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Students Perceived Quality of a Mathematics Game- Based Materials

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Abstract – *This study determine the quality of games students perceived for the game- based materials they develop after they experience playing a mathematics gameboard. Results from classical item and test analysis spreadsheet revealed that the prior knowledge of the students increased after the interventions were made and implemented and the characteristics of the game were considered helpful to improve the knowledge and confidence of the students in the lessons. These results have implications in- depth study and analysis to have conclusive results regarding the influence of the intervention in enhancing students' creativity.*

Keywords: *Game- based materials, Interventions, Prior Knowledge, Problem posing skills, Creativity, Retention, Criteria, Rubric Scoring guide*

INTRODUCTION

Game- based learning as a concept is structured around a learning process that uses specific game as the primary pedagogical tool which helps to arise and develop skills (Sousa & Rocha, 2019). For instance, in the teaching of Synthesizing Proteins (Cavalho, Beltramini,& Bossolan, 2019) utilizes a board game in providing a symbolic representation of the process synthesizing the protein through interactions and guided by the rules where students played the roles of molecules, simulated mechanisms and processes. These interactions, where done in a cooperative and competitive manner that promote a meaningful and prospective learning.

DepEd memorandum order number 270 s. 2008 stipulated that teachers are encouraged to develop a sustainable strategic intervention in the fields towards gearing up for global competitiveness. In the work of Crespo & Sinclair (2008), they presented an intervention approach explicitly problem posing,

where students acquire new concepts and ideas in Mathematics based on a given situation. This approach helped students develop their ability to solve higher mathematical problems that is related to the questions they formulated.

On the other hand, when students presented the mathematics concepts which are cognitively structured that develop higher levels of thinking, they usually cannot focus and easily get bored when working with these problems (Brown, Brown, & Bibby, 2008; Lazaries & Buchholz, 2019).

Considering the situations mentioned above, there is a need of developing an intervention approach in teaching to remove the presence of boredom and help improve students' performance. In this paper, this intervention can be used for developing the competencies and problem posing skills of the students. Through the use of games in teaching Mathematics, concepts such as the four fundamental operations and inequalities, exponentiation, and taking the square root of the numbers may improve the students' retention level and enjoy the process of learning. Although, it may sound a bit basic for the students by teaching of these concepts, especially for the higher level, e.g., grade 11, this is important since learning higher Mathematics requires the mastery of the basic operations. Recently, Fischer, Vilette, Joffredo-Lebrun, Morellato, Le Normand, Scheibling-Seve, & Richard, (2019)argued that teaching of these operations are important since there is a negative consequence of the possibility of using calculators, tablets, and computers in Mathematics classroom. Although it is easier to get a value when using such technology, but it could impair other competencies such as retention and automaticity of retrieval of information from long term memory.

On the other hand, students' creativity in creating games will be assessed through a problem posing approach. This approach is based on the problem posing structured developed by Brown and Walter (2005) and that will be used for the development of educational related games.

Conceptual Framework

Game-based learning is based on the integration of games into the classroom to create a level of motivation and achievement by Becker (2017). A number of studies revealed that these games have a positive effect on the students' education since they empower the engagement and attitude towards the lesson content (Blunt, 2009).

Jean Piaget's theory of constructivism offers a window into what students are interested in and able to achieve at different stages of their development. Also, it argues that students produce knowledge and form meaning based upon their experiences. This theory also provides a roadmap for teachers, especially in Mathematics to help childrens' cognitive development by applying games to get a better knowledge (Ojose, 2008).

In this matter, a game- based learning is built upon a constructivist type of learning. Wherein, constructivism posits the need to provide student with necessary tools such as game so they can build their own procedures in order to solve a mathematical problem. This implies a participatory process by students, who interact with their environment to solve the situation that is being set out to them in order to learn.

However, learning may occur in a variety of locations such as school, classroom, laboratory, field and so on. Learning environment not only refers to physical locations, it encompasses learning resources and technology such as game- based materials. This learning material may be considered as a new environment in the reason that the students learned a new way of the learning process where this material helps to enhance and motivate students' interest and understanding and develop students' knowledge and skills in mathematics.

Accordingly, learning through games allows any person to accommodate with the new environment, overcome the obstacles and reaches balance again (Becker, 2017). Becker also identifies that in the 21st century students are no more accustomed to the drill and practice strategies. They build their individual learning in their own pace and evolve it to cover deep learning process through enhancing the retention of the concepts. Nurturing structured problem posing ability can enhance creativity. These characteristics help those students developed games, since the game requires a certain level of creativity and interactivity.

The theories mentioned above, students determined the characteristics of the game that they considered helpful such as competitive (Menesini et. al., 2018) where the students improve their teamwork and collaboration, enhance social and emotional learning, increase respect for academics and interest in learning, increase intrinsic motivation, enhance beneficial peer comparisons, and strengthen academic self-concept, cooperative (Atxurra, et. al., 2015) where it helps to raise students' achievement, build positive relationships among students which are important for creating a learning community that values diversity, and provide experiences that develop both good learning and social skills, and meaningful (Spooren, et. al., 2008) where it helps to stimulate the learner to bring in a lot of prior knowledge and personal experience that makes the learning more meaningful and to reinforce the learning and improves long-term memory. These characteristics serve as a tool to the students in developing game- based materials.

Students' creativity in creating games assessed through a problem posing approach. This approach of creating a game is based on the problem posing structured approach developed by Brown and Walter (2005), in which students developed constructive learning based on the work of many psychologists and educators like Jean Piaget, Jerome Bruner and Lev Vygotsky (Saad, 2014). It builds on prior knowledge and connects it to the new information; thus, the students apply personal learning (Dewey, 1916; Von Glaserfeld, 1987) where learning is produced in the context of constructivism, in which the problem posing approach was applied through their experiences and learning in playing the game. These are the reasons that the students develop their own games. This works on the initial function of the mind where it creates and views things in a chronological order (Piaget, 1971). Robinson (2004) supports the work of Piaget (1980) that getting older changes the minds' conceptualization, especially through experimentation. This testing gives students a credit in full understanding without forgetting the experiment (Piaget, 1980). In addition, Vygotsky (1978) established a "zone of proximal development" in which the student depends on others' teaching to reach full understanding.

The theory mentioned fits in this research since students enthusiastically form on their prior knowledge, and get support from one of the advanced students. This is to achieve the goal when students face new knowledge and encounter it with existing ones. Saad (2014) affirms from Cooper (1993) that constructivists assure that learning is deep-down and inspiring accompanied by problem posing and investigating. They considered that the students build their personal education based on lively investigations and becomes active students when placed in a real-world environment.

Research Problems

This study determined the quality of games students perceived for the game- based materials they develop after they experience in playing mathematics boardgame.

Specifically, it provided answers to the following:

1. What is the level of students' prior knowledge in terms of the following operations:

1.1. addition;

1.2. subtraction;

1.3. multiplication;

1.4. division;

1.5. inequalities symbols such as < and >;

1.6. exponentiation; and

1.7. taking the square root of a number?

2. After the first intervention, how did the students' evaluate the value of games in connection to their knowledge in the operations mentioned in problem 1?

3. To what extent are the following characteristics of the game that students considered helpful in terms of:

3.1 Competitive;

3.2 Cooperative; and

3.3 Meaningful?

4. From the students developed criteria, what scoring guide can be developed?

5. What are the games developed by the students based on the games they encountered?

METHOD

In gathering the needed information and data, the researcher will utilize single case design Riley-Tillman, Burns, and Kilgus, (2020) particularly the B-design. The design is a descriptive one, unlike the experimental single case, the single case will only provide correlation rather than effect since there other variables not measured in the study that might cause the results to improve.

The pre- test will be conducted before the interventions implemented to measure the students' prior knowledge in the following terms such as addition, subtraction, multiplication, division, inequalities such as < and >, exponentiation and taking square root of a number. During the interventions, students' evaluate the value of games in connection to their knowledge in the operations mentioned in problem 1, determine the characteristics of the game considered helpful, develop scoring guide based on how students perceived the important of a criteria and from their developed new criteria, develop games and the mathematics teachers use their developed criteria to judge the games they developed based on the game they previously encountered. After the interventions implemented, students are given a break of weeks before the post- test will be conducted. To determine if the knowledge of students improve through the exposure of the interventions implemented, the different between the pre and post- test will be computed.

RESULTS AND DISCUSSION

Table 1. Level of Knowledge in Pre and Post test

Level of Knowledge in terms of	Pre-test		Post- test		Diff.
	$\bar{X}$	SD	$\bar{X}$	SD	
+	0.90	0.70	2.60	0.62	1.70
–	2.26	1.00	3.65	0.57	1.39

×	1.89	0.75	2.72	0.55	0.83
÷	3.18	1.52	5.38	0.85	2.20
<, >	0.82	0.70	1.63	0.59	0.81
$\mathbf{X^2}$	2.74	1.34	4.57	0.71	1.83
√	1.16	0.69	1.58	0.62	0.42
Ave	13.5	4.27	22.1	2.98	8.61

Table shows the level of knowledge of the students of the same type of questions and number of test items as tabulated and interpreted in pre- test where the mean and standard deviation of addition, subtraction, multiplication, division, inequalities such as < and >, exponentiation, and taking square root of a number are as follows: 0.90(0.70), 2.26(1.00), 1.89(0.75), 3.18(1.52), 0.82(0.70), 2.74(1.34) and 1.16(0.69), where the average mean and standard deviation is 13.50 (4.27) indicating that the level of students' knowledge is "low". Whereas, the mean and standard deviation of the students' knowledge in terms of addition, subtraction, multiplication, division, inequalities such as < and >, exponentiation, and taking square root of a number in post- test are as follows: 2.60(0.62), 3.65(0.57), 2.72(0.55), 5.38(0.85), 1.63(0.59), 4.57(0.71) and 1.58(0.62), where the average mean and standard deviation is 22.11(2.98) indicating that the level of students' knowledge is "high". The difference mean of students' knowledge in terms of as mentioned above are as follows: 1.70, 1.39, 0.83, 2.20, 0.81, 1.83, and 0.42 with an average mean of 8.61 indicates that the games help students to improve their knowledge. As a matter of fact, students' knowledge with the highest average mean (M= 22.11, SD= 2.98) described as "strongly prove" that their knowledge highly increases through their developed games. Meanwhile, with the lowest average mean (M=13.50, SD= 4.27) described as "prove" that the teacher let his students develop and play an educational games.

Thus, with the highest mean where students preferred to develop and play educational games, this only means that the students improve their retention and enjoy the process of learning. While this remains an advantage, there is also an advantage in terms of the students' problem posing skills through playing educational games. On top of it was that, the teachers were helped their students to develop creativity through games.

This simply corresponded that students develop their ability to solve higher mathematical problems that are related to the questions they developed while creating/developing and playing educational games instead.

The students were evaluated of the value of games through the characteristics of the games considered helpful to their learning such as competitive, cooperative and meaningful as shown in table 2.

Table 2. Extent of the Characteristics of the Games that Considered Helpful

Characteristics of the Games	$\bar{X}$	SD	QD	VI	RANK
A. Competitive	3.364	0.426	VH	SA	2
B. Cooperative	3.390	0.442	VH	SA	1
C. Meaningful	3.348	0.444	VH	SA	3
Average	3.367	0.432	VH	SA	

Tabular values showed that respondents agreed with "strong conviction" of the characteristics of the games that are considered helpful. In fact, the overall mean of 3.367 (SD = 0.432) indicates that participants "strongly agree" that these characteristics helped students to boost their knowledge as well as their confidence in terms of the operations mentioned in problem 1.

From the students developed criteria, a rubric scoring guide for the games they developed. In fact, it is important for the students to be able to evaluate the existing knowledge and skills of the students in terms of defined criteria as well as to include themselves in the evaluation process.

The games developed by the students based on the games they encountered are the mathematical board games.

Findings

The findings are as follows:

1. The students results from the pre-test showed that their scores on the items are moderately high, that is, out of 40 items the average score is about 24. This means that students prior knowledge on the contents used in the test is at the average level.
2. Students' developed a scoring rubric according to how they perceived a game to be useful and effective. These developed rubrics were used by the teachers for evaluating the games they created after they experience in playing the game. The characteristics of the game that students considered helpful were competitive, cooperative, and meaningful. Although they did not explicitly describe what is meant by meaningful.
3. The games students developed varies a little from the original game they encountered by simply adding colors, "emoji" or images of faces. The emoji they used are commonly found in social media as a form of reactions for the post a member of the platform created.
4. The intervention of using problem posing as an approach to vary the elements of the game students can create did not help much in their developed games.
5. The developed games of students did not show much of creativity since the original form of the games were they have experience playing with almost reflect the same form compared to their creations.

Conclusions

Based on the findings presented in this study, it is concluded that:

1. The games removed the presence of boredom in order to improve student's performance. Also, it impaired other competencies such as retention and automaticity of information from long term memory.
2. The students find appreciation for the games they played and find it meaningful but this did not transform into the level where they can apply. While this remains an advantage, there is an advantage also in terms of the characteristics of the games suitable to the learning needs of the students.
3. The characteristics of the game such as competitive, cooperative, and meaningful were considered helpful to improve the knowledge of the students based on how they perceived important characteristics a game must contain as well as their confidence to participate the lessons. The explicit meaning of these concepts was not given and explains further by the students.

4. The scoring guide helped students in evaluating the parts and products of the games they developed also the teachers who evaluated the games they developed. Thus, it demonstrated that the students made evaluations as "good".
5. The students developed board games for developing their competencies in Mathematics using problem posing approach, it did not vary much from the original games, hence, creativity was not enhanced. The games students developed almost replicate the previous game they encountered.

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