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Study on Mathematics Self-Efficacy and Anxiety among Malaysian Upper Secondary Students using Fuzzy Conjoint Analysis

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ABSTRACT

This paper attempted to ascertain the levels of self-efficacy and anxiety of mathematics among upper secondary students in Malaysia. A descriptive survey study was conducted with 842 secondary students. Instrument consisted of 29 attributes. Attributes' ratings were analysed using Fuzzy Conjoint Analysis (FCA). Results attested that students' mathematics self-efficacy was low and their anxiety was high. Findings also suggested that students' high anxiety is a consequence of their low self-efficacy. In particular, students had low belief in their mathematics learning ability and were highly worried about getting good grades in mathematics. As self-efficacy and anxiety have significant effects on mathematics performance and achievement, findings indicated an unfavourable existing state of mathematics learning among upper secondary students to the nation's aspiration for excellence in Science, Technology, Engineering and Mathematics (STEM).

Keywords: Mathematics self-efficacy and anxiety, fuzzy conjoint analysis, STEM.

1. Introduction

Science, Technology, Engineering and Mathematics (STEM) education has become a global agenda in this era of digitisation. This is no exception for Malaysia as well, especially in the country's efforts to prepare for the Fourth Industrial Revolution (IR 4.0). STEM is about creating innovators of the future and connected to new emerging jobs. However, talents that are currently available in Malaysia are very limited and hence, more talents will be required in the near future.

Mathematics is one of the core components that cuts across all the disciplines in STEM education (see Singh et al. (2018)). Hence, acquisition of mathematical skills is vital for students to excel in STEM disciplines. However, Malaysian students are showing less competence in mathematics, as seen in international assessment studies, evidenced by disappointing performance and achievement in Trends in International Mathematics and Science Study (TIMSS) assessment and Programme for International Student Assessment (PISA) Bahrum et al. (2017); Fadzil and Saat (2014); Gopal et al. (2019); Ibrahim et al. (2019b); Jayarajah et al. (2014); Meng et al. (2014); Thien et al. (2015); Thien and Ong (2015). Moreover, Malaysia had also recorded the steepest decline in TIMSS (Meisenberg and Woodley (2013)). In a similar vein, Malaysian students' interest in mathematics is waning (Ibrahim et al. (2019a); Mahmud et al. (2020); Meng et al. (2014, 2013); Nasir et al. (2017); Ramli et al. (2020); Singh et al. (2018); Thien et al. (2015)). This is reflected in the poor enrolment into science stream at national secondary schools each year, in contrast to the advocated 60:40 (Science:Arts) ratio policy that was re-highlighted in the Malaysian Education Blueprint (2013 - 2025) (see Fadzil and Saat (2014); Jayarajah et al. (2014); Khairani (2017); Meng et al. (2014, 2013); Nasir et al. (2017); Singh et al. (2018)). The decline in appetite for mathematics (or STEM in general) is a matter of grave concern to the country's vision in this regard.

Students' affective characteristics (*personality traits*) have gained importance in educational research in recent times due to its significant effect on their learning outcome as outlined in Bloom's student learning model (see Garcia (2016); Thien and Ong (2015)). Affective is usually viewed as, but not limited to students feelings or emotions towards mathematics (see Thien et al. (2015)). An array of research indicated that affective characteristics such as self-efficacy, anxiety, engagement, motivation, self-concept and attitudes towards mathematics are highly correlated with mathematics performance and influenced their mathematics achievement. Hence, determining the levels of two vital affective characteristics i.e. self-efficacy and anxiety is undertaken in this study (see Cargnelutti et al. (2017); Lee and Stankov (2016); Pipere and Mierina (2017); Timmerman et al. (2017)).

1.1 Mathematics Self-Efficacy

Self-efficacy is formally defined as belief in individual's capability to perform the courses of action (see Jiang et al. (2014)). Based on the general definition, mathematics self-efficacy can be regarded as the extent to which students perceive their abilities to solve mathematics problems, perform mathematics related-tasks or do well in mathematics tests (see Rakoczy et al. (2019)). Essentially, it deals with their attained confidence level when facing mathematical tasks (see Carney et al. (2016)). As one of the pioneers in affective characteristics' studies, self-efficacy often exhibited positive relationship with academic performance (see Bernacki et al. (2015); Skaalvik et al. (2015)). Stankov and Lee (2017) asserted that mathematics self-efficacy is one of the most significant predictors of mathematics achievement. Several studies supported that higher level of self-efficacy increased students' accuracy in mathematical computations, their endurance on difficult problems, and their tendency to achieve high (see Carney et al. (2016); Rakoczy et al. (2019); Toland and Usher (2016)).

1.2 Mathematics Anxiety

Mathematics anxiety is concerned about students' negative response with a feeling of nervousness or stress when dealing with mathematics inDowker et al. (2016). It is closely related with their perceptions of mathematics performance and achievement (see Puteh and Khalin (2016)). Previous studies revealed that higher mathematics anxiety led to students' low confidence in their ability to do mathematics, eventually obstruct their performance in solving mathematical tasks (see Beilock and Maloney (2015); Carey et al. (2016); Foley et al. (2017)). Low anxiety is positively correlated with high mathematics performance and achievement in Foley et al. (2017); Mutawah and Ali (2015); Passolunghi et al. (2016). Anxiety is believed to become apparent when students are called on to solve a problem and during their mathematics tests (see Stoehr (2017)).

In contrast to the global research interest, studies on mathematics self-efficacy and anxiety for secondary students were limited in Malaysia. There are not many recent studies as well, since self-efficacy and anxiety were given more attention at the tertiary education level only. Some previous studies on self-efficacy for secondary level are such as Thien and Ong (2015) identified the extent to which the affective characteristics of Malaysian and Singaporean students' attainment compared to the Organisation for Economic Co-operation and Development (OECD) countries average in PISA. Thien et al. (2015) examined the relationships among affective characteristics-related variables at the student level, the aggregated school-level variables, and mathematics performance by using PISA 2012 dataset. Ng et al. (2012) explored the relationship between positive affect towards science and mathematics and achievement in science and mathematics among Malaysian and Singaporean Grade 8 students using TIMSS 2007 dataset Elias et al. (2009) explored the self-efficacy beliefs of at risk students in their learning of mathematics and examined the relationship between self-efficacy and academic performance for lower secondary students. Elias et al. (2007) examined the relationship between emotional literacy and mathematics self-efficacy among at risk upper secondary students.

Previous local studies on anxiety are such as Puteh and Khalin (2016) determined level of mathematics anxiety and its relationship with achievement of upper secondary students. Zakaria et al. (2012) determined mathematics anxiety level and its relationship with mathematics achievement. Mohamed and Tarmizi (2010) compared mathematical anxiety levels and its impacts on performance between Malaysia and Tanzania lower secondary students. Idris (2006) investigated the effect of graphing calculator on mathematics anxiety and achievement. In essence, literature indicated that higher level of mathematics self-efficacy and lower level of mathematics anxiety is directly proportional to higher mathematics performance and achievement. Consequently, the purpose of this paper is to ascertain the levels of self-efficacy and anxiety of mathematics among upper secondary students in Malaysia. This study is also the first one in Malaysia to employ Fuzzy Conjoint Analysis for this purpose.

2. Methodology

2.1 Research Design and Sample

The authors employed a descriptive survey design in this study. A mathematics camp was held in Universiti Putra Malaysia, participated by 980 upper secondary students from 32 national secondary schools nationwide. The authors randomly selected 842 students to be the sample with 427 male and 415 female students. The authors were unable to include in the sample all of the camp participants due to time and manpower constraint. The sample consisted of 183 students from 6 schools in northern region, 223 from 9 schools in central region, 176 from 6 schools in southern region, 141 from 6 schools in the east coast and remaining 119 students from 5 schools in East Malaysia (including 1 school in the Federal Territory of Labuan). Complete demographic details are given in Table 1.

Table 1: Demographics

Region	Number of Schools	Male	Female	Total
Northern	6	80	63	183
Central	9	95	87	223
Southern	6	70	68	176
East Coast	6	56	45	141
East Malaysia	5	56	45	119
Total	32	427	415	842

2.2 Survey Instrument

The survey instrument of this study was adapted from Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ), developed by May (2009). It aims to address perceptions of self-efficacy and feelings of anxiety towards mathematics among students pertaining to various aspects of mathematics learning. MSEAQ contained 29 attributes with 14 attributes for mathematics self-efficacy and 15 attributes for mathematics anxiety. Examples of attributes are provided in Table 2 and Table 3. Construction of MSEAQ consisted of both quantitative and qualitative components. The attributes were mainly constructed based on the wordings and phrases available in the interview transcripts and adapted from previously established instruments. The final set of attributes in the instrument was resulted from teachers' comments, classroom observations, student interviews, series of pilot-tests and revisions. MSEAQ was validated using factor analysis. The overall reliability index for MSEAQ was 0.94, while the Cronbach's α values for self-efficacy and anxiety were 0.90 and 0.91 respectively, as evaluated by May (2009). The reliability indices indicated a high strength of internal consistency of the attributes in the survey instrument.

Table 2: Examples of mathematics self-efficacy attributes

Code.	Attribute
SE1	I feel confident enough to ask questions in my mathematics class.
SE2	I believe I can do well on a mathematics test.
SE14	I feel confident when taking a mathematics test.
SE10	I believe I am the type of person who can do mathematics.
SE6	I believe I can understand the content in mathematics subject.

Table 3: Examples of mathematics anxiety attributes

Code	Attribute
A1	I get tense when I prepare for a mathematics test.
A2	I get nervous when I have to use mathematics outside of school.
A7	I get nervous when asking questions in class.
A15	I am afraid to give an incorrect answer during my mathematics class.
A8	Working on mathematics homework is stressful for me.

All attributes were rated by students with a five point Likert scale corresponding to the linguistic variables of agreement, L. The corresponding scale for each L are provided in Table 4. Next, the collected ratings are then compiled for Fuzzy Conjoint Analysis.

Table 4: Likert scale and corresponding linguistic variables

Likert scale	Notation	Linguistic variable, L
1	L_1	*Strongly disagree*
2	L_2	*Disagree*
3	L_3	*Neutral*
4	L_4	*Agree*
5	L_5	*Strongly agree*

2.3 Fuzzy Conjoint Analysis (FCA)

Expressing human perceptions is subjective in nature and always lead to high degree of uncertainty. Furthermore, as perceptions are usually expressed in linguistics (natural language) using words (linguistic variables, L) like *disagree*, it often leads to vagueness (see Abiyev et al. (2016)). As an example from this study, if a student rated **agree** (scale 4 or L_4) for the attribute that states *mathematics is boring*, it is difficult to clearly reflect how much does the student perceived that mathematics is boring in reality. As such, the use of conventional metrics may not allow us to reach a concrete conclusion (see Abiyev et al. (2016)). Fuzzy sets approach becomes handy to handle the ambiguity present in linguistic variables (see Sarala and Kavitha (2017). The fuzziness are handled by transforming the ratings on attributes into degree of similarities, a numerical value in the interval [0, 1] to represent the strength of the ratings (see Sofian and Rambely (2018)).

The basis of conventional conjoint model is preferences. As such, fuzzy sets can be integrated with the conjoint model resulting in Fuzzy Preference Model (FPM), a vector preference model. In FPM, ratings on L (linguistic ratings) are represented using a fuzzy membership function (again, a fuzzy set) for each of them on the measurement scale (Likert scale). Fuzzy Conjoint Model (FCM), a fuzzified vector conjoint model was developed by Turksen and Willson (1994) by integrating fuzzy membership function with FPM. The input to FCM is the standard fuzzy sets, F defined for the linguistic ratings. On the other hand, the output of FCM is the calculated membership (or overall preference) fuzzy sets, R which are basically the linear combinations of the weights of the attributes (see Sarala and Kavitha (2017)). The approximate degree of membership, $\mu_R(y_j, A_m)$ for each domain element (linguistic variable), y_j in R for an attribute A_m is given in Equation 1 (see 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:

- μ_R : weighted sum of the domain elements' membership in each attribute A_m; $\mu_R \in [0, 1]$
- y_j and x_j : elements of domain; $j = 1, 2, \ldots, 5$ (number of linguistic variables)
- A_m : specific attribute, m : number of attributes $(m = 1, 2, \ldots, M)$, $M = 14$ for mathematics self-efficacy & $M = 15$ for mathematics anxiety
- $\mu_{F_i}(x_j)$: F_i (linguistic rating's membership value) at a given linguistic level x_j (elements of the standard fuzzy sets F at level x_j)
- r_i : crisp weight obtained from the questionnaire (students' ratings on the attributes) i.e. $r_i = 1, 2, \ldots, 5$
- $W_{(r_i, A_m)}$: fuzzified weight for linguistic rating r_i corresponding to attribute A_m and $W_{(r_i, A_m)} = \frac{\sum r_i}{\sum_{k=1}^{j} r_{(k, A_m)}}$
  where $\sum r_i$: sum of the particular rating r across students for attribute A_m and $\sum_{k=1}^{j} r_{(k, A_m)}$: sum of all the ratings across attribute A_m

The membership for linguistic ratings in F, $\mu_{F_i}(x_j)$ are predefined values obtained from Zimmermann (2001), based on Zadeh's seminal paper on concept of linguistic variables and its application to approximate reasoning. The fuzzy sets, F corresponding for each L are given as below:

$$F_1 = (1.00/1, 0.75/2, 0.50/3, 0.00/4, 0.00/5)$$
$$F_2 = (0.50/1, 1.00/2, 0.75/3, 0.25/4, 0.00/5)$$
$$F_3 = (0.00/1, 0.50/2, 1.00/3, 0.50/4, 0.00/5)$$
$$F_4 = (0.00/1, 0.25/2, 0.75/3, 1.00/4, 0.50/5)$$
$$F_5 = (0.00/1, 0.00/2, 0.50/3, 0.75/4, 1.00/5)$$

F is anchored to each L_i, $i = 1, 2, \ldots, 5$ (or the equivalent linguistic variables) as given in Table 3. The elements of F are not numerical fractions, instead the notation a/b is defined as rating a at linguistic variable b (see Zimmermann (2001)). For example, in F_2, the first element 0.50 / 1 means the compatibility of rating '1' with L_1 (*strongly disagree*) is 0.50. Similarity degree, s is the final output of FCA. s is a fuzzy similarity measure which basically is the sum of the Euclidean distance between corresponding elements in fuzzy sets R and F (see Sofian and Rambely (2018)). The s for each linguistic ratings for an attribute A is given in Equation 2 (Turksen and Willson (1995)).

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

where:

- $\mu_F(y_j, L_i)$: elements of F corresponding to linguistic term L_i (students' actual overall response) and j : number of linguistic terms, $j = 1, 2, \ldots, 5$
- $\mu_R(y_j)$: calculated membership degree based on original ratings in questionnaire for the attributes (using Equation 1)

The value of s ($s \in [0, 1]$) for each linguistic rating indicates the strength (intensity) of students' agreement on their given rating for each attribute in Abiyev et al. (2016). The strength is directly proportional to s, i.e. as $s \to 1$, the strength of increases and otherwise. Upon obtaining the values of s, first, the highest s value (denoted by s^*) and its corresponding L (denoted by $L(s^*)$) are selected to be used as the overall rating for a specific attribute. s^* and $L(s^*)$ represent the strongest agreement among the ratings. Then, the nature of perception (*positive*, *neutral* or *negative*) on a particular attribute is obtained based on $L(s^*)$ and the sentiment of the attribute. Say, there is an attribute, A that states *mathematics is relevant.* Next, if $L(s^*)$ of $A = L_1$ or L_2, hence most of the students disagreed that mathematics was relevant, drawing a negative perception. If $L(s^*)$ of $A = L_4$ or L_5, then they agreed that mathematics was relevant, implying positive perception. Neutral perception is drawn if $L(s^*)$ of $A = L_3$, which means students doubted the relevance of mathematics. After that, rank the s^* values in descending order to identify the most influential attribute. Using the rank (ordinal information), it can be deduced that the attribute with highest rank has the most influence (or significant effect) on students' rating tendency (feelings or perceptions). Other attributes (rank > 1) are useful to provide information regarding aspects of self-efficacy and anxiety that contributed to negative and neutral perceptions towards students' mathematics learning outcome. Finally, levels of mathematics self-efficacy and mathematics anxiety are determined based on the nature of perceptions that is dominant. For example if self-efficacy is highly positively perceived, then it can be inferred that students' self-efficacy level is high. The computation process of FCA is illustrated below using attribute SE1:

1. Ratings of SE1 are collected:
   $n('1') = 5, \quad n('2') = 34, \quad n('3') = 199, \quad n('4') = 191, \quad n('5') = 133,$
   where n is the number of rating.
2. Sum for each rating, $\sum r_i$ is computed:
   $r_1 = 5(1) = 5,\ r_2 = 34(2) = 68,\ r_3 = 199(3) = 597,\ r_4 = 191(4) = 764,$
   $r_5 = 133(5) = 665.$
3. Sum of all ratings throughout SE1 is computed:
   $\sum_{i=1}^{5} r_i = 5 + 68 + 597 + 764 + 665 = 2099.$
4. Fuzzified weight for each rating, W_{r_i} is computed:
   $W_{r_1} = 5 \div 2099 = 0.002382, \quad W_{r_2} = 34 \div 2099 = 0.032396,$
   $W_{r_3} = 199 \div 2099 = 0.284421, \quad W_{r_4} = 191 \div 2099 = 0.363983,$
   $W_{r_5} = 133 \div 2099 = 0.316818.$
5. Degree of membership, $\mu_R(y_j)$ is computed:
   $\mu_R(y_1) = W_{r_1} \cdot \mu_{F_1}(x_1) + W_{r_2} \cdot \mu_{F_2}(x_1) + \cdots + W_{r_5} \cdot \mu_{F_5}(x_1)$
   $= 0.002382(1) + 0.032396(0.5) + 0.284421(0) + 0.363983(0) + 0.316818(0)$
   $= 0.018580,$
   Similarly:
   $\mu_R(y_2) = 0.751906, \quad \mu_R(y_3) = 0.741305,$
   $\mu_R(y_4) = 0.267389, \quad \mu_R(y_5) = 0.498809.$
6. Similarity degree, $s_i(SE1)$ is computed:
   $s_1 = 1 \div (1 + \sqrt{[\mu_R(y_1) - \mu_{F_1}(y_1)]^2 + [\mu_R(y_2) - \mu_{F_1}(y_2)]^2 + \cdots + [\mu_R(y_5) - \mu_{F_1}(y_5)]^2})$
   $= 1 \div ([0.018580 - 1]^2 + [0.267389 - 0.75]^2 + [0.741305 - 0.5]^2$
   $+ [0.751906 - 0]^2 + [0.498809 - 0]^2)$
   $= 0.410134.$
   Similarly:
   $s_2 = 0.800288, \quad s_3 = 0.602949$
   $, s_4 = 0.470229, \quad s_5 = 0.618250$
   $. \therefore s^*(SE1) = 0.800288 = s_2$ and $L(s^*) = L_2$.

3. Results

3.1 Mathematics Self-Efficacy

As seen in Table 5, the most influential attribute of mathematics self-efficacy was SE8 ($s = 0.831058$, rating: *disagree* (L_2)), where 83.8% (including L_1 ratings) of students disagreed that they believe they can learn mathematics well. This showed that majority of the students had low belief in their mathematics learning ability. Along with SE8, there were another 8 attributes that were negatively perceived. These attributes are concerned with students' belief about scoring high marks in mathematics test (rank = 2), belief about their ability to do well in future mathematics lessons (rank = 5), confidence in asking mathematics questions (rank = 7), confidence when taking mathematics test (rank

= 10), belief in their ability to use mathematics in future career (rank = 11), belief about being good at mathematics (rank = 12), belief in their ability to complete mathematics homework (rank = 13), and belief about their thinking capability like a mathematician (rank = 14).

Rest of the attributes were neutrally perceived. SE10 ($s = 0.821214$, rank = 3) was at the highest rank among these attributes, for which students were unsure if they are the type of person who can do mathematics. The remaining 4 attributes were regarding students' belief on their ability do mathematics in classroom (rank = 4), confidence when using mathematics outside of school (rank = 6), belief on their ability to understand the content in mathematics lesson (rank = 8), and belief on their ability to do well in mathematics test. Out of 14 mathematics self-efficacy attributes, 9 were negatively perceived while the rest were neutrally perceived, and there were no positive perceptions found. Thus, it is evident that students' mathematics self-efficacy was clearly low.

Table 5: Similarity degree between fuzzy sets R and F for mathematics self-efficacy (SE) attributes.

Attribute	L_1	L_2	L_3	L_4	L_5	s^*	$L(s^*)$	Rank
SE1	0.410134	0.800288	0.602949	0.470229	0.618250	0.800288	L_2	7
SE2	0.708714	0.530325	0.787756	0.387350	0.431382	0.787756	L_3	9
SE3	0.426989	0.732788	0.687920	0.506131	0.548074	0.732788	L_2	13
SE4	0.425364	0.743420	0.673421	0.501325	0.558658	0.743420	L_2	12
SE5	0.506399	0.759125	0.740888	0.419098	0.380707	0.759125	L_2	11
SE6	0.572377	0.655143	0.798836	0.402197	0.454919	0.798836	L_3	8
SE7	0.604498	0.821272	0.610800	0.407571	0.468598	0.821272	L_2	2
SE8	0.397481	0.831058	0.449934	0.566540	0.652767	0.831058	L_2	1
SE9	0.641167	0.782497	0.580014	0.416918	0.485918	0.782497	L_2	10
SE10	0.623591	0.593820	0.821214	0.463994	0.405584	0.821214	L_3	3
SE11	0.678472	0.812796	0.549134	0.392672	0.441027	0.812796	L_2	5
SE12	0.436885	0.683896	0.817249	0.389741	0.541955	0.817249	L_3	4
SE13	0.720492	0.687247	0.531098	0.529470	0.441881	0.720492	L_1	14
SE14	0.604842	0.613239	0.807638	0.409557	0.472057	0.807638	L_3	6

3.2 Mathematics Anxiety

For mathematics anxiety, attribute A4 ($s = 0.832900$, rating: *agree* (L_4)) had the most significant effect, where 91.2% (including L_5 ratings) of students agreed that they were highly worried about getting good grades for mathematics. This revealed that majority of the students experienced anxiety due to the expectation of scoring high marks for their tests. Apart from A4, negative perceptions were present for another 11 attributes. These attributes are pertaining to students' worry about not being able to understand mathematics (rank = 2), worry that they do not know enough mathematics knowledge to do well in future mathematics lessons (rank = 3), being nervous when they have to use mathematics outside of school (rank = 4), feeling stressed when listening to mathematics teachers in classroom (rank = 5), getting tensed when preparing for mathematics test (rank = 6), being nervous when taking mathematics test (rank = 7), being stressful when working on mathematics homework (rank = 8), worry that they will be unable to learn mathematics well (rank = 9), being afraid to make mistakes during mathematics lesson (rank = 11), worry that they will be unable to do well in mathematics tests (rank = 13), and being nervous to ask questions in classroom (rank = 14).

Neutral perceptions were present for the rest of attributes. A12 (s = 0.759112, rank = 3) had the highest rank among them, for which students worry that they will be unable to get excellent grades for mathematics. The other 2 attributes were concerned about students being worried that they will not be able to complete every mathematics homework (rank = 12) and worried about their ability to use mathematics for future career (rank = 15). Clearly, negative perceptions were dominant with 12 out of 15 attributes were negatively perceived, 3 were neutrally perceived and none were positively perceived. Hence, it is evident that students' mathematics anxiety was high.

Table 6: Similarity degree between fuzzy sets R and F for mathematics anxiety (A) attributes.

Attribute	L_1	L_2	L_3	L_4	L_5	s^*	$L(s^*)$	Rank
A1	0.392670	0.437722	0.537710	0.777533	0.704787	0.777533	L_4	6
A2	0.415826	0.481792	0.627710	0.789796	0.592522	0.789796	L_4	4
A3	0.509816	0.647253	0.717884	0.570553	0.469557	0.717884	L_3	15
A4	0.401187	0.456288	0.577643	0.832900	0.639143	0.832900	L_4	1
A5	0.382579	0.421834	0.510853	0.745579	0.751892	0.751892	L_5	13
A6	0.378809	0.414915	0.497903	0.717868	0.784996	0.784996	L_5	5
A7	0.434545	0.504207	0.638020	0.735188	0.584583	0.735188	L_4	14
A8	0.393288	0.436963	0.533757	0.760913	0.715850	0.760913	L_4	8
A9	0.394918	0.443442	0.550917	0.805321	0.679002	0.805321	L_4	3
A10	0.470341	0.580316	0.753244	0.627551	0.496268	0.753244	L_3	12
A11	0.397172	0.448994	0.563630	0.828466	0.656789	0.828466	L_4	2
A12	0.482143	0.602111	0.759112	0.603058	0.484129	0.759112	L_3	10
A13	0.391571	0.429867	0.514307	0.716711	0.759245	0.759245	L_5	9
A14	0.476308	0.593860	0.484019	0.776257	0.605926	0.776257	L_4	7
A15	0.395063	0.438724	0.535122	0.753392	0.716202	0.753392	L_4	11

4. Conclusions

Results attested that students' mathematics self-efficacy was low and mathematics anxiety was high as students' perceptions were mostly negative, in accordance with the previous findings from Thien and Ong (2015). In addition to that, findings suggested that Malaysian students' high anxiety is a consequence of their low self-efficacy, in line with global findings by Hu (2018) and Villavicencio and Bernardo (2016). This can be illustrated with an example like '*I think I cannot,* (self-efficacy) *so I am afraid to try*' (anxiety). Fuzzy sets approach is valid and considered more reliable than the common techniques such as descriptive statistics (mean) or percentage for analyzing questionnaire data (see Abiyev et al. (2016)). Although using mean or percentage may be convincing but fuzzy sets approach yields a more accurate measurement of the variance within and between these rating (Likert) scale in Abdullah et al. (2004). Moreover, fuzzy sets approach is generally consistent with mean (central tendency measure that is often debatable for ordinal data) & percentage (alternative metric for expressing the frequency) in Abdullah et al. (2004); Abiyev et al. (2016). Application of FCA provided an overview of students' perceptions that reflected their mathematics self-efficacy and mathematics anxiety levels. Additionally, the authors also identified attributes that had the most significant effects on students' rating tendency. Identification of negatively and neutrally perceived attributes are important and useful information to education stakeholders to understand the difficulties and confusions faced by students in order to improve the teaching-learning process of mathematics, particularly in national secondary schools. It would be interesting for stakeholders to determine the causes of neutral perceptions and what students really mean by being neutral. As self-efficacy and anxiety have significant effects on mathematics performance and achievement, this study served as one of the attempts to determine the existing state of mathematics learning among upper secondary students, which is vital for the nation's aspiration towards excellence in STEM.

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