Vol. 1 · January 2013
Print ISSN 2244-1824 Online ISSN 2244-1816
doi: http://dx.doi.org/10.7719/irj.v1i1.206

JPAIR Institutional Research is produced
by PAIR, an ISO 9001:2008 QMS certified
by AJA Registrars, Inc.

Effects of Mathematical Games Strategy on the Achievement of Students in High School Geometry

RICHARD J. TACLAY
ORCID No. 0000-0002-7566-6064
richard.taclay@yahoo.com
Nueva Vizcaya State University
Bayombong, Nueva Vizcaya

ABSTRACT

Mathematical games have become an interesting area in educational research. The study was conducted to determine the effects of games on achievement in geometry. It was done in one of the public high schools in the Division of Nueva Vizcaya, Philippines. Quasi-experimental design, specifically the pretest-posttest control group design was adopted using two intact groups of fourth year students with 39 students each as the subjects of the study. The first group was assigned as the experimental group adopting the mathematical games strategy in teaching while the second group as the control group employing the traditional way of teaching. A 60-item multiple choice teacher-made test was the main instrument in the study. The test provided the scores for the pretest and posttest for the two groups of respondents. The test underwent a series of steps of validation and later on the reliability coefficient was determined at 0.91 using the KR20. The study found that the students who were exposed to mathematical games strategy obtained higher achievement scores compared to students taught using the traditional method. As a result, the researcher recommends the use of mathematical games strategy in presenting and discussing lessons for the purpose of achieving higher grades in Geometry.

Keywords - Mathematics education, mathematical games strategy, quasi experimental design, Philippines

INTRODUCTION

Confucius' statement ***"I hear and I forget, I see and I remember, I do and I understand"*** explains that the learner must be active enough and not passive to maximize learning. This assertion is parallel to the slogan of Geometry Integrated Mathematics Book, Second Edition, authored by Usiskin, et al. (2002): "Mathematics is not a spectator sport". This means that one cannot learn much just by watching other people do it. One must actively participate.

Generally mathematics is considered by many as uninteresting, boring and difficult. However, the performance of the students depends largely on the quality of teaching competencies of their teachers. They use a wide variety of techniques to arouse interest from students. In view of this, the teacher must determine the effective strategies that would motivate interests, abilities and needs of the students.

Teachers in mathematics play an important role in the development of a strong sense of numbers, mastering mathematical facts, using vocabulary skills and providing concrete activities to students. According to Ainsworth and Habgood (2009), when students are engaged in a 'balance' of mathematical activities, they can succeed where it counts - in applying their skills and reasoning ability to solve real-life problems requiring mathematical solutions.

One way to arouse their interest in learning mathematics is the integration of games. Games are essential for students and provide them with recreation and enjoyment. Games help and encourage many learners to sustain their interests and work and it is very evident that most of the students like games. Thus, to encourage students to actively participate in classroom activities is to use this strategy that is more competitive, relaxing and fun setting. In view of this, the researcher is interested to determine the significant effect/s of the use of mathematical games on the achievement of students in High School Geometry.

FRAMEWORK

A team of American researchers Bright, Harvey and Wheeler (1979) have carried out many studies on the use of games to teach mathematics. Two of the studies involved the use of games to reinforce basic multiplication and division facts with single digit factors. Gains in test performances showed that the games treatment was an effective way to retrain and reinforce children's skills with basic number facts.

Recently, computer games have been proposed as a potential learning tool by both educational researchers (e.g., Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005) and game developers (e.g., Aldrich, 2004; Prensky, 2001). Frequently-cited arguments

held by these researchers for using computer game in education are:

- computer games can invoke intense engagement in learners (Malone, 1981; Rieber, 1996)
- computer games can encourage active learning or learning by doing (Garris, Ahlers, & Driskell, 2002)
- empirical evidence exists that games can be effective tools for enhancing learning and understanding of complex subject matter (Ricci, Salas, & Cannon-Bowers, 1996), and
- computer games can foster collaboration among learners (Kaptelin & Cole, 2002).

Kebritchi, et al. (2010) found that games were effective teaching and learning tools because they (a) were experiential in nature, (b) offered an alternative way of teaching and learning, (c) gave the students reasons to learn mathematics to solve the game problems and progress in the games, (d) addressed students' mathematics phobias and (e) increased time on task. As one of the teachers stated "It [the games] makes them want to learn [math]."

Certain researchers, such as Barab, et al. (2005) and Squire (2003), examined what happens with students and their learning processes in game-based curricula of mathematics, science, and history. Barab, *et al.* (2005) built an educational adventure game (Quest Atlantis) from scratch while Squire (2003) customized a commercial off-the-shelf role-playing game (Civilization) for classroom application. Games, used in both studies, could be classified into simulation genre. As a complement to their works, the present study examined the use of puzzle games for drill and practice purpose. Two reasons underlie the selection of drill and practice games: (a) computer games have been used in education primarily as tools for supporting drill and practice, yet limited research has been done on the effectiveness of these games; (b) in comparison with simulation games, drill and practice games are easier to be introduced in a classroom and integrated into a traditional curriculum (Squire, 2003).

Ross and Morrison (2004), and Savenye and Robinson (2004), researchers in instructional technology suggested that games employ mixed, parallel methods to produce the most convincing body of evidence. Therefore, although the study adopted qualitative case study as the dominant paradigm to investigate a contemporary phenomenon – game-based learning – within its real-life context (Yin, 1984). Quantitative procedures are employed in the method of this study to corroborate and extend primarily the qualitative approach.

Rowe (1997) conducted an experiment in the use of games in the teaching of mental arithmetic, she found out that the students enjoyed the game and their

mental arithmetic scores improved as a result of it. Koay Phong Lee (1996), if games were selected carefully on the basis of the instructional objectives and incorporated into the instructional programme, they can enhance teaching and learning. In addition, through the dynamic interplay between the cooperative and competitive learning situations, games can be used to help children develop social skills. Hence, mathematical games do have a part to play in primary mathematics education and teachers should try to include games in their primary mathematics lessons.

It has been argued that differences in children's attitudes to mathematics are noticeable when playing games. Burnett (1992) considered that mathematical games capture children's enthusiasm and create environments favourable for learning. Research by Bright, et al. (1985) reported that games generate enthusiasm, excitement, total involvement and enjoyment.

A research conducted by Swan and Marshall (2011) showed that, given the right conditions, games can achieve an increase in basic fact skills in a stimulating and enjoyable environment. Vankus (2008) found that didactical games are for students' impetus for their active participation during games activities. Students were motivated by competitiveness to win the game alone in the case of pair games or to help their team gain the best score in the case of team games. Playing of some games is for students motivational also because of interesting game environment. He found out that didactical games are suitable for the improvement of pupils' attitudes towards mathematics and its teaching. Result of questionnaire showed that the used didactical games improved the pupils' attitudes towards mathematics. These researches inquired influences of the games on pupils' knowledge and skills, their motivation, performance and also influences on pupils' personal development.

De la Cruz (2011) determined whether or not games teach academic content and skills. He also underscored the use of stronger methodologies in the study designs, and a close examination of the different game design features will probably lead to learning. Like formative assessment in non-game settings, more evidence is needed to determine whether and how criteria of performance and scoring rules should be communicated to students to be useful for learning. Given that the incentive to seek additional feedback was most beneficial for students with lower prior knowledge, low self-efficacy, and low math self-concept—additional effort is necessary to examine different approaches in motivating students.

Further, Phillips (2010) strongly stated that games with manipulatives are also valuable in helping students apply what they learned to the real world, as well as provide a means in improving their math skills. Using board games and card games along with cooperative learning are ways that students become involved in a positive mathematical environment. Games are highly motivational to students and can be

used effectively to practice specific skills. Phillipis (2010) said that using games in the classroom and at home will maximize students' problem-solving competence, ability to communicate and reason mathematically, perception of the value of mathematics, and self-confidence in their ability to apply mathematical knowledge to new situations." Cooperative groups provide students a chance to exchange ideas, to ask questions freely, to explain to one another, to clarify ideas in meaningful ways and to express feelings about their learning. These skills acquired at an early age will be greatly beneficial throughout their adult working life.

Baker (2009) said that results suggest a new picture of the affective and behavioral differences between students playing a game, represented by Math Blaster, and using an intelligent tutor, represented by Aplusix. Based on the general perception of games, as well as past theoretical accounts about their benefits, it might have been reasonable to hypothesize that students would be on-task more often in the game, and would experience more engaged concentration and delight within the game.

OBJECTIVE OF THE STUDY

The main purpose of this study was to determine the effect of mathematical games strategy on the achievement of students in high school geometry among the third year students in one of the public high schools in the Nueva Vizcaya, Philippines during the School Year 2012-2013.

METHODOLOGY

Research Design

The study used the quasi experimental pre-test – post-test design. Comparisons of the results in the pre-test vs post-test in each group, post-test vs post-test of the two groups, and gain scores vs gain scores of the two groups were performed.

Subjects of the Study

The subjects of the study were the two intact third year classes in one of the public high schools in the Division of Nueva Vizcaya during the school year 2012-2013. The first class was randomly assigned to experimental treatment using Mathematical Game Strategy, and the other class was also randomly assigned to control group adopting the traditional way of teaching geometry. An informed consent form was used and signed to comply the research ethics requirement.

Research Instrument

The Achievement Test. The main source of data was the 60-items teacher- made Geometry Achievement Test. Items of this test was constructed based on the prepared Table of Specification (TOS). The first draft of the test underwent the content and face validation by the experts in mathematics. Corrections and suggestions were integrated before the second draft of the test was tried out to 150 students for the item analysis. The reliability coefficient 0.91 was also determined using the Kuder-Richardson formula 20 (KR20) before the final test was finalized. This implies that the Achievement Test is reliable enough to test the needed mathematical skills.

The Mathematical Games. The researcher himself prepared the different games for the experimental treatment like geometry walk game, classifying triangles game, angle jeopardy game, tower contest game, polygon or not? (online game), types of polygons (online game), polygon game, 2D shapes game, math baseball, interactive quadrilaterals, interior sum game, around the world, circle game, tangrams, soma cubes, and 3D shapes game. The objectives of the mathematical games are patterned to the PSSLC. Mathematical games are characterized as online games (adopted from the internet) and teacher- made games (playground and classroom games).

Analysis of Data

After 20 days of experimentation, data were analyzed using the frequency counts, simple percentage and mean to determine the respondents' profile and level of performance. t-test for independent and dependent populations was used to determine the significant difference.

RESULTS AND DISCUSSION

Profile of the Student Subjects

Majority of the students belonged to the 14 -15 years old range and most of these students were male. In terms of religious affiliation most of the students were Roman Catholic and most of them were belonged to the Ilocano ethnic group.

Performance Level in the Pre-test and Post-test of the Control and Experimental Groups

Table 1. Performance level of the control and experimental groups according to pre-test raw and mean scores

ACHIEVEMENT RATE (%)	Raw Score	Control		Experimental		Achievement Level
		N	%	N	%	
85.71 – 100.00	51 – 60	0	0.00	0	0.00	Very High
71.43 – 85.70	43 – 50	0	0.00	0	0.00	High
57.14 – 71.42	34 – 42	2	5.26	0	0.00	Moderately High
42.86 – 57.13	26 – 33	3	7.89	2	5.26	Average
28.57 – 42.85	17 – 25	20	52.63	16	42.11	Moderately Low
14.29 – 28.56	9 – 16	13	34.21	18	47.37	Low
0.00 – 14.28	0 – 8	0	0.00	2	5.26	Very Low
Total		38	100.00	38	100.00	
Mean		**19.11**		**17.34**		**18.23**
Achievement Level		Moderately Low		Moderately Low		Moderately Low

Table 1 shows that under the control group, 2 (5.26%) of the total number of students belong to the moderately high achievement level; 3 (7.89%) students belong to the average level; 20 (52.26%) students belong to the moderately low level of performance while 13 (34.21%) students belong to the low level of performance. On the other hand, in the experimental group 2 (5.26%) students belong to both average and very low achievement level; 16 (42.11%) students belong to the moderately low achievement level while 18 (47.37%) students belong to the low achievement level. It also shows that the mean of the control group is 19.11 while the mean of the experimental group is 17.34.

The findings indicate that prior to the study, the performances of the students in both control and experimental groups were moderately low and comparable.

Table 2. Performance level of the control and experimental groups according to post-test raw and mean scores

ACHIEVEMENT RATE (%)	Raw Score	Control		Experimental		Achievement Level
		N	%	N	%	
85.71 – 100.00	51 – 60	1	2.63	2	5.26	Very High
71.43 – 85.70	43 – 50	4	10.53	3	7.89	High
57.14 – 71.42	34 – 42	3	7.89	11	28.95	Moderately High
42.86 – 57.13	26 – 33	9	23.68	21	55.26	Average
28.57 – 42.85	17 – 25	21	55.26	1	2.63	Moderately Low
14.29 – 28.56	9 – 16	0	0.00	0	0.00	Low
0.00 – 14.28	0 – 8	0	0.00	0	0.00	Very Low
Total		38	100.00	38	100.00	
Mean		**27.68**		**34.13**		**30.91**
Achievement Level		Average		Moderately High		Average

Table 2 shows that under the control group, 1 (2.63%) of the total number of students belong to the very high achievement level; 4 (10.53%) students belong to the high achievement level; 3 (7.89%) students belong to the moderately high achievement level; 9 (23.68%) students belong to the average; 21 (55.26%) students belong to the moderately low while no student belong to both low and very low level of achievement. On the other hand, in the experimental group, 2 (5.26%) of the total students belong to the very high level of achievement; 3 (7.89) students belong to the high level of achievement; 11 (28.95%) students belong to the moderately high level of achievement; 21 (55.26%) students belong to the average while 1 (2.63%) student belong to the moderately low achievement level.

Table 2 also shows that the control group obtained a mean score of 27.68% which indicates that it belongs to the average level of achievement while the experimental group obtained a mean score of 34.13 which indicates that it belongs to the moderately high level of achievement. The overall performance level of the students was average.

Comparison between Pre-test Mean Scores of the Control Group and Experimental Group

The data contained in table 3 shows the t-test results between the pre-test mean scores of the control group and experimental group.

Table 3. Mean and standard deviation of the pre-test scores of control and experimental groups

	Control	Experimental	T-Value	P-Value
Mean	19.11	17.34	1.380[ns]	0.1718
Standard Deviation	5.87	5.25		

ns – not significant

Table 3 shows that the control group has a higher mean pre-test score than the experimental group. However, the t-test shows that there is no significant difference between the pre-test mean score of control and experimental group since p-value is greater than 0.05. This indicates that the control group and experimental group have almost the same scores during the start of the study. This is an indication that the subjects of the study have the same level of performance prior to the conduct of research.

Comparison between the Pre- test and Post- test Mean Scores of the Students in Control Group

The table below presents the t-test results between the pre-test and post-test mean scores in the control group.

Table 4. Mean and standard deviation of the pre-test and post-test mean scores of control group

	Pre – Test	Post – Test	T-Value	P-Value
Mean	19.11	27.68	9.266[s]	0.0000
Standard Deviation	5.87	8.84		

s –significant

Table 4 shows that the control group has a higher post-test mean score which is 27.68 than the pre-test mean score which is 19.11. Likewise, the t-test shows that there exists significant difference between the pre-test and post-test mean score of control group since p-value is less than the 0.05. This indicates that the performance in post-test of the control group is significantly higher than the performance in the pre-test. This is attributed to the fact that students have gained knowledge from the discussion through the use of traditional method of teaching.

Comparison between the Pre- test and Post- test Mean Scores of the Experimental Group

The data contained in table 5 shows the t-test results between the pre-test and post-test mean scores of the experimental group.

Table 5. Mean and standard deviation of the pre-test and post-test scores of experimental group

	Pre – Test	Post – Test	T-Value	P-Value
Mean	17.34	34.13	20.574[s]	0.0000
Standard Deviation	5.25	7.45		

s – significant

Table 5 shows that the experimental group has a higher post-test mean score which is 34.13 than the pre-test mean score which is 17.34. Similarly, the t-test shows that there exists a significant difference between the pre-test and post-test mean scores of the respondents in the experimental group since the p-value is less than the 0.05. This indicates that the post-test score of experimental group is significantly higher than the pre-test mean score. This is because the students have gained knowledge from the discussion and the students perform better when they are exposed to mathematical games strategy.

Comparison between Post-test Mean Scores of the Control and Experimental Groups

Table 6. Mean and standard deviation of the post-test scores of control and experimental groups

	Control	Experimental	T-Value	P-Value
Mean	27.68	34.13	3.437[s]	0.0010
Standard Deviation	8.84	7.45		

s – significant

Table 6 shows that the experimental group has higher post-test mean score than the control group. Likewise, the t-test suggests that there exists a significant difference between the post-test mean score of control and experimental group where p-value is less than the 0.05. This indicates that the experimental group has a significantly higher post-test score than the control group.

This can be attributed to the fact that most students could learn better if the teacher makes use of mathematical games strategy in teaching. This further supported the study conducted by Rowe (1997) which showed that the use of games in the teaching of mathematics improved the scores compared to scores of students subjected to traditional method of teaching. Likewise, it also goes with the study of the American researchers Bright, Harvey and Wheeler (1979) wherein the students gained more in test performances with the use of games than lecture method. They found out that games were effective to retain and reinforce students' skills with basic number facts.

Thus, students who were exposed to mathematical games strategy in teaching outperformed those who had the traditional method of teaching because the students in the class enjoyed playing while learning mathematical concepts as result of the student feedbacks and observations.

Comparison between the Mean Gain Scores of the Control Group and Experimental Group

The data contained in table 7 shows the t-test results between the mean gain scores of the control group and experimental group.

Table 7. Mean gain scores and standard deviation of the control group and experimental group

	Control	Experimental	T-Value	P-Value
Mean Gain	8.58	16.79	6.653[s]	0.0000
Standard Deviation	5.71	5.03		

s – significant

Table 7 indicates that the mean gain of the control group is 8.58 while the mean gain of the experimental group is 16.79. The computed t-value of 6.653 with a p-value of 0.0000 indicates that a significant difference between the mean gain scores exists. This further implies that the mean gain scores of the respondents in the experimental group is significantly higher than the mean gain scores of the respondents in the control group.

According to the study of Blunt (2010), the data analysis found that classes using the game had significantly higher mean scores than those classes that did not use the game and the students who were exposed to the games in teaching have a higher mean gain scores.

Student Feedback and Researcher Observations

The feedback of the students and observations of the researcher also showed the result of the findings that the students exposed to mathematical games strategy were more active and motivated compared to traditional method of teaching, and even outperformed the latter. The following were the students' feedback and researcher's observations.

On Mathematical Game Strategy

Majority of the interviewed students of the experimental group reported that they learned mathematics because of using games in teaching. They understood mathematics and their skills improved as a result of playing games. One of the students in experimental group stated that "A Geometry subject is interesting compared the Algebra subject because more games are involved in learning Geometry. It motivates us to participate in the games". The student feedback was the same with the researcher's observation that most students in this group learned and enjoyed the lessons using games.

Traditional Method of Teaching

As observed, students in this group were less motivated than the experimental

group. Majority of the feedbacks of this group were as follows: Mathematics is a boring subject, difficult to understand, solutions are too long, some problems are complicated,we don't like numbers, and some parts of the lesson are not interesting. The researcher also observed that almost 50% of the class was not participating.

CONCLUSIONS

The level of performance of students both experimental and control group had the same level of initial knowledge regarding Geometry of shape and size in terms of their pre-test scores. After the experimentation, the students exposed to traditional method and mathematical games strategy have increased their scores after the discussion. However, the group of students exposed to mathematical games strategy performed significantly better than the students exposed in a lecture or traditional method of teaching in terms of their posttest mean scores. In addition, students exposed to the Mathematical Games Strategy of teaching Geometry performed better than students subjected to the Traditional Method of Teaching in terms of their gain scores.

RECOMMENDATIONS

Since students improved their performance in mathematics after exposure to the mathematical games strategy, the administrators and teachers should consider adopting and the use of this strategy in discussing lessons for purposes of motivating the interests of students.

A replication of this study should be conducted in any branches of mathematics like Algebra, Trigonometry, or other fields of specialization if it will yield the same results.

LITERATURE CITED

Ainsworth, S. & Habgood, J.

2009 Exploring the Effectiveness of Intrinsic Integration in Serious Games. Proc. 13th biennial conference of the European Association for Research on Learning and Instruction (EARLI). Amsterdam, The Netherlands.

Baker, E. L., Herman, J. L., & Yeh, J. P.

1981 Fun and Games: Their contributions to the Basic Skills Instruction in Elementary Schools. American Educational Research Journal, 18(1), 83-92.

Barab, et al.
2005 Making Learning Fun: Quest Atlantis, A Game Without Guns. Educational Technology Research and Development, 53(1), 86-107.

Bright, G. W., Harvey, J. G., & Wheeler, M. M.
1985 Learning and Mathematics Games. Journal for Research in Mathematics Education, Monograph Number 1, 1-189.

Burnett, L.
1992 Using Instructional Games to Construct Number Understanding and Skills. In M. Horne & M. Supple (Eds.), Mathematics: Meeting the challenge (pp. 223- 228). Melbourne: The Mathematical Association of Victoria.

Dela Cruz G.
2011 Games As Formative Assessment Environments: Examining the Impact of Explanations of Scoring and Incentives on Math Learning, Game Performance, and Help Seeking Information Sciences; Graduate School of Education & UCLA | University of California, Los Angeles

Kebritchi, M.
2010 The Effects of Modern Mathematics Computer Games on Mathematics Achievement and Class Motivation. Computers & Education, 55(2), 427-443.

Koay Phong Lee
1996 The Use of Mathematical Games in Teaching Primary Mathematics; The Mathematics Educator, 1(2), 172-180

Phillips M. C.
2010 Manipulatives: The Missing Link in High School Math.

Rowe J.
1997 An Experiment in the Use of Games in the Teaching of Mental Arithmetic.

Swan P. & Marshall L.
2011 Mathematics Games: Time wasters or time well spent?; Faculty of Education and Arts, Edith Cowan University, Joondalup, Western Australia, 6027. p.swan@ecu.edu.au l.marshall@ecu.edu.au

Vankus P.
2008 Games Based Learning in Teaching of Mathematics at Lower Secondary School. Acta Didactica Universitatis Comenianae Mathematics, Issue 8.

Usiskin Z. et al.
2002 Geometry Integrated Mathematics. Second Edition. Pearson Education Asia Pte Ltd. 2002