Effect of computer game-based learning on the performance in trigonometry of the ESEP high school students

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ARTICLE INFORMATION

ABSTRACT

Many students perceive mathematics   as a difficult subject, so they perform poorly. Teachers try adopting various strategies to make the learning of Mathematics meaningful and enjoyable. One potential learning strategy is Game-Based Learning (CGBL). The study aimed to determine the effect of CGBL on the performance level in Trigonometry of ESEP high school students in Las Piñas National High School using quasi- experimental, one - shot single group. The sample group was purposively chosen among 4th year high school students for school year 2012-2013. The instruments used were the following: Performance Test, Perception questionnaire, Mental Benefit Questionnaire, Interview Guide, Documentary Analysis and Observer's Evaluation. The data gathered by the instruments were subjected to quantitative and qualitative analysis.

Results revealed that there is a significant difference in the students' performance in Trigonometry using CGBL at 0.05 level of significance, and that CGBL has a positive effect in the cognitive and affective domains of learning. The study concluded that CGBL could be a better learning tool than the conventional learning tools in improving their performance.

Introduction

Many students perceived mathematics as a difficult subject, so they perform poorly. Based on the results of the National Achievement Tests for school years 2004-2006 and 2010-2011, the results showed that Mathematics achievement is declining *(NETRC Report).* The problem can be attributed to many factors that include the time spent by the students playing the computer games, instead of studying their lesson in mathematics.

Many students are attracted to computer games, because they are user-friendly and interactive, and they require very little or no supervision at all. The games also boost their self-esteem that motivate them to continue gaming without fear of being discriminated against by their peers or scolded by their teacher for committing mistakes. Furthermore, their previous gaming experience whether it is good or bad helps them construct new ideas that help them succeed.

The study believes that once the gaming environment is transferred to the classroom environment, there is a high possibility that the students' performance level in mathematics will also improve, because the modes of thinking in computer gaming and mathematics are very similar, especially in the use of words, pictures and equations in managing a task.

The students first explore a mathematical problem by "playing with it" then use successive refinements orientation to get the "big picture" first and filling-in the details later.

The "picture" in mathematics resembles the main feature of the Computer-Game Based Learning (CGBL) that it calls "visual" which accounts for the strong appeal to simple apprehension that produces a mental idea. It can provide the students a clear idea of the problem and bridges the gap in the other modes of thinking that guide them to judge and correctly to succeed in a given task.

As such, the purpose of the study was to determine the effect of CGBL on the performance level in Trigonometry of ESEP high school students in Las Piñas National High School (LPNHS), utilizing three developed instruments namely: the performance test in Trigonometry, mental benefits questionnaire and document analysis. The findings of the study would be beneficial to the students, mathematics teachers, school administrators, curriculum and software developers and future researchers on the same topic.

Research Questions

To determine the effect of CGBL on the performance level in Trigonometry of ESEP high school students in LPNHS, the study attempted to answer these questions:

1. What is the students' performance in Trigonometry before and after using the CGBL?

2. Is there a difference between the students' performance in Trigonometry before and after using CGBL?

3. What is their perception on the use of CGBL in Trigonometry?

Literature Review

CGBL is a learning tool used in a student-centered learning environment to motivate and improve the students' performance in Trigonometry. When engaged, the students undergo the cognitive process. The engagement is such a dynamic process that students continually correct their mistakes to have a complete and clear memory picture of the lesson.

CGBL provides a clear memory picture, because it provides a more efficient recall of pictures based on the theory of dual coding by Pavio (1978, 1986). The theory postulates two types of memory coding: Verbal and Image system. Verbally presented material is encoded only in the Verbal System, while visually presented material in both the Verbal and Image systems.

In contrast with the memory's "single coding" for text, pictures have "dual coding" in two types of memory codes; if these two codes provide more cues for recall, then it generally should be easier to remember pictures than text.

The two memory codes can also provide cues for students to learn more things, as they transfer the mental skills from gaming to learning. As pointed out by Schnotz (1993), "Graphics offer various advantages to the process of knowledge acquisition which go far beyond a mere memory effect."

Many studies provide different kinds of CGBL software like the Battlefield 1942, Robomemo, Counterstrike and Dimexians. The present study used as its CGBL subject software the Angry Birds Rio Game-Smuggler's Den (ABRG-SD), a game inspired by a sketch of a wingless bird with the objective of destroying a structure and free the caged exotic birds (http://www.angrybirdstees.com/angry-birds-bio-history-and-characters.html).

ABRG-SD provides the students an experience on cognitive learning to: 1. Simple yet engaging interaction concept; 2) Cleverly managed response time; 3) Short-term memory management; 4) Mystery; 5) How things sound; 6) How things look; and 7) Measuring that which some say cannot be measured. In the context of Angry Birds Game, success is bound up in slowing down that which could be fast, erasing which is easily renewable, and making mysterious and memorable visual (http://www.mauronewmedia.com/blog/why-angry=birds=is-so-successful-a-cognitive-teardown-of-the-user-experience).

ABRG-SD also provides the students a cognitive workout, because it requires high level and abstract thinking to master. These are some of the mental benefits the students can get from ABRG-SD: 1) Problem solving and logic; 2) Resource management and logistics; 3) Multitasking ; 4) Spatial skills, fine motor and hand-eye coordination; 5) Anticipation and strategy; 6) Perseverance; 7) Pattern recognition; 8) Hypothesis testing and inductive reasoning; 9) Mapping; 10) Memory; and 11) Reasoning and judgments (http://angrybirdsandroid.org/mental-benefits-of-playing-angry-birds-on-android.html).

Because of: 1) Simplicity, 2) Success/failure, 3) Progress, 4) satisfaction and 5) Completion ABRG-SD tends to be addictive. (http://www.makeuseof.com/tag/5-reasons-angry-birds-damn-addictive).

Based on the review of literature, CGBL like ABRG-SD has the potentials to provide more benefits in the learning of mathematics than the traditional teaching methods. It has more content knowledge and skill that require all the components of plans, goals and assumptions; it provides practice opportunities for cognitive skill; its game design is well defined with elements of learning and engagement; and finally, it helps the students "learn how to learn".

Results of many studies revealed the same findings (Kirreimuir,2002; Haugland, 1992; Ko (2002), Cutis and Lawson (2002); Cagitlay, 2007; Attewell, 2003; Zagal, Rick and His, 2006; and Tabula ,2008).

The CGBL effects are manifested on both the cognitive and affective domains of learning. The study of Cutis and Lawson (2002) and CagitlIay (2007) revealed that in the cognitive domain, the students improved their problem solving and logic skills, multitasking and spatial skills, anticipation and strategy, pattern recognition, and memory. In the affective domain, the students developed motivation, perseverance, and self-esteem.

However, despite the many advantages of CGBL as a learning tool in mathematics, it has also its weak points. According to Blake (2008), anyone who plays the computer game will end up doing in the real world what he exactly did in his or her virtual world; hence, he did not recommend the use of computer games as a learning tool and suggested that it must be done in a right environment.

As such, the study supports the claim that CGBL can help improve the performance of the students in mathematics when it is properly applied in an apt learning atmosphere.

Conceptual Framework

Based on related literature and studies, the diagram below shows the relationship of CGBL, ABRG-SD, and the students' performance in Trigonometry. Figure 1 shows the conceptual framework of the study.
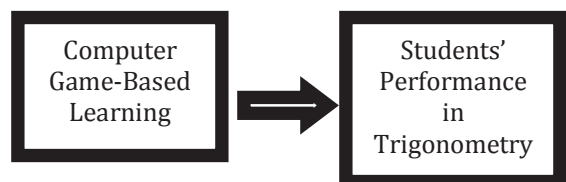

Figure 1. The Conceptual Framework of the Study

Research Hypothesis

The study hypothesizes that there is a significant difference between the mean of the pretest and post test scores of the students in Trigonometry before and after using CGBL-ABRG-SD.

Method

The Participants

The sample group of the study was purposively chosen from twenty 4th year students at LPNHS handled by the teacher-researcher.

Using the fish bowl technique, the research chose 20 respondents out of the 25 fourth year students to be part of the study consisting of 11 male and 9 female students. Furthermore, 90% of the students or 18 out of the 20 respondents used computer in their research. This means that the sample group has sufficient background knowledge in computer and qualified to use CGBL-ABRG-SD in learning Trigonometry.

Research Design

The design of the study is quasi-experimental, one-shot single group. It used a pretest - posttest to determine the effect of CGBL in learning Trigonometry as shown in Figure 2.
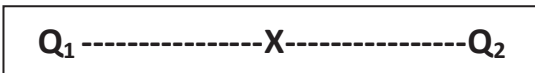
$$Q_1 \text{----------------} X \text{----------------} Q_2$$

Figure 2. The Research Design of the Study

Based on Figure 2, Q_1 represents the pretest, X the CGBL-ABRG-SD as a learning tool, and Q_2 the posttest. Quantitative analysis was used to determine the students' performance in Trigonometry by interpreting the results of the pre-test and post-test scores. Qualitative analysis was also used to gather more information about the effect of CGBL to the performance level of the students.

Research Instruments

The study used the following instruments to gather the data about the effect of CGBL in the students' performance: 1) Performance test, 2) Perception Questionnaire, 3) Mental Benefit Questionnaire, 4) Interview Guide, 5) Documentary Analysis and 6) Observer's Evaluation. The first, third and fifth instruments were developed by the researcher herself, while the second, fourth and sixth adapted and modified.

The Performance Test has 30 multiple choice items covering the topics in Trigonometry namely: 1) Properties of right triangles; 2) Solving problems involving right triangles; and 3) Problem solving related to the applications of Trigonometry. It was content validated by the Head Teacher, Master Teacher, and Math Teachers where the researcher is currently connected.

The Perception Questionnaire of 15 items was adapted from Epres (2010) and modified by the researcher. It covered the perceptions of the students on the use of CGBL as a learning tool on statements number 4, 8, 9, 10, 14 and 15. The questionnaire also described how CGBL affects the interest of the students in learning right triangles and its applications, as shown in the statement numbers 1,2,3, 5,6,7,11,12 and 13.It used a 5 point-Likert scale with 5 as strongly agree, 4 as agree, 3 as slightly agree, 2 as disagree and 1 as strongly agree.

The Mental Benefits Questionnaire of 10 items was based on the mental benefits identified in Android. Each item in the Mental Benefits Questionnaire corresponds to the mental benefits the students get from playing the ABGR-SD. It was validated by education experts teaching logic at Technological University of the Philippines-Cavite Campus.

The Interview Guide asks questions in the cognitive domain of learning found in items 2, 5, 6, 7, 8 and 9 and affective domain in items 1, 3, 4 and 10. Modified to fit the study was adapted from Epres (2010), validated by experts, translated in Filipino by a Filipino teacher, and checked by a Filipino Head Teacher for the students to fully understand the questions in each item.

The documents analyzed by the study were: 1) The grades in mathematics of the sample group during the 1st and 2nd grading period; 2) Activity sheet of the students; 3) Article entitled "Angry Birds for Android and Addiction Issues" that outlined the 11 mental benefits from playing the Game, and five of which were used by the students; as well as 4) The Observer's Evaluation administered among mathematics teachers.

Finally, the Observers' Evaluation of five items was used to avoid possible bias in teaching. It had a 5 point-Likert Scale with 4 as strongly agree, 3 as agree, 2 as slightly

agree and 1 as disagree. The contents were also validated by experts.

The data gathering procedure had undergone three phases of development: Pre-experimental phase, actual usage and post-testing phase.

In Phase I, the researcher sought the approval of the school authorities in LPNHS to conduct the study in the school and use 20 computers in the Computer Laboratory to administer CGBL. She also sought the permission from the parents of the sample group for a one-hour extension of their class In Phase II, CGBL was administered to the sample group from November 12 to December 18, 2012 with a ratio of 1:1; and finally, in Phase III, the posttest to the sample group simultaneous with the administration of the Perception Questionnaire, Mental Benefits Questionnaire, Interview Guide, and Documentary analysis.

Statistical Treatment of Data

The study used both quantitative and qualitative analyses on the gathered data. From the Performance Test, the study collected quantitative data. Based on which the mean and standard deviation were computed to determine the respondents' measure of central tendency and the spread of their answers.

The mean and standard deviations were used in the *t*-test for dependent samples to determine the difference in their performance in the pre-test and post-test using CGBL. The result of the *t*-test was used to accept or deny the hypothesis of the study.

To validate further the difference in their level of performance using CGBL, the study also administered a survey questionnaire. Besides quantitative data, the study collected qualitative data using the Mental Ability Questionnaire and Interview Guide. Finally, the study conducted a Documentary Analysis on the four documents about the sample group.

Results and Discussion

Based on the Performance Test scores in Trigonometry, the results show that the respondents' performance increased from 35.33% mean percentage score to 78.00% after being exposed to CGBL which is above the minimum level of mastery. Table 1 sums up the respondents' Performance Test scores.

Table 1
Summary of the Respondents' Performance Test Scores
($n = 20$)

Descriptive Statistics	Pretest Scores	Posttest Scores
Highest Score	14	29
Lowest Score	8	16
Mean	10.60	23.40
Std. Deviation	1.759	3.169
Mean Percentage Score	35.33%	78.00%

Based on Table 1, the highest score in the pre-test is 14 while in the post-test is 29; the lowest score in the pre-test is 8 while in the post-test 16; the mean in the pre-test 10.60 while in the post-test 23.40; and the standard deviation in the pre-test 1.759 while in the post-test 3.169. The results indicate that the students' level of performance in Trigonometry has increased in the post-test after being exposed to CGBL.

Furthermore, the difference between the pre-test and post-test scores of the students in Trigonometry is significant. Table 2 summarizes the paired t-test for the respondents' mean scores.

Table 2
Summary of Paired t-test for the Mean Scores of the Respondents

Pretest Mean	Posttest Mean	Mean Difference	t-value	p-value	Remark
10.60	23.40	12.800	16.410	0.000	Significant

*p<0.05

Table 2 shows that the p value is less than the adopted level of significance ($p < 0.05$). There is high probability of 95% that the difference between the pre-test and post-test scores of the students is due to the effect of CGBL, not to other intervening or moderating variables.

The significant difference between the pre-test and post-test scores of the students can be attributed to their positive perception toward CGBL in Trigonometry with an overall mean rating of 4.45, as shown in Table 3.

Table 3
Frequency Distribution of the perception of the students toward CGBL

	Perceptions	Mean	Remarks
1	I develop positive attitudes towards trigonometry.	4.40	Agree
2	The teacher is in control of the class.	4.35	Agree
3	I learn more when I hear my classmates explain their opinions and estimation in their own words.	3.85	Agree
4	I find the Computer-Game based Learning student centered.	4.40	Agree
5	I learn more because I am motivated.	4.50	Strongly Agree
6	I am encouraged to participate in classroom activities.	4.65	Strongly Agree
7	I have more input and involvement in the classroom	4.65	Strongly Agree
8	I find CGBL-allotted time enough for learning purposes.	4.65	Strongly Agree
9	I appreciate the teachers role as a facilitator rather than the source of all knowledge.	4.30	Agree
10	I learn better in right triagles with the use of Computer-Game Base Learning	4.25	Agree
11	I learn to accept mistakes.	4.35	Agree
12	I listen to the explanation of the other members of the group.	4.40	Agree
13	I have the opportunity to express my opinion in CGBL.	4.55	Strongly Agree
14	I develop pattern and relations in trigonometry through CGBL.	4.60	Strongly Agree
15	I enjoy Trigonometry through CGBL.	4.90	Strongly Agree
	Over-all mean	4.45	Agree

Based on Table 3, the highest mean is shown on the statement that they enjoy learning Trigonometry through CGBL number 15 with a mean of 4.90 interpreted as strongly agree, while the lowest mean on the statement on whether they learn more when they hear their classmates explain their opinions and estimations in their own word number 3 with a mean of 3.85 interpreted as agree. The results show that since the students have a positive perception toward CGBL, it could have changed their negative attitude, too, towards Trigonometry.

The significant difference between the pre-test and post-test scores of the students can also be attributed to the mental benefits they have acquired from CGBL. Table 4 shows the responses of the students on the mental benefits questionnaire.

Table 4
Responses to the Mental Benefits Questionnaire

Mental Abilities	Yes	No
1. Did you make a solution plan?	16	4
2. Did you persevere to find the correct equation?	15	5
3. Did you figure out the pattern of the word problem?	18	2
4. Did you get the big picture of the problem and filling in the details later?	16	4
5. Did you remember your previous learning ecperience in work problem?	20	0

Based on Table 4,16 out of 20 or 80% of the respondents made a solution plan; 15 out of 20 or 75% of the respondents persevered to find the correct equation; 18 out of 20 or 90% of the respondents could figure out the pattern in solving the word problem; 16 out of 20 or 80% of the respondents got the big picture of the problem and were able to filled-in the details; and 20 out of 20 or 100% of the respondents remembered their previous learning experience in word problem.

The results of the Perception Questionnaire Survey and the Mental Benefits Questionnaire explain the reason behind the significant difference in the students' performance before and after having been exposed to CGBL and the increase in their level of performance in Trigonometry. Because the students have a positive attitude towards CGBL and Trigonometry, they have acquired many mental benefits used in problem solving.

Some of the reasons given by the respondents on their positive attitude toward CGBL based on the Interview Guide comprised of: *"…the usage of the computer games is related to the lessons…the respondents can visualize the lesson… Opo… lalo na pagdating sa Trigonometry, nagiging malinaw sa amin ang mga lessons (…the computer games help them in Trigonometry… the lesson became clear) …and it does not make the learners feel bored during the class."*

The other reasons provided by the students about the learning environment using CGBL consisted of: *"…learning is fun…learning is satisfying and enjoyable…it is more fun in learning Trigonometry with the help of computer game, because it is a little bit boring if the teacher is the only one explaining each lesson…"*

Based on Documentary Analysis, the results of the post-test scores of the respondents showed that there was an improvement in the students' level of performance when their individual grades were compared to their grades in the 1st grading period and the 2nd grading period when CGBL was administered. Table 5 shows the grades of the sample group in Mathematics from the two grading periods.

Table 5
Summary of the Grades of the Sample Group in Mathematics from the 1st to 2nd Grading Period

Students	First Grading	Second Grading
A	89	92
B	89	91
C	87	90
d	88	89
I	87	87
J	86	88
K	87	87
L	86	87
Q	84	85
R	80	83
S	81	82
T	78	82

Based on Table 5, the results showed that there was a high increase in the level of performance of these respondents: I, J, K, L, Q, R, S and T. A slight increase was also noted on respondents A, B, C and D.

Finally, based on the Observers' Evaluation, the mathematics teachers agreed on the usage of CGBL in the teaching of Mathematics as an effective learning tool compared to the conventional instructional tool, because it could affect the students' cognitive and affective domains of learning with an overall mean rating of 4.40. Table 6 sums up the observer's evaluation.

Table 6
Summary of Observers' Evaluation

Observer	Mean	Interpretation
1	4.20	Agree
2	4.40	Agree
3	4.60	Strongly Agree
Overall Mean	4.40	Agree

Based on the analysis and interpretation of the data, the findings of the study showed that: 1) There is a significant difference in the performance of the students in Trigonometry using CGBL at 0.05 level of significance;2) The significant difference can be attributed to the positive perceptions of the students toward CGBL and the mental benefits they developed;3)In the affective domain, CGBL has enhanced the positive attitude of the students towards Trigonometry such as: Motivation, self-esteem, respect of authorities, cooperative learning and teamwork; and 4) In the cognitive domain of learning, CGBL has enhanced the mental abilities of the students.

Conclusion and Recommendations

In light of the above findings, these conclusions were drawn: 1) The increase in the posttest scores is due to the use of CGBL as a learning tool in Trigonometry; 2) CGBL has a positive effect in the cognitive and affective domains of learning; and 3) it has a strong potential to increase the students' level of performance in Mathematics when applied in the correct learning environment.

The study recommends that:

1. School administrators set resources for the training of mathematics teachers on the usage of visual instructional materials

like CGBL in the teaching and learning of mathematics;

2. They regularly upgrade the lesson plans of mathematics teachers by integrating the use of visual instructional materials like CGBL in the classroom activities;

3. Mathematics' teachers use more visual instructional materials in the classroom activities to enable the students to construct a complete, concrete memory model of the mathematics problems on hand and to enable them to easily recall mathematics information in the succeeding tasks; and

4. Further studies on the effects of CGBL on the cognitive domain of learning of the students in Trigonometry be conducted.

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