EVALUATION OF STUDENTS' PERCEPTIONS OF GAME-BASED MATHEMATICS CLASSROOM USING FUZZY CONJOINT ANALYSIS

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Abstract

Teaching mathematics can be challenging with students of weak mathematical background. Most of these students are uninterested and perform poorly in written assessments. Game-based learning is one of the approaches to increase students' motivation and engagement in the classroom. This study aims to investigate the students' perceptions of game-based mathematics classrooms by fuzzy set conjoint analysis. The study involves a survey collected from 83 undergraduate students of Faculty of Computer and Mathematical Sciences (FSKM), Raub Campus. The survey consists of 16 items of the students' perceptions of incorporating mathematical board game in the classroom. Eight items are about students' involvement during the game, and the other eight items are about cooperation during the game. A seven-point Likert scale was used to collect students' responses for each of the items. Then, the fuzzy set was used to represent the Likert scale, and the scores of students' perceptions were the degree of similarities. The findings showed that the items related to students' involvement were recorded at the highest degree of similarity at 0.52 with the level of 'Agree' that students' ideas and suggestions were used during the discussions in the game. Likewise, the items related to cooperation obtained the highest degree of similarity at 0.518, also with the level of 'Agree' that the students cooperate with other students during the activity. This study found students generally had a positive perception towards game-based mathematics classroom.

Keyword: Fuzzy Conjoint Analysis; Game-Based Classroom; Mathematics; Students' Perceptions

Introduction

Teaching mathematics can be challenging, especially when dealing with students of weak mathematical background. In the classroom, most of these students appear uninterested and often inactive during discussions. Most of them are inclined to memorise the concepts and formulas instead of understanding the application. Consequently, this problem leads to poor performance in written assessments. As an educator, it is crucial to attract the attention of the students and maintain students' engagement during lessons. However, with the rise of technology, students' participation is becoming more difficult. The traditional 'chalk and talk' is not enough to appeal to young students. Today's generation of students can learn and find almost anything just at their fingertips. Educators thus need to find new ways to gauge students' interest and make sure that they are at the students' pace. Hence, that is why selecting the best

approach to teach mathematics in the classroom is not an easy task.

One of the trending approaches in teaching is gamification or also known as Game-Based Learning (GBL). The previous literature suggested some tools to implement GBL in teaching and learning. Stranger-Johannessen (2018) conducted the immersive nature of virtual reality head-mounted displays (HMDs) to test the effects of a quasi-experiment towards Grade 5 students in Norway. HMDs was implemented for six weeks during multiplication lesson, and the results indicated that the performance of the boys was significantly lower than girls. Another study by Perera et al., (2017) used Unity 5, a cross-platform game engine to implement GBL for e-learning of mathematics. Faghihi et al., (2014) compared a tutorial program that is well known in US colleges, Assessment and Learning, K-12, Higher Education (ALEKS) with MathDungeon, an educational game which uses the Artificial Intelligence Tutor system in learning mathematical concepts. Their findings showed that MathDungeon is powerful and practical in teaching mathematics.

Fuzzy conjoint analysis method has been widely used in many previous studies to analyse the users' preferences in selecting products, services or ideas from their overall rating or rankings in practical techniques. A study by Rasmani and Shahari (2007) used the fuzzy set analysis in the measurement of job satisfaction level among 100 academics staff in UiTM from main campus and branch campus. Their study focused on investigating the suitability of fuzzy conjoint method rather than to make inference about the population. They concluded that their findings are generally consistent with the results obtained from analysis based on percentage. However, Yusoff et al., (2013) showed in their evaluation of employers' satisfaction level for the engineering graduates' performance that fuzzy conjoint method yields more consistent outcomes, but the differences are not too significant compared to the statistic mean and percentage. Presumably, the fuzzy conjoint method could provide useful information for decision making in finding the attributes that needed enhancement in performance satisfaction for real practices.

There have been a few studies which proposed the fuzzy set conjoint model to analyse respondents' perceptions in education because of perception towards learning attributes are subjective indeed. Abdullah and Md Tap (2009) employed a fuzzy approach to measure mathematics teachers' beliefs about mathematics. They outlined the teachers' belief about mathematics into two categories, which are beliefs about the nature of mathematics and beliefs about learning mathematics. For each category, it consists of three different attributes to be measured, and the degree of similarity was used to describe the subjectivity of teachers' beliefs. The highest degree of similarity was scored by 'Drill and Practice' as one of the attributes measured to find the best ways of learning mathematics. In another study by Abdullah et al., (2011), the fuzzy set conjoint model was applied in explaining students' perceptions on the use of computer algebra system (CAS) in learning secondary school level mathematics subject.

Recent studies have also applied fuzzy set conjoint analysis in evaluating teaching and learning activities. Sofian and Rambely (2017) proposed the fuzzy set conjoint analysis to evaluate students' performance on game-based learning program (GBL). As a result, interest, passion and teamwork were the most substantial values obtained from GBL activities as participants stated 'Very Strongly Agree' that these attributes fulfilled their preferences in every module. Finally, Othman et al., (2019) also applied the fuzzy set conjoint method to analyse the students' satisfaction in learning basic integration concepts using PowerPoint applications.

In this study, a game-based mathematics lesson was introduced to undergraduate students. The main objective of this study is to investigate the students' perceptions of game-based mathematics classroom by using fuzzy set conjoint analysis.

The remaining part of this paper is organised as follows. The next section introduces some basic definitions and notations that are used throughout this paper. Section 3 explains the methodology for measuring students' perceptions of the game-based mathematics classroom.

Section 4 discusses the results and findings. Finally, conclusion and recommendations are given in the last section.

Methodology

Fuzzy Sets and Likert Scale

Fuzzy set was introduced by Zadeh (1965) to deal with imprecision and vagueness in human judgement. A fuzzy set A in a universe of discourse X is defined as the following set of pairs

$$A = \{\mu_A(x)/x : x \in X\}, \quad (1)$$

where $\mu_A : X \rightarrow [0,1]$ is a mapping of the membership function of the fuzzy set A and $\mu_A(x)$ is the membership degree of $x \in X$ in the fuzzy set A.

In this study, fuzzy sets were used to represent linguistic terms of the Likert scale defined as L_k ={very strongly disagree, strongly disagree, disagree, neutral, agree, strongly agree, very strongly agree}. **Table 1** presents the fuzzy sets for each linguistic term, $L_k(k = 1, 2, 3, 4, 5, 6, 7)$.

Table 1 Fuzzy sets representing each linguistic term, taken from Rasmani and Shahari (2007)

Likert scale rating	Linguistic term	Fuzzy sets
1	Very Strongly Disagree (VSD)	$L_1 = \{1/1, 0.7/2, 0.2/3, 0.1/4, 0/5, 0/6, 0/7\}$
2	Strongly Disagree (SD)	$L_2 = \{0.6/1, 1/2, 0.6/3, 0.3/4, 0.1/5, 0/6, 0/7\}$
3	Disagree (D)	$L_3 = \{0.2/1, 0.7/2, 1/3, 0.7/4, 0.2/5, 0.1/6, 0/7\}$
4	Neutral (N)	$L_4 = \{0/1, 0.1/2, 0.7/3, 1/4, 0.7/5, 0.1/6, 0/7\}$
5	Agree (A)	$L_5 = \{0/1, 0.1/2, 0.2/3, 0.7/4, 1/5, 0.7/6, 0.2/7\}$
6	Strongly Agree (SA)	$L_6 = \{0/1, 0/2, 0.1/3, 0.3/4, 0.6/5, 1/6, 0.6/7\}$
7	Very Strongly Agree (VSA)	$L_7 = \{0/1, 0/2, 0/3, 0.1/4, 0.2/5, 0.7/6, 1/7\}$

Fuzzy Conjoint Analysis

The fuzzy conjoint model was proposed by Burhan and Wilson (1994) to analyse consumers' preferences. A fuzzy set R was formed to represent the respondents' evaluation for all attributes. The membership degree of each element $y_j = 1, 2, 3, \dots, t$, in the fuzzy set R representing item M is denoted as $\mu_{R_i}(y_j, M)$, defined as follows.

$$\mu_{R_i}(y_j, M) = \sum_{i=1}^{n} W_i \cdot \mu_{L_i}(x_j, M), \quad (2)$$

where W_i is the weight that represents the level of agreement, with

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i}, \quad (3)$$

as w_i is a score of linguistic values given by the i-th respondent, $\mu_{L_i}(x_j, M)$ is the membership degree for element x_j for item M according to linguistic term $x_j = 1, 2, 3, \dots, t$. M denotes an item in the questionnaire, t is the linguistic terms, and n is the number of respondents.

The values of the membership degree represented the fuzzy set of responses R. The fuzzy set R is compared to the fuzzy set defined by expert L_k, for $k = 1, 2, \dots, t$. The levels of similarity between the two sets are measured using the formula based on Euclidean distance, given as follows.

$$Sim(R, L_k) = \frac{1}{\left[1+\sqrt{\Sigma_{j=1}^{7}\left(\mu_R(j,A)-\mu_{L_k}(j)\right)^2}\right]}, \quad (4)$$

where $\mu_R(j, A)$ and $\mu_{L_k}(j)$ are membership degree for fuzzy set calculated based on responses and membership degree for fuzzy set defined by experts.

Measurement Procedure

The calculations were done based on a series of steps taken from Abdullah, Md Tap, and Abdullah (2011), detailed as follows.

Step 1: Obtain students' responses for each attribute M_i.
Step 2: Calculate the frequency of students' responses w_i of each linguistic value for each attribute M_i.
Step 3: Calculate the weights W_i of each linguistic value using Eq. (3) for each attribute M_i.
Step 4: Obtain the membership value of each element in fuzzy set of students' responses R using Eq. (2).
Step 5: Obtain similarity measures between fuzzy set R and fuzzy set L_k, $k = 1, 2, \dots, 7$ using Eq. (4).
Step 6: Select the linguistic value L which has the maximum degree of similarity.

AN EXPERIMENT: GAME-BASED TUTORIAL SESSION

Students' Background

The study involved undergraduate students from the Faculty of Computer and Mathematical Sciences (FSKM). The sample consists of 83 students, 57 males and 26 females. Some of the students did not meet the minimum mathematics entry requirement. Although all of the students passed Modern Mathematics subject in their SPM, a high percentage (41%) of them obtained the grades D, E, and G for their Additional Mathematics. Based on the result of the faculty's online mathematics diagnostic test, the percentage of students with excellent, moderate and weak scores were 1%, 74%, and 25%, respectively. Overall, most of the students have average to below average mathematical background.

The students involved in this study are students that were registered for the course "Calculus I" which syllabus covers topics such as functions, differentiations and integrations, as well as the applications. The course has been notoriously known as the 'killer subject' as it has recorded a failure rate of more than 20% for every semester since 2016.

Monopoly® Based Board Game

Three tutorial sessions were conducted with the use of a modified version of the popular board game, Monopoly®. The board game consists of coloured squares with point values. Different coloured squares indicate different mathematical concepts. The difficulty level of the question or problems increases with higher point-values. Students form teams of two in a session and will take turn to roll the dice. When a team lands on a square, they will work together to answer the question correctly within the specified time to collect the points. If the answer is incorrect, the point-value will be deducted from their total points. The team with the highest points wins the game. The students were given one hour to play the board game for each game session. They were encouraged to refer to their books and notes in order to help them answer the questions and review their understanding of the mathematical concepts. The game also allows other teams to challenge the solutions presented by their opponents. The students learn to debate and defend their answers.

Figure 1 The board game session during tutorial

Survey on Students' Perceptions

A survey was constructed based on a questionnaire by Afari et al., (2013) which investigates students' perceptions in learning environment as well as students' attitude in the classroom. However, in our study, we only investigated the students' perceptions towards classroom learning environment, specifically the elements of involvement and cooperation among students during the game session. The survey consists of 16 attributes of the students' perceptions of incorporating mathematical board game in the classroom. Eight attributes were about students' involvement, and the other eight attributes were about cooperation among students during the game. The attributes of the survey are presented in **Table 2**.

Table 2 The attributes of the survey on students' perceptions towards involvement and cooperation during the game session

Involvement		**Cooperation**	
Attribute	**Statement**	**Attribute**	**Statement**
M_1	I discuss ideas during the game session.	M_9	I cooperate with other students when trying to solve the questions.
M_2	I give my opinions during the game session.	M_{10}	I share my books and resources with other students when solving the questions.
M_3	Other students listen carefully to my ideas.	M_{11}	When I work in groups, there is teamwork.
M_4	My ideas and suggestions are used during game session.	M_{12}	I work with other students in this class during the game session.
M_5	I ask other students to explain their ideas.	M_{13}	I learn from other students when solving the questions.
M_6	I explain my ideas to other students.	M_{14}	I work with other students in this class.
M_7	Other students discuss with me how to go about solving the problems.	M_{15}	I cooperate with other students on the class activities.
M_8	I am asked to explain how I solve the problems.	M_{16}	Other students work with me to achieve learning goals.

The students were asked to complete the survey immediately after the game session ended in order to capture their prompt opinions. All attributes used the response alternatives of seven linguistic terms, $j = 1, 2, 3, \ldots, 7$, which are Very Strongly Disagree (VSD), Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A), Strongly Agree (SA), and Very Strongly Agree

(VSA). The fuzzy sets representing linguistic values were taken from Rasmani and Shahari (2007). **Table 3** shows the frequency of students' responses for each attribute M_i.

Table 3 The frequency of students' responses for each attribute M_i.

	Attribute	VSD	SD	D	N	A	SA	VSA	Total
Involvement	M_1	0	4	1	6	38	17	17	83
	M_2	0	6	2	12	33	20	10	83
	M_3	0	2	3	21	35	19	3	83
	M_4	0	2	4	19	37	19	2	83
	M_5	0	4	0	14	39	20	6	83
	M_6	0	4	3	16	47	10	3	83
	M_7	0	3	1	12	41	20	6	83
	M_8	2	3	6	20	35	13	4	83
Cooperation	M_9	1	3	1	7	42	21	8	83
	M_{10}	4	4	6	13	33	17	6	83
	M_{11}	1	3	4	4	35	21	15	83
	M_{12}	0	4	2	10	38	18	11	83
	M_{13}	0	4	2	7	33	22	15	83
	M_{14}	1	1	4	11	35	21	10	83
	M_{15}	1	2	3	9	40	19	9	83
	M_{16}	1	2	3	14	37	17	9	83

The weight for each attribute M_i related to linguistic value j was calculated using Eq. (3), as shown in **Table 3**.

Table 3 Weight for attribute M_i related to linguistic values, $j = 1, 2, 3, \ldots, 7$.

	Attribute	VSD	SD	D	N	A	SA	VSA
Involvement	M_1	0	0.048	0.012	0.072	0.458	0.205	0.205
	M_2	0	0.072	0.024	0.145	0.398	0.241	0.121
	M_3	0	0.024	0.036	0.253	0.422	0.229	0.036
	M_4	0	0.024	0.048	0.229	0.446	0.229	0.024
	M_5	0	0.048	0	0.169	0.470	0.241	0.072
	M_6	0	0.048	0.036	0.193	0.567	0.121	0.036
	M_7	0	0.036	0.012	0.145	0.494	0.241	0.072
	M_8	0.024	0.036	0.072	0.241	0.422	0.157	0.048
Cooperation	M_9	0.012	0.036	0.012	0.084	0.506	0.253	0.096
	M_{10}	0.048	0.048	0.072	0.157	0.398	0.205	0.072
	M_{11}	0.012	0.036	0.048	0.048	0.422	0.253	0.181
	M_{12}	0	0.048	0.024	0.121	0.458	0.217	0.133
	M_{13}	0	0.048	0.024	0.084	0.398	0.265	0.181
	M_{14}	0.012	0.012	0.048	0.133	0.422	0.253	0.121
	M_{15}	0.012	0.024	0.036	0.108	0.482	0.229	0.108
	M_{16}	0.012	0.024	0.036	0.169	0.446	0.205	0.108

The membership degree for fuzzy sets based on students' responses were obtained using Eq. (2). The calculations had to be done for all attributes corresponding to each linguistic value, $j = 1, 2, 3, \ldots, 7$. Table 4 presents the membership value of each element of fuzzy set R for each attribute M_i corresponding to linguistic value: Very Strongly Disagree ($j = 1$).

Table 4 Membership degree of each element of fuzzy sets R corresponding to linguistic value, VSD ($j = 1$) for each attribute M_i.

	Attribute	VSD	SD	D	N	A	SA	VSA
Involvement	M_1	0	0.0337	0.0024	0.0072	0	0	0
	M_2	0	0.0506	0.0048	0.0145	0	0	0
	M_3	0	0.0169	0.0072	0.0253	0	0	0
	M_4	0	0.0169	0.0096	0.0229	0	0	0
	M_5	0	0.0337	0.0000	0.0169	0	0	0
	M_6	0	0.0337	0.0072	0.0193	0	0	0
	M_7	0	0.0253	0.0024	0.0145	0	0	0
	M_8	0.0241	0.0253	0.0145	0.0241	0	0	0
C m	M_9	0.0120	0.0253	0.0024	0.0084	0	0	0
	M_{10}	0.0482	0.0337	0.0145	0.0157	0	0	0

M_{11}	0.0120	0.0253	0.0096	0.0048	0	0	0
M_{12}	0	0.0337	0.0048	0.0120	0	0	0
M_{13}	0	0.0337	0.0048	0.0084	0	0	0
M_{14}	0.0120	0.0084	0.0096	0.0133	0	0	0
M_{15}	0.0120	0.0169	0.0072	0.0108	0	0	0
M_{16}	0.0120	0.0169	0.0072	0.0169	0	0	0

Next, the level of similarity between the fuzzy sets based on students' responses R and fuzzy sets L_k were computed using Eq. (4). The degree of similarity of all fuzzy sets for each attribute was calculated corresponding to every linguistic value, $j = 1, 2, 3, \ldots, 7$. **Table 5** shows the values of similarity degree between fuzzy sets R and L_k, for all attributes M_i.

Table 5 Values of similarity degree between fuzzy sets based on students' responses R and fuzzy sets L_k for all attributes M_i.

	Attribute	VSD	SD	D	N	A	SA	VSA	Max Similarity
Involvement	M_1	0.4502	0.4342	0.4205	0.4538	0.5037	0.5173	0.5068	0.5173
	M_2	0.4522	0.4390	0.4275	0.4658	0.5104	0.5157	0.4962	0.5157
	M_3	0.4487	0.4340	0.4320	0.4881	0.5255	0.5063	0.4746	0.5255
	M_4	0.4488	0.4344	0.4325	0.4873	0.5262	0.5053	0.4717	0.5262
	M_5	0.4502	0.4347	0.4244	0.4710	0.5228	0.5130	0.4824	0.5228
	M_6	0.4505	0.4369	0.4307	0.4864	0.5221	0.4869	0.4570	0.5221
	M_7	0.4494	0.4334	0.4240	0.4695	0.5231	0.5133	0.4813	0.5231
	M_8	0.4539	0.4387	0.4372	0.4930	0.5153	0.4935	0.4694	0.5153
Cooperation	M_9	0.4513	0.4334	0.4207	0.4593	0.5170	0.5165	0.4868	0.5170
	M_{10}	0.4588	0.4408	0.4333	0.4754	0.5076	0.5028	0.4817	0.5076
	M_{11}	0.4514	0.4347	0.4228	0.4521	0.5017	0.5228	0.5095	0.5228
	M_{12}	0.4503	0.4354	0.4248	0.4651	0.5130	0.5142	0.4932	0.5142
	M_{13}	0.4503	0.4349	0.4226	0.4537	0.5044	0.5261	0.5128	0.5261
	M_{14}	0.4496	0.4323	0.4263	0.4672	0.5141	0.5202	0.4968	0.5202
	M_{15}	0.4505	0.4332	0.4243	0.4656	0.5158	0.5143	0.4883	0.5158
	M_{16}	0.4506	0.4338	0.4276	0.4746	0.5166	0.5105	0.4873	0.5166

Result and Discussion

Based on **Table 5**, for the attributes related to students' involvement, attribute M_4 had the highest degree of similarity with $Sim(R, agree)_{max}$ =0.5262. The similarity value can be viewed as students had a high consensus level at 'Agree' that their ideas and suggestions were used during the game session. Note that for attributes M_3 to M_8, the maximum degree of similarity was also at level 'Agree'. However, for both attributes M_1 and M_2, the maximum similarity degree was at level 'Strongly Agree' with $Sim(R, strongly\ agree)_{max}$ =0.5173 and $Sim(R, strongly\ agree)_{max}$ =0.5157, respectively. These values show that students had a high unanimity at level 'Strongly Agree' that they discussed ideas and give opinions during the game session.

For attributes related to students' cooperation, attribute M_{13} had the highest degree of similarity with $Sim(R, strongly\ agree)_{max}$ = 0.5261. The value shows that students had a high agreement at the level of 'Strongly Agree' for the statement "I learn from other students when solving the questions". Three other attributes, M_{11}, M_{12}, and M_{14} also had maximum similarity measure at level 'Strongly Agree', with scores 0.5228, 0.5142, 0.5261, and 0.5202, respectively. The values can be viewed as a high degree of similarity among students who strongly agreed that there was teamwork and the students could work and learn from other students when solving the questions during the game session. While for the remaining attributes, M_9, M_{10}, M_{15}, and M_{16}, the maximum similarity degrees were at level 'Agree'.

The results of the analysis using fuzzy set conjoint model was also compared with the results obtained by percentage and statistical mean, as presented in **Tables 6** and **7**. The maximum value for percent and similarity degree for each attribute were highlighted.

Table 6 Comparison of results based on percentage, mean and fuzzy conjoint model for attributes M_1 to M_8 (Students' Involvement during the Game Session)

Attribute	Method	VSD	SD	D	U	A	SA	VSA	Level
M_1	Percent	0	4.8	1.2	7.2	45.8	20.5	20.5	Agree
	Mean				5.37				Agree
	Fuzzy Conjoint	0.4502	0.4342	0.4205	0.4538	0.5037	0.5173	0.5068	Strongly Agree
M_2	Percent	0	7.2	2.4	14.5	39.8	24.1	12.0	Agree
	Mean				5.07				Agree
	Fuzzy Conjoint	0.4522	0.4390	0.4275	0.4658	0.5104	0.5157	0.4962	Strongly Agree
M_3	Percent	0	2.4	3.6	25.3	42.2	22.9	3.6	Agree
	Mean				4.90				Agree
	Fuzzy Conjoint	0.4487	0.4340	0.4320	0.4881	0.5255	0.5063	0.4746	Agree
M_4	Percent	0	2.4	4.8	22.9	44.6	22.9	2.4	Agree
	Mean				4.88				Agree
	Fuzzy Conjoint	0.4488	0.4344	0.4325	0.4873	0.5262	0.5053	0.4717	Agree
M_5	Percent	0	4.8	0	16.9	47	24.1	7.2	Agree
	Mean				5.07				Agree
	Fuzzy Conjoint	0.4502	0.4347	0.4244	0.4710	0.5228	0.5130	0.4824	Agree
M_6	Percent	0	4.8	3.6	19.3	56.6	12.0	3.6	Agree
	Mean				4.78				Agree
	Fuzzy Conjoint	0.4505	0.4369	0.4307	0.4864	0.5221	0.4869	0.4570	Agree
M_7	Percent	0	3.6	1.2	14.5	49.4	24.1	7.2	Agree
	Mean				5.11				Agree
	Fuzzy Conjoint	0.4494	0.4334	0.4240	0.4695	0.5231	0.5133	0.4813	Agree
M_8	Percent	2.4	3.6	7.2	24.1	42.2	15.7	4.8	Agree
	Mean				4.66				Agree
	Fuzzy Conjoint	0.4539	0.4387	0.4372	0.4930	0.5153	0.4935	0.4694	Agree

Table 7 Comparison of results based on percentage, mean and fuzzy conjoint model for attributes M_9 to M_{16} (Students' Cooperation during the Game Session)

Attribute	Method	VSD	SD	D	U	A	SA	VSA	Level
M_9	Percent	1.2	3.6	1.2	8.4	50.6	25.3	9.6	Agree
	Mean				5.18				Agree
	Fuzzy Conjoint	0.4513	0.4334	0.4207	0.4593	0.5170	0.5165	0.4868	Agree
M_{10}	Percent	4.8	4.8	7.2	15.7	39.8	20.5	7.2	Agree
	Mean				4.71				Agree
	Fuzzy Conjoint	0.4588	0.4408	0.4207	0.4593	0.5170	0.5028	0.4868	Agree
M_{11}	Percent	1.2	3.6	4.8	4.8	42.2	25.3	18.1	Agree
	Mean				5.31				Agree
	Fuzzy Conjoint	0.4514	0.4347	0.4228	0.4521	0.5130	0.5228	0.4817	Strongly Agree
M_{12}	Percent	0	4.8	2.4	12	45.8	21.7	13.3	Agree
	Mean				5.17				Agree
	Fuzzy Conjoint	0.4503	0.4354	0.4248	0.4651	0.5130	0.5142	0.4932	Strongly Agree
M_{13}	Percent	0	4.8	2.4	8.4	39.8	26.5	18.1	Agree
	Mean				5.35				Agree
	Fuzzy Conjoint	0.4503	0.4349	0.4226	0.4537	0.5044	0.5261	0.5128	Strongly Agree
M_{14}	Percent	1.2	1.2	4.8	13.3	42.2	25.3	12.0	Agree
	Mean				5.18				Agree
	Fuzzy Conjoint	0.4496	0.4323	0.4263	0.4672	0.5141	0.5202	0.4968	Strongly Agree
M_{15}	Percent	1.2	2.4	3.6	10.8	48.2	22.9	10.8	Agree
	Mean				5.14				Agree
	Fuzzy Conjoint	0.4505	0.4332	0.4243	0.4656	0.5158	0.5143	0.4883	Agree
M_{16}	Percent	1.2	2.4	3.6	16.9	44.6	20.5	10.8	Agree
	Mean				5.06				Agree
	Fuzzy Conjoint	0.4506	0.4338	0.4276	0.4746	0.5166	0.5105	0.4873	Agree

Based on **Table 6**, for attributes M_3 to M_8, the results found by using fuzzy conjoint analysis were consistent with results obtained by percentage and statistical mean which were at linguistic value 'Agree'. However, for attributes M_1 and M_2, the linguistic values selected by fuzzy conjoint model were both 'Strongly Agree' which was not the same as the results recorded by percentage and statistical mean which were 'Agree'. Although the highest percentage for attributes M_1 and M_2 (45.8% and 39.8%, respectively) were at level 'Agree', the students had a high degree of similarity at level 'Strongly Agree'.

Based on **Table 7**, for attributes M_9, M_{10}, M_{15}, and M_{16}, the linguistic values obtained via fuzzy conjoint model were consistent with the results based on percentage and statistical mean which were at level 'Agree'. On the other hand, for attributes M_{11} to M_{14}, the results yielded

by fuzzy conjoint analysis differed from the calculated percentage and statistical mean. While the highest percentage for attributes M_{11}, M_{12}, M_{13}, and M_{14} (42.2%, 45.8%, 39.8%, and 42.2%, respectively) were at level 'Agree', the maximum similarity measure in students' perception were at level 'Strongly Agree'.

Even though the percentage for linguistic value 'Strongly Agree' was significantly lower than 'Agree', the degree of similarity among students' responses for 'Strongly Agree' were higher than 'Agree'. This can be seen, for example, for attribute M_{12} where the percentage between 'Strongly Agree' (21.7%) was lower than 'Agree' (45.8%). Yet, the maximum similarity degree for 'Strongly Agree' (0.5142) was slightly higher than 'Agree' (0.5130).

Conclusion

This paper is to study the students' perceptions of game-based mathematics classrooms by fuzzy set conjoint analysis. The survey was conducted to obtain the students' perceptions towards classroom learning environment. The Likert scale was represented by fuzzy set and, the scores of students' perceptions were the degree of similarities. As a result, from students' involvement, the highest degree of similarity was 0.52 which represented the level of 'Agree' that students' ideas and suggestions were used during the discussions in the game. While for cooperation item the highest of similarity at 0.518 with the level of 'Agree' were recorded. A positive perception among the student towards the game-based mathematics classroom was concluded from this result.

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Conflict of Interests

Author declares no conflict of interest.

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