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STUDENTS PERCEIVED QUALITY OF A SELF-CREATED MATHEMATICS GAME-BASED MATERIALS

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Abstract

This study determined the quality of games students perceived for the game-based materials they develop after they experience playing a mathematics gameboard. The participants in this study were 88 students in 11th-grade Senior High School composed of 40 students in Sohoton General Academic Strand and 48 students in Kanlanuk Technical-Vocational Livelihood, selected through convenience non-random sampling. Through created games by students, it removed the presence of boredom that improved their performance. It impaired other competencies such as retention and automaticity of information from long-term memory. Moreover, students have developed the competitive, cooperative, and meaningful characteristics of the games, which was considered helpful in improving their knowledge based on how they perceived its' characteristics are important to contain in the game, and their confidence to participate in the lessons. Results from the classical item and test analysis spreadsheet revealed that the prior knowledge of the students increased after the interventions were made and implemented. The characteristics of the game were considered helpful to improve students' knowledge and confidence in the lessons. These results have implications for in-depth study and analysis to have conclusive results regarding the influence of the intervention in enhancing students' creativity.

Keywords: Creativity, Game-based materials, Prior knowledge, Problem posing skills, Rubric scoring guidelines.

Abstrak

Penelitian ini menentukan kualitas permainan yang dipersepsikan siswa untuk materi berbasis permainan yang mereka kembangkan setelah mereka mengalami bermain papan permainan matematika. Partisipan dalam penelitian ini adalah 88 siswa kelas 11 SMA yang terdiri dari 40 siswa Sohoton General Academic Strand, dan 48 siswa Kanlanuk Technical-Vocational Livelihood, yang dipilih melalui convenience non-random sampling. Melalui permainan yang dibuat siswa, itu telah menghilangkan hadirnya kebosanan sehingga meningkatkan kinerja mereka. Hal ini merusak kompetensi lain seperti retensi dan otomatisitas informasi dari memori jangka panjang. Selain itu, siswa telah mengembangkan karakteristik kompetitif, kooperatif, dan bermakna yang dianggap membantu mereka meningkatkan pengetahuan berdasarkan bagaimana mereka mempersepsikan karakteristik tersebut penting untuk terkandung dalam permainan, dan kepercayaan diri mereka untuk berpartisipasi dalam pelajaran. Hasil dari spreadsheet analisis item dan tes klasik mengungkapkan bahwa pengetahuan awal siswa meningkat setelah intervensi dibuat dan dilaksanakan. Karakteristik permainan dianggap membantu untuk meningkatkan pengetahuan dan kepercayaan diri siswa dalam pelajaran. Hasil ini berimplikasi pada kajian dan analisis mendalam untuk mendapatkan hasil konklusif mengenai pengaruh intervensi dalam meningkatkan kreativitas siswa.

Kata kunci: *Keterampilan mengajukan masalah, Kreativitas, Materi berbasis permainan, Pedoman rubrik penskoran, Pengetahuan awal.*

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INTRODUCTION

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

DepEd Memorandum No.270 s.2008 (Department of Education Republic of the Philippines, 2008) stipulated to teachers are encouraged to develop a sustainable strategic intervention in the fields towards gearing up for global competitiveness. In the work of Crespo and 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 are 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; Lazarides & 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. This skill creates new problems for investigating a given situation as well as reformulating a problem during its solving process by Shafie, Shahdan, and Liew (2010). Furthermore, this problem posing skill is relevant to the mentioned situation, it was the students formulate or make a question about the given situation and then they solve it as Asfaroh and Ekawati (2019) claimed in their study. The study was conducted through pre-solution posing which focused on making questions based on the situation or information that will provide an open problem that can develop students' mathematical connections. Apart from that, a semi-structured situation is one of the situations on problem posing that ask students to pose a problem from an

open condition which has a chance to be completed by applying prior mathematical knowledge or concepts. 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 that teaching these concepts, especially for the higher level, e.g., 11^{th} grade, this is important since learning higher Mathematics requires the mastery of the basic operations. Recently, Fischer et al. (2019) argued that teaching 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, 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 developed the problem posing structure by Brown and Walter (2005) and it 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 (Becker, 2017). A number of studies revealed that these games have a positive effect on students' education since they empower their engagement and attitude toward 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 on their experiences. This theory also provides a roadmap for teachers, especially in Mathematics to help children's cognitive development by applying games to get better knowledge (Ojose, 2008).

In this matter, game-based learning is built upon a constructivist type of learning. Wherein, constructivism posits the need to provide students with necessary tools such as games 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 schools, classrooms, laboratories, fields, and so on. Learning environment not only refers to physical locations but also encompasses learning resources and technology such as game-based materials. This learning material may be considered as a new environment for 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 the new environment, overcome obstacles, and reach 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 at their own pace and evolve it to cover the deep learning process by enhancing the retention of the concepts. Nurturing structured problem posing ability can enhance creativity. These characteristics help those students develop 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, Tassi, & Nocentini, 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, Villardon-Gallego, & Calvete, 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, Mortelmans, & Denekens, 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 for the students to develop game-based materials.

Students' creativity in creating games was assessed through a problem posing approach. This approach of creating a game is based on the developed problem posing structure approach 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 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 and Cole (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 Cooper (1993) about 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 become active students when placed in a real-world environment.

Research Problems

This study determined the quality of games that students perceived for their developed game-based materials after they had experienced 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: (a) addition, (b) subtraction, (c) multiplication, (d) division, (e) inequalities symbols such as < and >, (f) exponentiation, and (g) 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 of the mentioned operations on problem 1?
3. To what extent are the following characteristics of the game that students considered helpful in terms of: (a) Competitive, (b) Cooperative, and (c) 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?

RESEARCH METHODS

In gathering the needed information and data, the researcher will utilize a 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 were other variables not measured in the study that might cause the results to improve. There were 88 students who participated in this study who are composed of 15 males and 25 females a total of 40 students in Grade-11 Sohoton General Academic Strand (GAS) and 28 males and 20 females a total of 48 students in Grade-11 Kanlanuk Technical-Vocational Livelihood (TVL) of a Senior High School were the study is conducted.

The scheme visualized the research procedure to answer problems for this study is shown in Figure 1.

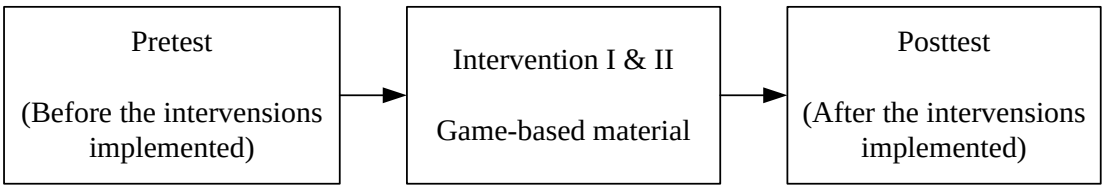

Figure 1. Research procedure's scheme

Based on Figure 1, a pretest had been conducted before the interventions were implemented. It was to measure the students' prior knowledge in the following terms such as addition, subtraction, multiplication, division, inequalities such as < and >, exponentiation, and taking the square root of a number. During the interventions, students evaluate the value of games in connection to their knowledge of the operations mentioned in problem 1, determine the characteristics of the game considered helpful (the category refers to Table 1), develop a scoring guide based on how students perceived the important criteria and their developed new criteria, develop games and then the mathematics teachers use their developed criteria to judge the games they developed based on the game they previously encountered.

After the interventions had been implemented, students were given a break of weeks before the posttest will be conducted. To determine if students' knowledge improved through the implemented interventions, the difference between the pre and posttest will be compared. Through students' experiences had been playing the introduced games by their teacher, the 88 students who participated in this study developed their own games.

As a matter of fact, in their developed games, it is also developed their competencies in mathematics and a problem posing approach to help them gain a competitive advantage globally. Also, through using these games, concepts such as the mentioned operations in the problem are highly improved in terms of their retention and enjoyment in the process of learning.

Tabel 1. Scale for characteristics of the game

Scale	Verbal Interpretation (VI)	Qualitative Description (QD)
1 – 1.75	Strongly Disagree (SD)	Very Low (VL)
1.76 – 2.5	Disagree (D)	Low (L)
2.51 – 3.25	Agree (A)	High (H)
3.26 – 4	Strongly Agree (SA)	Very High (VH)

RESULTS AND DISCUSSION

Table 2 shows the level of knowledge of the students of the same type of questions and number of test items as tabulated and interpreted in a pretest where the mean and standard deviation of addition, subtraction, multiplication, division, inequalities such as < and >, exponentiation, and taking the 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 student's knowledge is "low".

Table 2. Level of Knowledge in Pre and Post test

Level of Knowledge in terms of	Pretest		Posttest		Diff.
	$\overline{X}$	*SD*	$\overline{X}$	*SD*	
$+$	0.90	0.70	2.60	0.62	1.70
$-$	2.26	1.00	3.65	0.57	1.39
$\times$	1.89	0.75	2.72	0.55	0.83
$\div$	3.18	1.52	5.38	0.85	2.20
$<,>$	0.82	0.70	1.63	0.59	0.81
X^2	2.74	1.34	4.57	0.71	1.83
$\surd$	1.16	0.69	1.58	0.62	0.42
Average	13.5	4.27	22.1	2.98	8.61

Also, the minimum and maximum are 12 and 32 in the level of students' prior knowledge test where the scale is also used in students' gain knowledge test. Whereas, the mean and standard deviation of students' knowledge in terms of addition, subtraction, multiplication, division, inequalities such as < and >, exponentiation, and taking the square root of a number in posttest 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 the standard deviation is 22.11(2.98) indicating that the level of student's knowledge is "high". Also, the minimum and maximum are 16 and 25 in the level of students' gain knowledge test. The difference mean scores 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 indicating 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) was described as "strong proof" that their knowledge highly increases through their developed games. Meanwhile, the lowest average mean (*M*=13.50, *SD*= 4.27) was described as "proof" that the teacher let his students develop and play 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. Teachers 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 by the value of games through the games' characteristics that have been considered helpful to their learning. These games' characteristics were competitive, cooperative, and meaningful. The mean and standard deviation of these characteristics have been computed by students' evaluation in their statements about how the description of the game is related to the three characteristics, it is shown in Table 3.

Table 3. Extent of the Characteristics of the Games that Considered Helpful

Characteristics of the Games	$\overline{X}$	*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	

Table 3 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 developed criteria by students, they developed the rubric scoring guidelines for the games. In fact, it is important for students able to evaluate their existing knowledge and skills. The developed guidelines are about the terms of defined criteria by them, and they included themselves in the evaluation process.

The developed games by students is the mathematical board game based on the games encountered themselves.

Findings

The findings are as follows. (1) The student's results from the pretest, according to Fischer et al. (2019), showed that their scores on the items are moderately high, that is, out of 40 items the average score is about 24. It means that students' prior knowledge about the used contents in the test is on the average level. (2) Students developed a scoring rubric, according to Ak (2012), it is about how they perceived a game to be useful and effective. These developed rubrics were used by the teachers for evaluating the created games by students after students experienced playing the game. The characteristics of the game were considered helpful to students such as competitive by Menesini et al. (2018), cooperative by Atxurra et. al. (2015), and meaningful by Spooren et. al. (2008). Although they did not explicitly describe what is meant by meaningful. (3) The developed games by students had little variation rather than the original game encountered them. They just added simple colors, the "emoji" or images of faces. Students used common emojis which can be found in social media as a reaction to the created post by platform members. (4) Varying the games' elements by students' creation through the problem posing approach did not help much to their developed games. (5) The developed games by students did not show much creativity since the original form of the games almost reflects the same form of their experienced games if it was compared to their creations.

CONCLUSION

Based on the findings presented in this study, it is concluded that: (1) The games removed the presence of boredom in order to improve students' performance. Also, it impaired other competencies such as retention and automaticity of information from long-term memory. (2) The students found appreciation and meaning for the played games, but it did not transform into the level where they can apply. While this remains an advantage,

there is an advantage also in terms of the suitability of games' characteristics with students' needs for learning. (3) The characteristics of the game such as competitive, cooperative, and meaningful were considered helpful to improve students' knowledge based on how they perceived the important characteristics to be contained as well as their confidence to participate in the lessons. The explicit meaning of these concepts was not given or explained further by the students. (4) The scoring guideline not only helped students to evaluate the parts and products of the developed games by them but also the teachers evaluated the games. Thus, it demonstrated that the students made evaluations as "good". (5) The students developed board games for improving their competencies in Mathematics by using the problem posing approach, it did not vary much from the original games, hence, creativity was not enhanced. The developed games by students almost replicate with they encountered in the previous game.

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