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IMPROVING STUDENTS' MATHEMATICS SELF-EFFICACY AND LEARNING ACHIEVEMENT THROUGH GAME-BASED APPROACH IN INSTRUCTION

Gerald DG. Mabuti
Faculty, Nueva Ecija University of Science and
Technology, Cabanatuan City, 3100, Nueva Ecija, Philippines
mabutigerald17@gmail.com, +639264474920

ABSTRACT

This study entitled "Improving Students' Mathematics Self-Efficacy and Learning Achievement Through Game-Based Approach in Instruction" determined and investigated the effects of the integration of game-based approach in instruction in the students' mathematics self-efficacy and learning achievement. This study was conducted at Aliaga National High School during the first quarter of the school year 2022-2023. The subjects, with a total of forty (40) students, were selected using purposive sampling. The quasi-experimental research design was utilized in this study, specifically the pretest-posttest design. The findings of this study revealed that the integration of game-based approach in instruction yield a positive effect on both mathematics self-efficacy and learning achievement. The students' mathematics self-efficacy and learning achievement was improved as reflected on the scores obtained by the students. There is a significant difference in the mathematics self-efficacy and learning achievement of the students before and after the integration of game-based approach in instruction. Game-based approach in instruction contributed in improving the students' mathematics self-efficacy and learning achievement. It was also found out that there is a significant relationship between the mathematics self-efficacy and learning achievement of the students.

Keywords: game-based, self-efficacy, learning achievement

INTRODUCTION

In most cases of everyday classroom discussions, it is not surprising that learning mathematics has been one of the most challenging learning tasks. Learning mathematics provides various challenges to most of the students due to the difficult nature of the subject (Tokac et.al, 2018). According to Mahanta (2019), mathematics tends to be difficult to those students who lack an understanding on the fundamental concepts in mathematics. In addition, students do not have enough confidence on their skills that is why they are afraid on doing Mathematical calculations. Another factor is that some students are lacking adequate support in learning Mathematics concepts which are harder to understand. As a result, majority of the students failed to master the competencies in Mathematics which implies a low performance on the subject.

At present times, low achievement and low participation in mathematics are matters of concern in many countries including the Philippines. The 2018 Program for International Student Assessment (PISA) results showed that the Philippines scored 353 in Mathematics which was below the average of participating countries. During the international assessment conducted by the Trends in International Mathematics and Science Study 2019 (TIMSS), it

was revealed that the Philippines scored significantly lower than any other country that participated in math and science assessments.

Mathematics learning achievement refers to the knowledge and skills a student has learned in particular content areas in mathematics (Shear, 2020). Many studies over the years have been conducted in an effort to improve the learning achievement of the students in mathematics. In the study conducted by Ishmirekha (2017), data revealed that online learning has a positive impact on the learning achievements of the students. Similar findings were presented by Elfaki et.al (2019) who concluded that online learning significantly improved the academic performances and learning processes of the students compared to the traditional learning. Choi and Chang's (2011) study revealed that students' attitudes toward mathematics also had a significant effect on their mathematics performance. This implies that when the students have a positive attitude towards mathematics, they tend to perform better in mathematics classes. Additionally, Suren and Kandemir (2020) found out that mathematics anxiety and motivation affects students' mathematics learning achievement. Based on these researches, it can be synthesized that teacher's strategies or approaches in instruction and affective factors in learning have significant effect in the students' learning achievement in mathematics.

Successful mathematics instruction is centered on the interests and the experiences of the learners (Linder, 2015). One classroom activity that promotes student-centeredness is the integration of game-based approach in learning (White and McCoy, 2019). Basically, Game-based approach in instruction is a kind of pedagogical activity, which integrates games into teaching in achieving the educational goals (Zhang, 2018). The application of game-based learning is seen to be beneficial in improving the quality of the teaching and learning process and it encourages students to solve problems and self-learning thus, enabling students to learn mathematical concepts (Ramli et.al, 2020). Game-based learning was found out to be effective in developing students' motivation and critical thinking (Cicchino, 2015; Habgood and Ainsworth, 2011). Researchers who conducted studies to develop educational games for learning mathematics proved that game-based approach could facilitate mathematics performance, enjoyment, and self-efficacy (Ku et al. 2014; McLaren et al. 2017). Game-based approach in instruction develops good basic mathematical skills (Okur and Aygenc, 2018).

Another important factor that determines the students' learning achievement in the learning process is the self-efficacy. According to Perez and Ye (2013), in an academic setting, self-efficacy reflects the confidence of the students in performing specific learning tasks. Self-efficacy determines the students' motivation as reflected in the efforts exerted and the length of time dedicated in the completion of certain tasks (Negara et.al, 2021). Similarly, mathematics self-efficacy can be described as how confident the students are in completing various learning tasks, from understanding the basic concepts to solving problems in mathematics (Masitoh and Fitriyani, 2018). Students with low mathematics self-efficacy tends to show lack of efforts in completing the tasks at hand and in solving problems in mathematics. They are also the students who lack motivation in learning mathematics. Thus, self-efficacy has a direct effect on how the students learn.

The integration of game-based approach in instruction is a shift on the traditional approach on how students learn and in turn, how learners will be taught. Therefore, there is a need to

understand its effect on the students' learning achievement and also on their mathematics self-efficacy, as an important factor in learning. In light of this, the researcher decided to conduct this study entitled "Improving Students' Mathematics Self-Efficacy and Learning Achievement Through Game-Based Approach in Instruction". This study aims to assess the effects of the integration of game-based approach in instruction in the students' mathematics self-efficacy and learning achievement.

Statement of the Problem

Generally, this study aimed to determine and investigate the effects of game-based instruction on the students' mathematics self-efficacy and learning achievement.

Specifically, this research sought to answer the following questions:

1. How may the students' mathematics self-efficacy and learning achievement be described before the integration of game-based approach in instruction?
2. How may the students' mathematics self-efficacy and learning achievement be described after the integration of game-based approach in instruction?
3. Is there a significant difference in the students' mathematics self-efficacy and learning achievement before and after the experiment?
4. Is there a significant relationship between the students' mathematics self-efficacy and learning achievement?

Hypothesis

Ho_1 = There is no significant difference in the mathematics self-efficacy of the students before and after the integration of game-based approach in instruction.

Ho_2 = There is no significant difference in the mathematics learning achievement of the students before and after the integration of game-based approach in instruction.

Ho_3 = There is no significant relationship between the mathematics self-efficacy and learning achievement of the students.

Research Design

One group pretest posttest quasi-experimental research design was utilized in this study. Like the true experimental design of research, quasi-experimental design also aims to establish a cause-and-effect relationship between the independent and dependent variables. However, it does not rely on randomization among the students. Instead, they are assigned to groups based on non-random criteria set by the researcher (Thomas, 2020).

Research Locale

This research study was conducted at Aliaga National High School located at Poblacion East II, Aliaga, Nueva Ecija. Established on 1946, Aliaga National High School is one of the oldest high schools in the province, and also one of the top performing schools in the field of mathematics in the Division of Nueva Ecija.

Subjects of the Study

The subjects of this study comprised of Grade 7 students from Aliaga National High School. The participants of this study consisted of twenty-three (23) male and nineteen (19) female students with a total population of forty-two (42).

Research Instruments

In obtaining the data needed for the different stages of this study, the researcher utilized two (2) instruments, as follows: Modified Mathematics Self-Efficacy Questionnaire and Proficiency Test in Mathematics 7 - Quarter 1.

Proficiency Test in Mathematics 7 – Quarter 1. This instrument was a teacher-made test consisting of 50 multiple choice items with mathematics competencies taught under the First Quarter of the school year. This was used to assess the learning achievement of the respondents before and after the integration of game-based approach in instruction. The students were given one point for every correct response.

Modified Mathematics Self-Efficacy Questionnaire. This instrument was designed to measure the level of self-efficacy of the subjects of this study before and after the integration of game-based approach in instruction. It was adopted from an existing instrument called Mathematics Self-Efficacy Questionnaire which was already used by many authors to measure the level of self-efficacy of the students with regards to mathematics.

Data Gathering Procedures

The following are the different stages by which the researcher underwent in conducting this study:

- The researcher ensured that a permission to conduct the study was given by the authority before the experiment started.
- The researcher prepared drafts of the instruments used and validated by the experts in the field which consisted of one (1) master teacher and one (1) head teacher. After feedbacks were provided by the experts in the field, the instruments were utilized.
- Modified Mathematics Self-Efficacy Questionnaire and the pretest was administered to determine the initial self-efficacy and learning achievement of the students before conducting the experiment.
- Game-based approach in instruction was employed once every week for the whole first quarter of the school year 2022-2023. The different classroom games served as the activities during the application stage of the instruction. These include “Last Mathematician Standing”, “Integer War Game”, “Integer Android Game”, “Team Quiz Bee”, “Flash Cards Mania”, “My Tribe Will Survive” and “Family Feud”.
- The instruments were administered again to determine the students’ mathematics self-efficacy and learning achievement after the integration of game-based approach in instruction.
- After administering the tests and obtaining the scores, significant differences were determined between the pretest and posttest scores of the students. Comparison between

the mathematics self-efficacy before and after the experiment was done. Responses from the subjects were recorded and subjected for data analysis.

Data Analysis Technique

The data gathered in this study were organized, presented, analyzed, and interpreted using statistical tools such as t-test for dependent samples and Pearson r. Statistical software such as Excel 2019 and Statistical Packages for Social Sciences (SPSS) were utilized.

1. To describe the students' mathematics self-efficacy before and after the experiment, **scores and weighted mean score** were used and were interpreted using the following interval.

Interval	Verbal Interpretation
64 – 75	Very High
52 – 63	High
40 – 51	Medium
28 – 39	Low
15 – 27	Very Low

2. To describe the students' mathematics learning achievement before and after the experiment, **scores and mean score** in each group were used and were interpreted using the following interval.

Interval	Verbal Interpretation
41 – 50	Excellent
31 – 40	Very satisfactory
21 – 30	Satisfactory
11 – 20	Fair
0 – 10	Needs improvement

3. To determine if there is a significant difference between the pre-test and post-test scores of the students, **T– test for dependent samples** was used.
4. To determine if there is a significant difference between the mathematics self-efficacy before and after the game-based instruction, **t-test for dependent samples** was also employed in data analysis.
5. To determine if there is a relationship between the students' mathematics self-efficacy and learning achievement, **Pearson r** was utilized.

RESULTS AND DISCUSSIONS

1. Mathematics Self-Efficacy and Learning Achievement Before the Integration of Game-Based Approach in Instruction

a. Mathematics Self-Efficacy

Before the integration of game-based approach in instruction, the students were tasked to answer the Modified Self-Efficacy Questionnaire to determine their initial mathematics self-efficacy. Based on the results, data revealed that majority of the students

have low mathematics self-efficacy (69.05%). Overall, the mathematics self-efficacy scores of the students were 37.33 in average. Summary of the findings was presented on Figure 1.

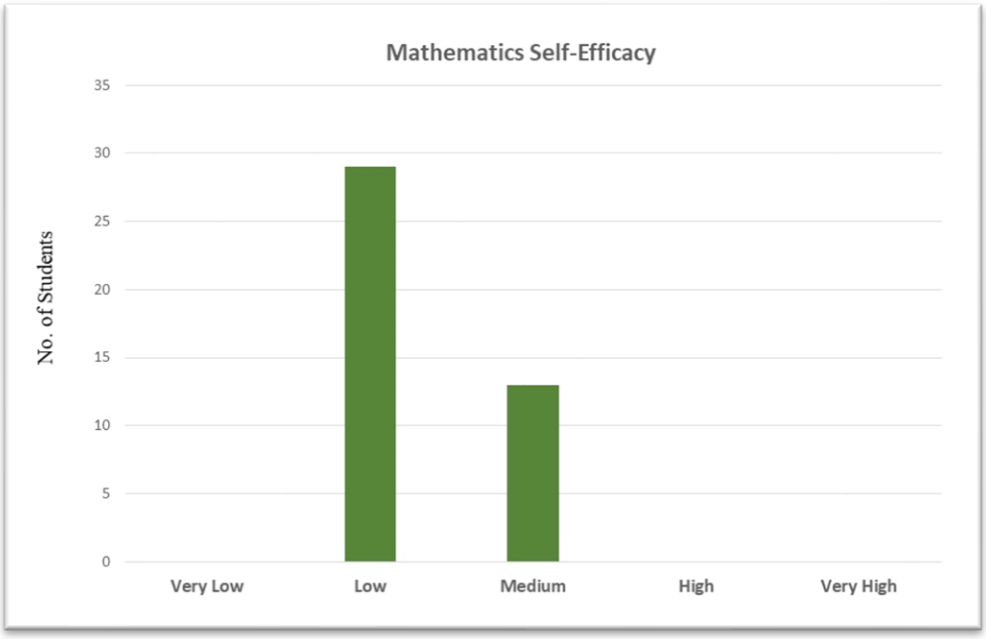

Figure 1. Mathematics Self-Efficacy Before the Experiment

b. Learning Achievement

Learning achievement is a measure of the success of the students in learning a particular subject matter. In this study, learning achievement refers to the test scores of the students in the Proficiency Test in Mathematics 7 – Quarter 1.

Figure 2. Learning Achievements of the Students Before the Experiment

The data revealed that the learning achievement of the subjects before the integration of game-based approach in instruction is "fair" with a mean score of 20.48. It can be inferred that the

subjects have a limited knowledge on the mathematics competencies for the first quarter of the school year. There was a need for intervention to improve their skills in these competencies.

2. **Mathematics Self-Efficacy and Learning Achievement After the Integration of Game-Based Approach in Instruction**

a. **Mathematics Self-Efficacy**

After the integration of the game-based approach in instruction, the mathematics self-efficacy of the students was once again measured using the Modified Mathematics Self-Efficacy Questionnaire. Results were presented on Figure 3.

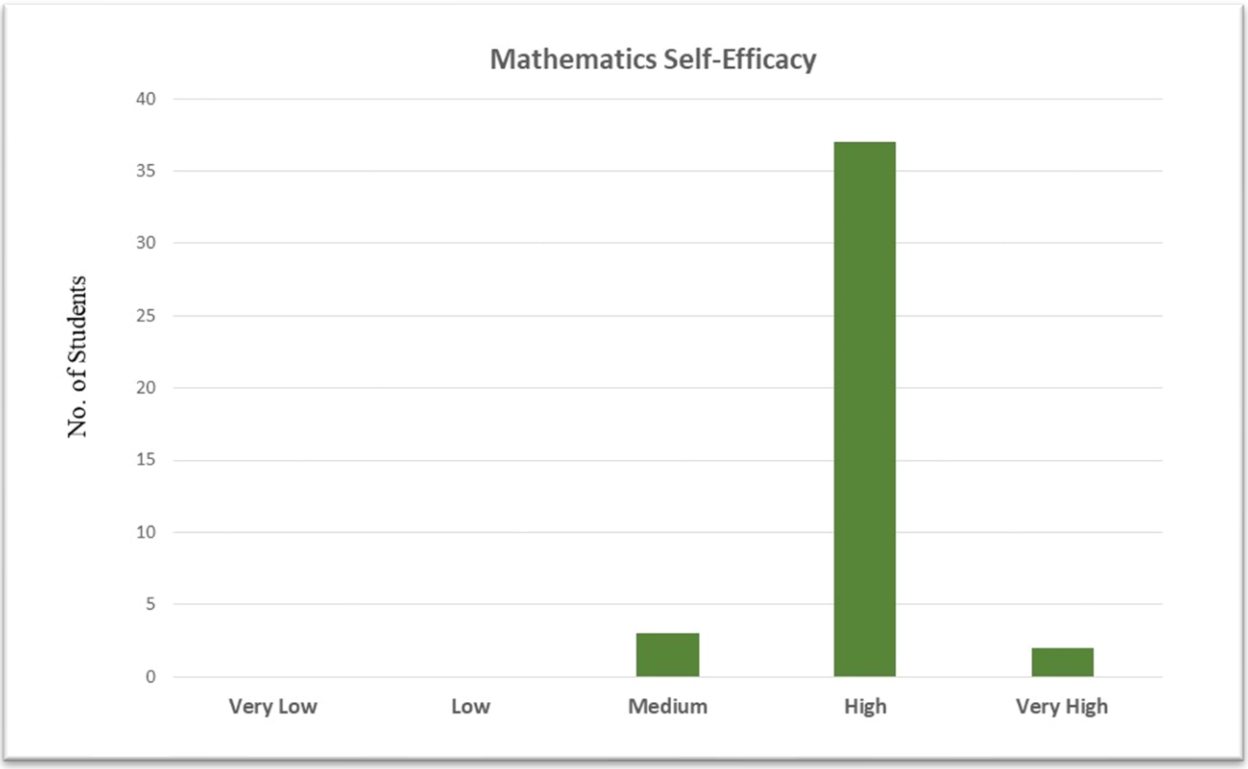

Figure 3. Mathematics Self-Efficacy Before the Experiment

Based on the findings, there were an increase in terms of the average score of students' self-efficacy. It means that the mean score in initial condition of students' mathematics self-efficacy is 37.33 (low category) increased to be 57.64 (high category). The percentage of students who have high self-efficacy reached 92.5%, and 7.5% of the students have medium level self-efficacy.

b. Learning Achievement

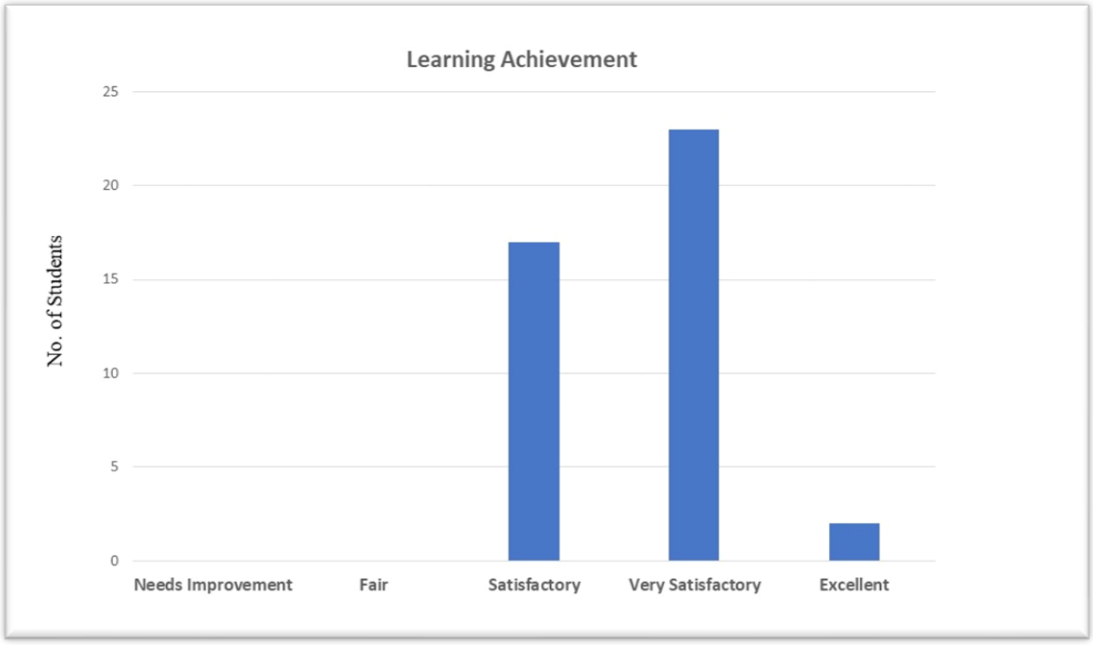

Figure 4. Learning Achievement of the Students After the Experiment

It is evident in the data presented that the mean posttest score (33.69) is significantly higher than the mean pretest score (20.48). The students, in general, performed satisfactorily on the Proficiency Test. Majority of the students or 54.76% obtained a very satisfactory score on the posttest while 4.76% of the students obtained an excellent score. The mean scores of the students improved after the integration of the game-based approach in instruction. Therefore, the significant positive impact of the game-based approach in instruction can be confirmed. This result can further solidify the claims of Chan et.al (2021) in their study of the effects of game-based learning. Results suggest that after integrating game-based approach, students would likely yield higher improvement in terms of their learning outcome.

3. Significant Difference in The Students' Mathematics Self-Efficacy and Learning Achievement Before and After the Experiment

a. Mathematics Self-Efficacy

T-test for dependent samples was used to determine if there exists a significant difference between the students' mathematics self-efficacy before and after the integration of game-based approach in instruction. All analyses were significant at 0.05 level of significance.

Table 1 T-test for dependent samples for the Mathematics Self-Efficacy

	Mean	SD	t-value	p-value
Before	37.33	4.40	19.948	0.000
After	57.64	3.89		

In general, the findings indicate that there existed a significant difference in the mathematics self-efficacy of the students before and after the integration of the game-based approach in instruction, **t = 19.948, p = 0.000.** Hence, Ho_1 (There is no significant difference in the mathematics self-efficacy of the students before and after the integration of game-based approach in instruction) was rejected because the p-value was less than 0.05. This further confirms the positive effect of the game-based instruction in improving the mathematics self-efficacy of the students. Results from the study conducted by Pratama and Setyaningrum (2018) indicated that students who underwent game-based learning obtain positive effect on cognitive and affective aspects. Yu and Tsuei (2021) also found out, through their research on the effects of digital game-based learning on language learning, attention and self-efficacy, that game-based approach in instruction have significant positive effect on students' attention and self-efficacy.

b. Learning Achievement

Pretest and posttest mean scores were analyzed using t – test for dependent samples to determine if there was a significant difference between the students' learning achievement under the control and experimental groups before and after the experiment.

Table 2 T-test for dependent samples for the Learning Achievement

	Mean	SD	t- value	p-value
Pretest	20.48	4.07	31.293	0.000
Posttest	33.69	5.02		

Hence, from the above findings, Ho_2 (There is no significant difference in the mathematics learning achievement of the students before and after the integration of game-based approach in instruction) was rejected because the p-value was less than 0.05. This implies that the learning achievement of the students was improved after the implementation of the game-based approach in instruction. This is similar to the findings of the research conducted by Tokac, et.al (2018). Game-based learning contributed in improving the students' mathematics learning achievement.

4. Significant Relationship Between the Students' Mathematics Self-Efficacy and Learning Achievement

After the integration of the game-based approach in instruction, data involving the students' mathematics self-efficacy and learning achievement was utilized. Further analysis was carried out to identify the relationship between students' mathematics self-efficacy and mathematics learning achievement. For this reason, the Pearson correlation test was conducted to determine the relationship between these two factors. Summary of the results is presented on Table 3.

Table 3 Students' Mathematics Self-Efficacy and Learning Achievement Correlation

	Mean	r	p-value
Self-Efficacy	57.64	0.435	0.004
Learning Achievement	33.69		

Data revealed that there was a positive relationship between the students' mathematics self-efficacy and learning achievement after the integration of game-based approach in instruction with a correlation coefficient of **r = 0.435**. Additionally, Ho_3 (There is no significant relationship between the mathematics self-efficacy and learning achievement of the students) was rejected because the p-value was less than 0.05 (**p = 0.04**). The results of this correlation implies that the higher self-efficacy, the higher the learning achievement of the students in mathematics and the lower the self-efficacy, the lower the learning achievement. These findings support the results of previous researches of Negara et.al (2021), Wang Y et.al (2017) and Skaalvic et.al (2015) which indicate that there is a positive relationship between the two variables.

CONCLUSION

Data from this study revealed the following:

- In terms of the students' mathematics self-efficacy before the integration of game-based approach in instruction, majority of the students have low mathematics self-efficacy. In terms of learning achievement, the students obtained a "fair" score with an average of 20.48.
- After the integration of game-based approach in instruction, the students' mathematics self-efficacy was increased and categorized as "high category". In terms of learning achievement, the mean posttest score is significantly higher than the mean pretest score. The students, in general, performed satisfactorily. Thus, both the students' mathematics self-efficacy and learning achievement have increased suggesting a positive effect of game-based approach in instruction.
- T-test for dependent samples suggests that there is a significant difference in the mathematics self-efficacy and learning achievement of the students before and after the integration of game-based approach in instruction. Game-based approach in instruction contributed in improving the students' mathematics self-efficacy and learning achievement.
- There is a significant relationship between the mathematics self-efficacy and learning achievement of the students. The results of this correlation implies that the higher self-efficacy, the higher the learning achievement of the students in mathematics and the lower the self-efficacy, the lower the learning achievement

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