is defined as (Turksen and Willson, 1995):

$$\mu_R(y_j, A_m) = \sum_{i=1}^{j} W_{(r_i, A_m)} \cdot \mu_{F_i}(x_j) \tag{1}$$

where:

- y_j and x_j are domain elements, with j as the number of linguistics terms, $j = 1, 2, \ldots, 5$
- A_m is a particular attribute with m is the number of attributes, $m = 1, 2, \ldots, d$ where $d = 22$ for affective engagement, $d = 20$ for cognitive engagement and $d = 12$ for behavioural engagement
- $\mu_{F_i}(x_j)$ is the membership value of the respondent's linguistic rating F_i at given linguistic level x_j (elements of the standard fuzzy set F at x_j)
- $W_{(r_i,A_m)}$ is the fuzzified weight for linguistic rating r_i corresponding to attribute A_m and $W_{(r_i,A_m)} = \dfrac{\sum r_i}{\sum_{k=1}^{j} r_{(k,A_m)}}$ with $\sum r_i$ being the sum of the particular rating r throughout the respondents for attribute A_m and $\sum_{k=1}^{j} r_{(k,A_m)}$ is the sum of all the ratings throughout the attribute A_m

For instance, the membership degree of the domain element *agree* in the overall calculated fuzzy set R is the weighted sum of the membership of the domain element *agree* in each of the attribute evaluation sets. The crisp rating weight r_i is a directly obtained respondents' rating of the attribute's agreement from 1 to 5. An overall fuzzy membership value, $\mu_R \in [0, 1]$ is the final output of fuzzy conjoint model (Turksen and Willson, 1994).

The membership (linguistics) values for each linguistic variable (term) $\mu_{F_i}(x_j)$ are obtained using the triangular membership function with fixed parameters defined in the seminal works by Zadeh for fuzzy set theory (Zimmermann, 2001). The five linguistics variables, L of this study are anchored to the measurement scale (5-point Likert scale) levels. The fuzzy sets representing the linguistics values (degree of agreement) for the linguistics variables are given as:

$$
\begin{aligned}
F_1 &= (0.50/1, 1.00/2, 0.75/3, 0.25/4, 0.00/5)\\
F_2 &= (0.50/1, 1.00/2, 0.75/3, 0.25/4, 0.00/5)\\
F_3 &= (0.00/1, 0.50/2, 1.00/3, 0.50/4, 0.00/5)\\
F_4 &= (0.00/1, 0.25/2, 0.75/3, 1.00/4, 0.50/5)\\
F_5 &= (0.00/1, 0.00/2, 0.50/3, 0.75/4, 1.00/5)
\end{aligned}
$$

that correspond to the linguistic values $L = (L_1, L_2, L_3, L_4, L_5)$ or the equivalent terms, $L =$ (*Strongly disagree, Disagree, Neutral, Agree, Strongly agree*). Note that, in the fuzzy sets F, x/y means x at level y. For example, in F_4 that corresponds to L_4, the final element of the set (0.50/5) means the compatibility of rating 5 with *strongly agree* (L_4) is 0.50.

In FCA, a fuzzy similarity measure is used to compute the sum of the Euclidean distance between corresponding elements in the calculated fuzzy set R and standard fuzzy set F. The similarity degree s between the elements of fuzzy sets R and F for a particular attribute A_m is given as (Turksen and Willson, 1995):

$$
s_j(R,F) = \frac{1}{1+\sqrt{\sum_{i=1}^{j}[\mu_R(y_j) - \mu_F(y_j, L_i)]^2}} \tag{2}
$$

where:

- $\mu_F(y_j, L_i)$ is the elements of the standard fuzzy set corresponding to linguistic term L_i (respondent's actual overall evaluation) and with j as the number of linguistic terms, $j = 1, 2, \ldots, 5$
- $\mu_R(y_j)$ is the calculated membership degree using respondents ratings for attributes from Equation 1

Similarity degrees, $s \in [0, 1]$ provide ordinal information (rank), used to determine the importance of attributes (Sofian and Rambely, 2018). The final outcome of FCA is determined based on the maximum similarity degree, s^{max}

according to the attributes (Turksen and Willson, 1994). The preference level for each attribute is derived by obtaining the s^{max}. For example if an attribute, A_1 has the following s values corresponding to each linguistic rating, L (0.1 for L_1, 0.2 for L_2, 0.8 for L_3, 0.7 for L_4 and 0.5 for L_5), then the s^{max} is obviously 0.8 which corresponds to the linguistic rating *unsure* (L_3). This s^{max} value would represent the attribute in the overall ranking. The nature of perception (positive, neutral or negative) for a particular attribute is elicited using the linguistic term that corresponds to s^{max}. Perceptions' nature depends on the attribute's meaning and the linguistic value that corresponds to the s^{max} of that attribute. For example, an attribute A_2 that says *I like mathematics* (students' interest) with the s^{max} of A_2 obtained for linguistic value L. If $L = L_4$ or L_5 (i.e. *agree* or *strongly agree*), it means most of the students agree that they like mathematics, hence deriving a positive perception. However if $L = L_3$ (i.e. *neutral*), it means that students neither like nor dislike mathematics, deriving a neutral perception. Negative perception is derived if $L = L_1$ or L_2 (i.e. *strongly disagree* or *disagree*) in which most students disagree that they like mathematics i.e. they dislike mathematics.

Upon obtaining individual s^{max} values, the attributes are ranked in descending order of s^{max}. Attribute with the highest s^{max} (rank = 1) is the most significant (important) attribute that influenced respondents' perceptions and otherwise. However, attributes with lower s^{max} (i.e. rank > 1) are no less important and useful to infer on the agreement level for the particular attributes, as well as to describe respondents' perceptions (Abiyev et al., 2016). As a matter of fact, the magnitude of s^{max} varies the attribute's significance, where if $s^{max} \to 1$, it is more significant; while if $s^{max} \to 0$, it is less significant. Significance in this context measures how influential an attribute was in drawing respondents' perceptions (Sarala and Kavitha, 2017). The flow of FCA is summarised in Figure 1 (Sofian and Rambely, 2018).

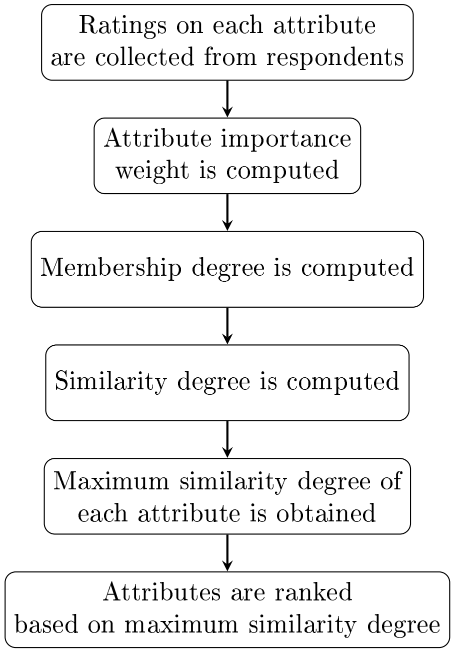

Figure 1: Flow of FCA

3. Results and Discussion

3.1 Affective Engagement

Based on Table 6, the first significant affective engagement's attribute ($s = 0.815373$, $rating = agree$ (L_4)) was AE3, which revealed that students had satisfaction in doing their mathematics exercise, corresponding to the interest dimension. The second significant attribute, AE1 ($s =0.811868$, $rating = agree$ (L_4)) depicted that students find mathematics knowledge interesting and mathematics learning enjoyable in the classroom (interest). The third significant attribute, AE12 ($s = 0.811587$, $rating = strongly\ agree$ (L_5)) disclosed that students were satisfied when they get good results, despite mathematics being a tough subject, reflecting students' achievement orientation. Highest rating was on the linguistic value *agree* (L_4) for most of the remaining attributes. This contributed to positive perceptions. Thus, it can be inferred that students' perceptions were generally positive with respect to these attributes. Furthermore, students' affective engagement was mainly influenced by their interest and achievement orientation in mathematics learning. Neutral perceptions were found on attributes relating to students' anxiety encountered during mathematics tests.

The existence of negative perceptions was clearly inevitable. This can be evidenced by the least significant attribute, AE16 (s =0.699928, *rating* = *disagree* (L_2)) which indicated that students were always afraid of getting poor results in mathematics tests. Besides that, the second least significant attribute, AE17 (s = 0.729036, *rating* = *neutral* (L_3)) showed that students' anxiety level was instable when facing unsolvable problems during tests. The third least significant attribute, AE13 (s = 0.729921, *rating* = *neutral* (L_3)) revealed that students had varying nervousness during mathematics test. These three attributes were clearly corresponding to the anxiety dimension. Referring to students' agreement level towards these attributes, anxiety of mathematics and frustration developed during mathematics tests were identified as the primary source of students' negative perceptions in the context of affective engagement.

Table 6: Similarity degree between fuzzy sets R and F for affective engagement (AE) attributes

Attribute	L_1	L_2	L_3	L_4	L_5	s^{max}	$L(s^{max})$	Rank
AE1	0.397859	0.448948	0.562385	0.811869	0.663569	0.811869	L_4	2
AE2	0.395969	0.445557	0.555792	0.808825	0.672270	0.808825	L_4	6
AE3	0.397677	0.448835	0.562362	0.815373	0.662485	0.815373	L_4	1
AE4	0.396731	0.446832	0.558089	0.808988	0.669525	0.808988	L_4	5
AE5	0.397938	0.448657	0.561521	0.807907	0.665813	0.807907	L_4	7
AE6	0.395263	0.444341	0.553195	0.809109	0.675115	0.809109	L_4	4
AE7	0.382274	0.421670	0.510470	0.750179	0.748880	0.750179	L_4	17
AE8	0.394705	0.439184	0.536463	0.767836	0.709121	0.767836	L_4	13
AE9	0.381075	0.418190	0.503305	0.723590	0.775057	0.775057	L_5	12
AE10	0.383929	0.424015	0.514528	0.752032	0.744099	0.752032	L_4	16
AE11	0.386463	0.428237	0.521798	0.764513	0.729313	0.764513	L_4	14
AE12	0.376009	0.409868	0.488627	0.698083	0.811587	0.811587	L_5	3
AE13	0.479151	0.588161	0.729921	0.621851	0.500507	0.729921	L_3	20
AE14	0.501719	0.631638	0.742396	0.577070	0.471812	0.742396	L_3	18
AE15	0.492645	0.617265	0.752426	0.588708	0.477449	0.752426	L_3	15
AE16	0.554424	0.699928	0.669989	0.528259	0.449580	0.699928	L_2	22
AE17	0.510068	0.645196	0.729036	0.568251	0.467214	0.729036	L_3	21
AE18	0.418157	0.481196	0.614043	0.782411	0.607293	0.782411	L_4	11
AE19	0.397918	0.446643	0.553061	0.795091	0.679301	0.795091	L_4	8
AE20	0.393423	0.434697	0.525899	0.737388	0.734667	0.737388	L_4	19
AE21	0.413436	0.471736	0.594784	0.785704	0.628846	0.785704	L_4	10
AE22	0.405285	0.457378	0.569100	0.789742	0.659803	0.789742	L_4	9

3.2 Cognitive Engagement

As seen in Table 7, the most prominent cognitive engagement's attribute was CE11 (s = 0.828598, *rating* = *agree* (L_4)). This showed that students tried to connect what they have learned in mathematics with what they have encountered in real life or in other subjects, reflecting students' deep strategy. The second prominent attribute, CE18 ($s = 0.822162$, $rating = agree$ (L_4)) revealed that students solved problems exactly as instructed by the teacher, revealing students' reliability on their teachers (reliance). The third prominent attribute, CE13 ($s = 0.818479$, $rating = agree$ (L_4)) indicated that in learning mathematics, students always tried to pose questions to themselves and those questions helped them to understand the core of mathematics (deep strategy). The highest rating for the remaining attributes was on *agree* (L_4) and corresponded to positive perceptions. Students' cognitive engagement was primarily influenced by surface strategy, followed by deep strategy and reliance dimensions.

The least prominent cognitive engagement attribute was CE3 (s =0.707839, $rating = agree$ (L_4)), in which students stated that memorising facts and details of a topic was better than understanding it holistically, relating to surface strategy dimension. The second least prominent attribute, CE12 ($s = 0.712648$, $rating = neutral$ (L_3)) indicated that students' out-of-class time were not really spent to deepen their understanding of the interesting aspects of mathematics (deep strategy). The third least prominent attribute, CE5 ($s = 0.723123$, $rating = agree$ (L_4)) disclosed that students found memorising mathematics was more effective than understanding it. No negative perceptions were found for cognitive engagement, however neutral perceptions were present. Inspection on several attributes corresponding to surface strategy dimension also showed that students were more comfortable to learn mathematics by memorising whatever was necessary instead of emphasizing on mathematics exercises, corresponding to deep strategy dimension.

Table 7: Similarity degree between fuzzy sets R and F for cognitive engagement (CE) attributes

Attribute	L_1	L_2	L_3	L_4	L_5	s^{max}	$L(s^{max})$	Rank
CE1	0.412132	0.473683	0.607389	0.805055	0.610944	0.805055	L_4	8
CE2	0.430696	0.505278	0.655986	0.747771	0.567989	0.747771	L_4	15
CE3	0.442316	0.523941	0.684713	0.707839	0.548760	0.707839	L_4	20
CE4	0.412482	0.475366	0.615497	0.797180	0.604775	0.797180	L_4	9
CE5	0.438180	0.516877	0.671248	0.723123	0.557266	0.723123	L_4	18
CE6	0.430242	0.507282	0.674962	0.734741	0.557715	0.734741	L_4	17
CE7	0.468318	0.569983	0.734903	0.638190	0.509487	0.734903	L_3	16
CE8	0.409847	0.471671	0.609060	0.810662	0.608436	0.810662	L_4	6
CE9	0.389503	0.435684	0.538866	0.805228	0.692161	0.805228	L_4	7
CE10	0.393376	0.439836	0.542619	0.790087	0.694104	0.790087	L_4	11
CE11	0.406137	0.466490	0.600816	0.828598	0.612969	0.828598	L_4	1
CE12	0.434556	0.519773	0.712648	0.705320	0.533989	0.712648	L_3	19
CE13	0.404416	0.461539	0.589144	0.818479	0.630028	0.818479	L_4	3
CE14	0.414358	0.480817	0.628976	0.795711	0.589511	0.795711	L_4	10
CE15	0.391820	0.437540	0.539606	0.786560	0.699212	0.786560	L_4	12
CE16	0.381653	0.421188	0.510446	0.753000	0.746889	0.753000	L_4	14
CE17	0.386606	0.430211	0.528115	0.785146	0.712132	0.785146	L_4	13
CE18	0.393851	0.443533	0.554272	0.822162	0.669456	0.822162	L_4	2
CE19	0.387930	0.434028	0.536541	0.814123	0.690065	0.814123	L_4	5
CE20	0.386823	0.432581	0.534196	0.815369	0.691258	0.815369	L_4	4

3.3 Behavioural Engagement

Table 8 shows that the most important behavioural engagement was BE9 (s = 0.833379, *rating* = *agree* (L_4)), which revealed that students had tried repeatedly if they were unable to tackle a given problem, indicating their diligence. The second important attribute, BE8 (s =0.829374, *rating* = *agree* (L_4)) indicated that students attempted again when they could not obtain the right answer straight away (diligence). As for the third important attribute BE3 (s = 0.827732, *rating* = *agree* (L_4)), students confirmed their great effort in the mathematics lesson, corresponding to their attentiveness.

The least important behavioural engagement attribute, BE11 (s =0.771384, *rating* = *agree* (L_4)) indicated that students had worked on problems persistently to obtain correct answers (diligence). The second least important attribute, BE2 (s = 0.776281, *rating* = *agree* (L_4)) revealed that students took an active part and raised their points in the discussion of new topics (attentiveness). For the third least important attribute, BE5 (s =0.788739, *rating* = *agree* (L_4)), students stated that they used every means to understand what has been taught in mathematics, showing their attentiveness. No negative and neutral perceptions were discovered for behavioural engagement and all twelve attributes' highest rating was *agree* (L_4), corresponding to positive perceptions. Students' behavioural engagement was primarily influenced by diligence dimension and followed by attentiveness dimension.

Table 8: Similarity degree between fuzzy sets R and F for behavioural engagement (BE) attributes

Attribute	L_1	L_2	L_3	L_4	L_5	s^{max}	$L(s^{max})$	Rank
BE1	0.393056	0.442482	0.552572	0.825644	0.669979	0.825644	L_4	4
BE2	0.418380	0.488181	0.644807	0.776281	0.577916	0.776281	L_4	11
BE3	0.394448	0.444748	0.556683	0.827732	0.664839	0.827732	L_4	3
BE4	0.394850	0.444988	0.556813	0.820753	0.667164	0.820753	L_4	6
BE5	0.388748	0.433441	0.533649	0.788739	0.704926	0.788739	L_4	10
BE6	0.407311	0.467905	0.601985	0.823901	0.612830	0.823901	L_4	5
BE7	0.389420	0.435481	0.538563	0.803348	0.693313	0.803348	L_4	9
BE8	0.394164	0.444223	0.554710	0.829374	0.666207	0.829374	L_4	2
BE9	0.394979	0.445841	0.558106	0.833379	0.661185	0.833379	L_4	1
BE10	0.390617	0.438360	0.544641	0.819307	0.680469	0.819307	L_4	7
BE11	0.385863	0.428202	0.523708	0.771384	0.723754	0.771384	L_4	12
BE12	0.394581	0.444149	0.554163	0.818056	0.670958	0.818056	L_4	8

4. Conclusion

Findings attested varying perceptions of learning mathematics among the students with mostly positive; some negative and neutral. Clearly, the significant attributes suggested that students' perceptions of learning mathematics were generally positive, in line with the findings from Meng et al. (2014). Students' overall perception could have been positive due to their existing interest in mathematics, in which students enjoyed learning mathematics although they were anxious and stressed, as reported in Thien et al. (2015). The findings further reveal the challenges in Malaysian secondary curriculum that might need to strike a balance between all three construct of students' engagement based on the varying perceptions.

The existence of neutral and negative perceptions was inevitable. Neutral perceptions were obtained for attributes pertinent to student's mathematics anxiety and frustration in the learning process, which are elements of their affective engagement. As it deals with emotions, attributes with neutral perceptions have to be given attention, as otherwise these perceptions may transform into negative ones in the future. Negative perceptions were mainly present for affective engagement, particularly for anxiety and frustration dimensions. Thus, students' primary cause of unfavourable perceptions that can lead to disinterest and disengagement is undoubtedly anxiety (and frustration). This information shed light on the importance of education stakeholders to enhance the affective components of classroom engagement or conducting intervention programs in order to eradicate students' negative perceptions.

This study is not without its' limitations. Although the proportion of respondents were almost balanced in terms of regions and gender, the sample size is not considerably high enough for any generalization of the findings. Nonetheless, the findings of this study suggested for this sample of distributed students that, overall they had positive perceptions of learning mathematics. This study also served as an initial attempt to investigate students' perception of learning mathematics in terms of their classroom engagement.

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