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Research Article

Embedding Game-Based Learning Approach to Strengthen Student's Achievement in Geometry

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Abstract

The aim of this analysis was to see how embedding a game-based learning method (GBL) affected learning achievement in geometry. In a two-week learning activity, a quasi-experimental configuration design was used. The participants included 685 junior high school students from selected private schools in Metro Manila. Each class was grouped into two. One class was assigned to be the control group, and the other was designated to be the experimental group. Game-based learning method was implemented to experimental group, while a conventional teaching method was used to control group. Data was collected using a Geometry Knowledge Test and a Survey on Learning Attitudes. The effect of the GBL on respondents' learning achievement and attitudes towards geometry was studied using ANOVA. The experimental groups' learning achievement in geometry was substantially higher than that of the control groups, according to the findings. Similar findings were gathered in terms of the respondents' learning attitudes. Furthermore, the majority of the students expressed enthusiasm for using the game-based learning method to learn geometry. In terms of learning achievements in geometry and learning attitudes, an in-depth study revealed no major differences between genders. This study found that using a game-based approach to learning would improve learning outcomes and attitudes. As a result, the significance of this study lies in the fact that it purports to capture a more holistic view of using the GBL method.

Keywords: game-based learning, geometry knowledge, learning achievements, learning attitudes

1. Introduction

Researchers have encouraged integrating technology in the mathematics classroom [1]. Several school districts have invested in student technology since research has shown that it can be used to improve students' learning, engagement, and mathematical achievement [5]. The iPad and mobile phones are two of the most recent technology products to be implemented into classrooms [20]. These systems have advanced applications in which multiple senses (e.g., auditory, visual, and tactile) are integrated. Interactive game-based learning and wireless Internet access through mobile phones and iPads may be used by educators to improve the current educational environment [10].

Educational mobile games are digital mobile games with educational elements that are designed to aid in the teaching and learning process. These are designed for education with appropriate educational values, according to the International Journal of Information System Modeling and Design. Educational games can be used in any educational setting using any gaming method to help students learn about specific topics, broaden concepts, promote development, appreciate a historical event or culture, or improve a skill while playing.

Many students, on the other hand, consider most mathematics subjects to be challenging. Mathematics, unsurprisingly, ranked first in terms of topic difficulty. Another factor contributing to this is that students do not fully comprehend certain mathematics topics because teachers are unable to explore them in depth due to time

constraints. This can lead to underachievement and academic, mental, and emotional problems, which can lead to many students dropping out of school.

Several researchers have suggested using game-based enrichment as a complement to educational activities to help students better participate in mathematical learning. During all of their interactions with school learning, students should not feel alienated or disconnected. Certain circumstances can encourage enthusiasm, arousal, and participation in the learning process, resulting in more meaningful learning. Educational games seem to be an ideal way to blend constructive learning with enjoyment. In addition, a number of professional-developed mobile games are available to pique students' interest in studying Mathematics. The impact of a game-based learning approach on student achievement in Geometry is investigated in this review. The following are the research topics:

1. The impact of a game-based learning approach on students' geometric conceptual comprehension.
2. The impact of a game-based learning approach on students' attitudes toward Geometry learning.
3. The impact of a game-based learning strategy on students of different genders.
4. Reviews from students on the game-based learning approach to Geometry.

2. Literature Review

Games are thought to be an excellent tool for encouraging students to engage in academic activities actively [2]. According to [7] and [11], game-based learning can be the most effective way to motivate students to learn. Furthermore, [3] stated that game-based learning is an excellent tool for stimulating students' thought during cognitive growth and further developing their higher-order thinking capacity. Furthermore, games have been shown to increase motivation due to their adventure and challenge elements [4]. As a result, students will learn happily while simultaneously improving their learning achievement if the game-based approach is used in any learning environment.

Several previous research had indicated the utility and usability features of mobile games by applying the GBL to different didactics, according to reference [24]. For example, it has been recorded that using video games for learning in primary schools' increases students' intrinsic motivation and learning achievement [22]. In addition, digital games in primary and secondary schools that concentrate on mathematics education have been shown to improve students' skills, competencies, and learning motivation [26]. Computer games, according to reference [16], improved students' learning attitudes and mathematics achievement, especially in geometry.

Furthermore, a number of intervention techniques have been developed to help students cultivate a positive attitude toward mathematics learning. Innovative learning tasks are incorporated into these interventions to make learning more enjoyable and engaging. Incorporating technical advancement into learning has been fashionable in recent years. For example, in a study comparing the efficacy of a game-based approach to conventional teaching in mathematics education for primary students, researchers discovered that students who received the game-based learning approach had a more optimistic attitude toward mathematics than those who received traditional teaching [17].

Moreover, gender disparities in mathematics are a major problem that many studies highlight. It's also debatable if there are gaps in math achievement between boys and girls. Several studies have consistently shown that by using a game-based learning strategy, boys and girls have equal mathematical abilities. However, some studies have found that girls outperformed boys [20], while others have found that boys outperformed girls [18]. Some researchers, on the other hand, found no gender gaps in children's numerical abilities [8].

Cognitive theory is one theory that was conceded as being connected to the game-based learning approach. It stressed out that learning foundational skills is necessary to acquire advanced skills further. It also illuminates that the process of learning is progressive and inductive.

Moreover, [9] stated that games need to arouse students' learning interest and make learning more meaningful. Reference [13] and [15] pointed out that learning happily through games is way better than best instructional materials and techniques. Besides, games are readily accepted and closer to the children's' world than other media of instruction [12].

A few game-based learning environments strive for more comprehensive mathematical learning outcomes including versatility and adaptability when solving arithmetic problems. Rohan Mahimker's Prodigy game-based intervention is one such example. Prodigy was created with the aim of increasing students' interest in studying geometry. Its personalized components recognized students' gaps in understanding and work with them to grasp prerequisite skills and set them to more advanced concepts. Teachers can also customize the game content and

align it with the curriculum. The program was user-friendly and was designed to teach and learn mathematics easier and enjoyable for students.

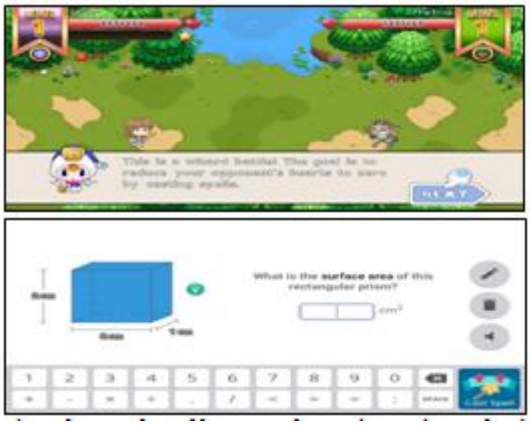

Fig 1. Screenshot of Prodigy

3. Methods

A quasi-experimental configuration design is used in this research. In their enrichment exercises, game-based approach was used to the experimental group, while the control group was taught using conventional textbook-based instruction. After the post-test, the parameters were switched, and the control group would play Prodigy for the remainder of the first quarter. This was done for ethical reasons and to keep volunteer teachers motivated during the implementation. In the test groups, there was no pseudo therapy.

Sample

According to [6,] experimental methodologies need at least 15 participants, and there should be at least 15 participants in both the control and experimental groups for comparison. So 685 junior high school students from Metro Manila's selected schools took part. The pre- and post-tests were performed as part of their daily schoolwork by all students in the experimental classes who played Prodigy as part of their mathematical instruction. The instructor for both the realistic and control classes is the same.

Procedure

To allow sub-group comparisons and better manage variance in how the Prodigy was used in the classroom by the teacher. Both participants completed the pre-test assessments and the questionnaire on learning attitudes toward Mathematics at the start of the first quarter.

The instructor was given details about the Prodigy's key features, as well as the general overview and goal of the analysis, prior to data collection. Since the Prodigy's general design is accessible and versatile, it aims to be appropriate for a variety of grade levels, the instructor received general guidance about the gaming sessions. Teachers can choose whether their students play the game in pairs or individually, and how the teams are selected is up to the instructor in the case of pair play. The experimental group's recommendations for teachers were to strive for about 2 hours of playing time each week, with at least two sessions of no less than 30 minutes each.

Following the pre-test, the study group participated in the intervention for two weeks, during which time they used d the Prodigy as part of their daily math lessons. The experimental group received the game after their teacher instructed them to download it. Gameplay is supposed to be incorporated into regular math classes. As a result, the intervention group would not undergo any further instruction than the control group. Many of the participants take a post-test after the intervention. In addition, the experimental group provided input on the Geometry game-based learning approach.

Measures

The Geometry Knowledge Test (GKT) was developed by [23] was used to assess the students' learning performance in geometry. The test had 50 items, each of which was worth one point if the students answered correctly. The test had a Kuder-Richardson reliability of 0.71.

The questionnaire created by [25] was adopted and updated to assess students' learning attitudes toward Mathematics. On a five-point Likert scale, it has twenty-four objects. The questionnaire's Cronbach's alpha value was 0.87, showing a high internal accuracy reliability.

Moreover, five-point Likert scale questionnaire with ten items was conducted to gather student input on the game-based learning approach, which included the topics of "effects of computer games on mathematics skills," "effects of computer games on mathematics attitudes," and "viewpoints of computer game-based learning." The questionnaire's face validity was determined with the aid of experts in the field of mathematics education, and the items were improved and rewritten based on their feedback and suggestions. During the study's pilot run, Grade 8 students from Phinma-Araullo University were given the final draft of the instrument, which consisted of ten items. Cronbach's alpha estimated the instrument's reliability coefficient to be 0.861. As a result, no items were removed.

4 Results

Learning Achievement

This study used the geometry awareness test pretest scores as the covariate for analysis of covariance to avoid the impact of the pretest on learning achievement in geometry (ANCOVA). The regression coefficients of each regression line must be homogeneous, which is one of ANCOVA's assumptions. The result reported no interaction effect between the independent variable and the geometry information test covariate ($F=1.93$, $p>.05$), indicating that the independent variable's levels had no effect on the relationship between the covariate; pre-test scores of geometry knowledge test and post-test scores of geometry knowledge test. As a result, additional ANCOVA research became necessary.

Table I shows the ANCOVA results for post-test of geometry knowledge test. The GKT had no impact on the pre-test scores, and the learning achievements of the two groups were significantly different ($F =20.01$, $p<.001$). The modified mean for the experimental group was 34.39, while the control group's was 27.64, implying that the experimental group's learning achievement was significantly higher than that of the control group, showing that implementing a game-based enrichment activity could effectively promote students' geometry learning achievement.

Table I. Post-test ANCOVA Results for the Geometry Knowledge Test

Variable	Group	N	Mean	SD	Adjusted Mean	Std. Error	*F*
Post test	Experimental	34	34.39	2.38	34.39	.43	20.01***
	Control	34	27.64	3.39	27.64	.43	

***$p<.001$

Learning Attitudes

The pretest scores from the Attitudes toward Learning Mathematics (ALM) questionnaire were used as a covariate in ANCOVA. The interaction effect between the independent variable and the questionnaire covariate was not meaningful ($F=1.37$, $p=.25$, $p>.05$), indicating that there is no significant association between the covariate and the independent variable (the pre-test scores). The ANCOVA could be replicated because the levels of the independent variable had no effect.

The learning achievements of the two groups were not significantly different after the influence of the geometry awareness pretest scores was excluded ($F =.19$, $p=.66$, $p>.05$), as shown in Table II, with the experimental group's adjusted mean of 4.98 and the control group's adjusted mean of 4.86. Although the experimental group's score was higher than the control group's, the difference was not statistically significant. Game-based enrichment did not change students' attitudes toward mathematics any more than traditional book-based instruction did.

Table II. The results of the ANCOVA on the ratings of attitudes toward studying mathematics

Variable	Group	N	Mean	SD	Adjusted Mean	Std. Error	*F*
Post test	Experimental	34	4.82	1.28	4.98	1.00	.19
	Control	34	4.52	2.01	4.86	1.00	

Learning Achievements between Genders

Following this learning exercise, a study was performed to compare gender differences in learning achievement in geometry and attitudes toward learning mathematics. The impact of related pre-test scores and pre-questionnaire ratings has been removed. Table III shows the ANCOVA results for the geometry comprehension test posttest scores and the post-questionnaire ratings for attitudes toward studying mathematics for both genders. In terms of the two dimensions, no significant differences between genders were found, meaning that game-based learning is beneficial to both genders in terms of improving learning and attitudes.

Table III. ANCOVA findings on different genders' post-test results

Variable	Group	N	Mean	SD	Adjusted Mean	Std. Error	*F*
Geometry Knowledge Test	Male	18	34.47	2.00	34.29	.50	1.00
	Female	16	33.38	2.68	33.57	.51	
Attitudes towards Learning Mathematics	Male	18	4.65	1.62	4.81	1.44	.00
	Female	16	3.94	2.05	3.83	1.49	

Reviews to the Game-based Learning Methodology

The survey of teaching perspectives on video game-based learning is presented in Table IV. 'I can better understand the Pythagorean theorem,' says 1.1 in Part 1 'Influence of video games on nutrition awareness.' (4.97), and 1.2 'I am much clearer about calculating the surface area and volume of geometric figures' (4.79), demonstrating that students strongly agree that video games have an effect on the acquisition of geometry skills. Number 2 item, I want to learn more about solving geometry problems' (Part 2, 'Influence of video games on attitudes toward learning mathematics'). The highest score (5.00) is for 2.2 'I have become more attentive in our math class,' while the lowest score (4.76) is for 2.2 'I have become more attentive in our math class,' showing that students are optimistic about the impact of a game-based approach on attitudes toward learning mathematics. Part 3 'Viewpoints on game-based learning' scores higher (4.94) for 4.2 'I hope that other courses will follow computer game-based learning,' while 4.1 'I believe that computer game-based learning is beneficial to me,' scores lower (4.73). This indicates that the students acknowledge the impact of video games on their academic achievement and attitude toward the subject, and that they plan to use game-based learning in the future.

Table IV. Survey Questions on game-based learning approach

Questions	N	Mean	SD
1.Influence of computer games on geometry knowledge		4.85	.22
1.1 I can better understand the Pythagorean theorem.	34	4.97	.17
1.2 I am much clearer about getting the surface area and volume of geometric figures.	34	4.79	.55
1.3 I am better able to understand how to get the slope of the line.	34	4.82	.53
1.4 I can know more about the importance of the Pythagorean Theorem on understanding distance formula.	34	4.82	.39
2. Influence of computer games on attitudes toward learning mathematics		4.89	.20
2.1 I will focus more on practicing my skills in solving problems.	34	4.91	.38
2.2 I have become more attentive in our math class.	34	4.76	.50
2.3 I want to learn more about solving geometry problems.	34	5.00	.00
3. Viewpoints on game-based learning		4.84	.24
3.1 I think that computer game-based learning is helpful to me.	34	4.73	.29
3.2 I hope that other courses can also adopt computer game-based learning.	34	4.94	.42
3.3 I understand our topic better when we are using game in class.	34	4.77	.63

5. Conclusions

The aim of this study is to look into the learning outcomes of students' geometry awareness using a game-based learning approach. The results of the study show that computer game-based learning can help students develop their learning abilities and attitudes.

Furthermore, both male and female students profit equally from the game-based learning approach in terms of geometry skills and learning attitudes. This result contrasts with previous research that found a gender gap in machine and network use [14].

While the results of this study are encouraging, more research with larger samples is needed in the future to determine the efficacy of the game-based learning method for learning geometry. The groundbreaking approach is expected to boost not only the students' geometry skills, but also their attitudes toward studying mathematics.

The use of a game-based learning method in mathematics has a positive impact on learning performance and learning attitudes, according to this report. As a result, learning developers and mathematics educators are encouraged to create materials for educational games in order to provide a new learning experience for students.

There are, however, a few drawbacks that should be noted. To further explore the utility of the game-based learning method for learning geometry, longer studies with larger samples will be performed in the future. Next, since each student plays games at a different pace, they can complete the game at a different pace. As a result, students who are less skilled at playing games are unable to fully participate in the learning process. However, if they continue to be provided with learning facilities that provide game-based learning, this issue will be resolved. Another issue is that Prodigy may not be suitable for use by students, especially those in rural areas. This is due to the fact that not every student has access to a computer or a cell phone.

Despite the limitations listed above, the findings of this study provide a foundation for future studies. For starters, this study was only conducted in a mathematics class, specifically for a geometry lesson. On the other hand, it was not applicable to other subjects, despite the fact that they had similar learning difficulties. It would be interesting if the game application included a variety of subjects and covered the entire academic year. Second, this study was a success in terms of implementing game-based learning, which was aided by the problem-solving process. Furthermore, this study revealed that learning developers could render all learning media game-based learning by incorporating other learning methods.

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