The Effect of Game-Based Learning on Science 10 Test Scores

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Abstract
Game-based learning (GBL) is one of many methods that enhance the classroom learning environment by increasing student motivation and engagement. In recent years, the availability of game resources on the internet and the ubiquity of mobile devices have generated more interest in game-based learning. There are few researches, however, on whether it improves retention or not. The purpose of this study is to explore the effect of game-based learning (GBL) on test scores (quick checks, quizzes, and forms) of Grade 10 students in Science class. The study used a one group post-test only design for a four-week learning activity. The participants included 204 Grade 10 students in six classes of Miriam College High School. Three classes were exposed to GBL (experimental group) and the other three classes learned with traditional teaching approach (control group). The Mann-Whitney test for independent samples revealed that quick check scores of students in the experimental group were significantly higher than that of the students in the control group. However, no significant difference was found between form and quiz test scores of the two groups. This suggests that game-based learning may be effective in improving short-term retention, leading to higher scores in post-tests administered shortly after the game. However, there is insufficient evidence to determine whether or not game-based learning is effective in improving long-term retention or scores in long-term post-tests.

Keywords: games, GBL, game-based learning, post-test scores, retention, Mann-Whitney Test

Introduction

Background of the Study

Science is a highly-conceptual subject matter. Some issues in Science learning include its abstraction, thus, many students tend to lose interest which oftentimes leads to boredom. Moreover, many of them do not see the relevance of Science in their lives (Osborne, et. al., 2003). According to Butler (2011), for Science teaching to become successful, a teacher must develop and include carefully constructed strategies which encourage students to learn and apply Science concepts in the classroom and in their lives.

Games are a regular part of students' lives, no matter what their grade level. Students play games throughout the day on their computers, the Internet, and their cell phones. One of the few places they don't regularly play games is in their classrooms. Although some teachers use games as a part of their instructional repertoire, most teachers do not, and those who do include them may not be using them to their full potential (Marzano, 2010).

As teachers of twenty-first century learners, the need to incorporate novel and varied strategies in order to engage students and sustain their interest in Science is apparent. Incorporating games and simulations in the classroom is an effective way to address this (Hsieh et al., 2015).

In addition to this, digital games used in the classroom have been proven to provide more engagement for the learner, provide personalized learning opportunities, teach twenty-first century skills, provide an environment for authentic and relevant assessment, and are founded on sound learning principles (Mc Clarty, 2012).

Significance of the Study

The results of the study will hopefully provide more evidence to show the positive effect of the use of game-based learning in the classroom. This has become especially relevant today, with the development of more digital games to engage students. This study could also affirm the use of game-based learning in improving student performance in Science.

Scope and Limitations of the Study

The participants of the study will be limited to six sections of MCHS Grade 10 students for school year 2016-2017. These girls fall within the age range of fourteen and fifteen years old. Three sections under one teacher will make-up the control group (not exposed to games), while the other three under another teacher will form the experimental group (exposed to games). Games used for the experimental group were limited to memory games. These include Four Pics One Word, Cash Cab, Pictionary, Pinoy Genyo, Find Your Partner Game, and Jeopardy.

Science 10 course materials such as PowerPoint presentations, lecture activities, laboratory activities, and quick check / quiz / form questionnaires for all six classes will be kept constant. The study will only consider the students' quick check, quiz and

form results as a basis of their performance for a lesson unit. The course materials (lesson plan, lesson presentation slides, games, and post-test questionnaires) used in the control and experimental groups were prepared by both teachers. Some of the games were based on famous television shows/games like Jeopardy and Cash Cab. While others were based on popular games like Pictionary, 4 pics 1 word and Call my Bluff.

The study covered the following lessons: Biomolecules, DNA Structure and Replication, Protein Synthesis, Mutation, Evolution, and Population Ecology. There were nine quick checks, four quizzes, and two forms within the span of the experiment.

Conceptual Framework

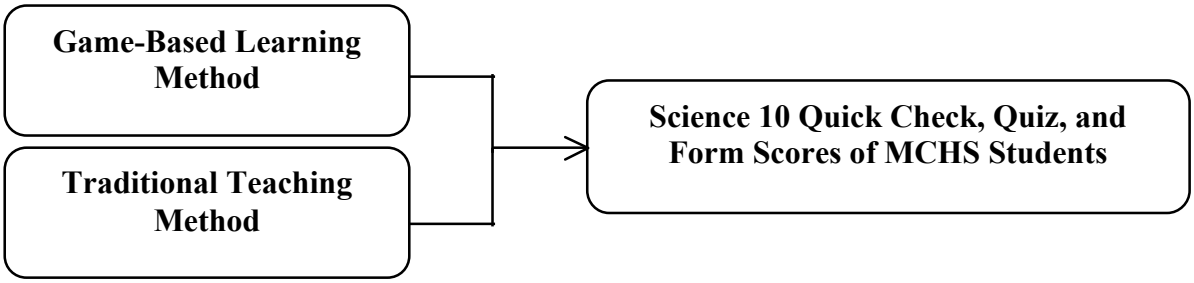

Figure 1. Framework for determining the effect of game-based learning on MCHS students' test scores in Science 10.

Referring to our conceptual framework (Figure 1), the study aims to determine the effect of game-based learning on Grade 10 students' Science posttest scores.

Statement of the Problem

The study seeks to determine if there is a difference in Science test scores between students exposed to game-based learning and those who were not. Specifically, it aims to answer the following questions:

1. Is there a significant difference between Science 10 form scores of regular classes and that of game-based learning classes?
2. Is there a significant difference between Science 10 quiz scores of regular classes and that of game-based learning classes?
3. Is there a significant difference between Science 10 quick check scores of regular classes and that of game-based learning classes?

Hypotheses

The following are the null hypotheses for the research:

H_{o1}: There is no significant difference between the quick check scores of the Science 10 regular group and game-based learning group.
H_{o2}: There is no significant difference between the quiz scores of the Science 10 regular group and game-based learning group.

H_{o3}: There is no significant difference between the form scores of the Science 10 regular group and game-based learning group.

Research Design

The study used a one group post-test only design. The students' quick check, quiz and form results were considered as the post-test scores after the implementation of game-based learning in the experimental group. Three sections under one teacher made up the control group, while the other three under another teacher formed the experimental group. The sample size is 204 MCHS Grade 10 students, with 104 students making up the control group (traditional learning) and 100 students making up the experimental group (game-based learning).

The difference in mean scores between the two groups was determined using the Mann-Whitney Test for independent samples upon learning that the scores were not normally distributed.

Participants

The participants of the study was limited to six sections of MCHS Grade 10 students for school year 2016-2017. These girls fall within the age range of fourteen and fifteen years old. Convenience sampling was utilized in gathering data, wherein one group was exposed to game-based learning while the other group was exposed to the regular / traditional lesson format. Three sections under one teacher made up the control group, while the other three under another teacher formed the experimental group. The sample size is 204 MCHS Grade 10 students, with 104 students making up the control group and 100 students making up the experimental group.

Research Instruments

Testing instruments include nine quick check questionnaires, four quiz questionnaires and two form questionnaires (refer to Appendix B). Quick check questions usually belong to the following test types:

• Identification,
• Fill in the blank, and
• True or False.

Quizzes usually have the following test types:

• Identification,
• Modified True or False,
• Labeling,
• Matching Type, and
• Application (short essay).

Forms, on the other hand, follow the multiple choice type of test but incorporate analysis questions involving:

• Sentence analysis,

• Sequencing,
• Always, Sometimes, Never (ASN), and
• Odd-one-out.

Procedures

Execution of Games

The game-based learning group, made up of three sections under one teacher, was exposed to games that were incorporated into the subject period as motivational activities or review games.

The first game that was played by the game-based learning group was 4 Pics 1 Word, which was used as a motivational activity for the lesson on carbohydrates. In the classroom adaptation, a PowerPoint template (refer to Appendix C.1) of the 4 Pics 1 Word game was used to display the four pictures and blank letter squares that serve as clues for the players to be able to guess the mystery word. All of the students were asked to bring out their tablets and use the whiteboard app to write their guess for what the mystery word might be. At the end of fifteen seconds (15 s), the students were asked to raise their iPads to display their answers. The students were asked to explain their answers before the correct answer was revealed by the teacher.

Call My Bluff was the game used in preparing for the quiz on biomolecules. In the modified classroom version, a PowerPoint template (refer to Appendix C.2) of the Call My Bluff game was used to display the pictures of three scientists who served as celebrity guests and their suggested answers to each question. All of the students were asked to bring out their tablets and use the whiteboard app to write down the name of the scientist / celebrity who they think is telling the truth. At the end of fifteen seconds (15 s), the students were asked to raise their iPads to display their answers. The students were asked to explain their answers before the correct answer was revealed by the teacher.

A Find Your Partner game was used to prepare for the quiz on DNA structure and replication. All students in class were given a piece of paper with a term or description written on it. They were asked not to read the term upon receiving the piece of paper. A signal was given to read their assigned term. They were then asked to find their partner without talking or communicating verbally. Upon finding their partner, they sat down next to their partner and waited for everyone in the class to finish. Each pair was then asked to read their assigned terms and explain why the two matched.

Pictionary was used to review for the quick check on transcription. A volunteer from the class was asked to draw the word / term on the board while the rest of the class guessed the word. The remaining students blurted out their guesses until correct word has been announced. If the word had not been uttered at the end of 3 minutes, the volunteer revealed the answer and explained what she was trying to depict in her drawing.

Pinoy Henyo was used to review for the quiz on protein synthesis. A mystery word was given to the class volunteer, which she held facing her classmates. The guesser

asked yes or no questions which were answered by the rest of the class in chorus until the guesser blurts out the correct answer. If the volunteer had not guessed the correct term at the end of two minutes, the teacher revealed the answer and had the volunteer think of questions that could have led to the correct answer.

Jeopardy was the game used as a review for the form on biomolecules. In the modified classroom version, a PowerPoint template (refer to Appendix C.8) of the Jeopardy game was used to display the categories and questions for the game. The students were grouped by column and took turns representing their group per round. Representatives for each column/group were stationed at the back of the classroom, behind their group mates. They were asked to bring their tablets and use the whiteboard app to write down their answers. They were asked to raise their iPads to display their answers at the end of 15 seconds. A volunteer scorekeeper kept track of each group's score on the board. Before revealing the correct answer, the teacher asked the remaining members of the group to answer the question before confirming the correct answer to the class.

A quiz bee game with three rounds (Easy, Average, and Difficult) was used as a review activity for the form on central dogma and mutations. The students formed groups of five and were asked to write their group's answer using a whiteboard app on their iPad. Each correct answer was worth one point in the Easy round, three points in the Average round and five points in the Difficult round. Before announcing the correct answer, the students were asked to explain their team's answer.

Data Collection

Quick checks are five- to ten-item tests that are administered midway and at the end of a lesson. Students are given five to ten minutes to accomplish the quick check. Quizzes range from twenty to thirty points. Students are given twenty to thirty minutes of the Science period to answer a quiz. Forms range from fifty to seventy points. The whole period of fifty-five minutes is allotted for this assessment. Quiz and form components are equivalent to twenty-five percent (25%) each of the final term grade. Quick check scores are recorded under the seat work / homework component which makes up fifteen percent (15%) of the Science 10 term grade. These are considered as short-term post-test scores while quiz and form scores are considered as long-term post-test scores.

Analysis of Data/Statistical Methods

The Test for Normality was performed prior to the deciding on the appropriate test for independent samples. Since the data was not normally distributed, the Mann-Whitney Test for independent samples was employed to determine if there is a statistically reliable difference between the post-test scores of Grade 10 Science students who were exposed to game-based learning and those who were not.

Conclusion

Results and Discussion

Data Distribution

The 204 Grade 10 students' quick check scores ranged from 13 to 58 (M = 42.25, SD = 7.728). The students' quick check scores were not normally distributed, W (204) = .979, p = .003. The Grade 10 students' quiz scores ranged from 43 to 129 (M = 104.62, SD = 15.419). The students' quiz scores were not normally distributed, W (204) = .957, p = .000. The Grade 10 students' form scores ranged from 39 to 89 (M = 72.69, SD = 10.982). The students' form scores were not normally distributed, W (204) = .949, p = .000. Table 1 shows the descriptive statistics of the data set while Table 2 presents the results of the Tests of Normality.

Table 1. Tests for Normality of Quick Check, Quiz, and Form Scores

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
TOT_QUIZ	.077	204	.005	.957	204	.000
TOT_F	.104	204	.000	.949	204	.000
TOT_QC	.055	204	.200*	.979	204	.003

Note: TOT_QUIZ = Total Quiz Scores, TOT_F = Total Form Scores, TOT_QC = Total Quick Check Scores

Table 2. Descriptive Statistics for Science 10 Quick Check, Quiz, and Form Scores

	N	Minimum	Maximum	Mean	Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic
student_game_exposure	204	1.00	2.00	1.4902	.50113
TOT_QUIZ	204	43	129	104.62	15.419
TOT_F	204	39	89	72.69	10.382
TOT_QC	204	13	58	42.45	7.728
Valid N (listwise)	204				

Note: TOT_QUIZ = Total Quiz Scores, TOT_F = Total Form Scores, TOT_QC = Total Quick Check Scores

The Mann-Whitney Test

The Mann-Whitney two-sample rank-sum test was conducted to examine whether there were significant differences in post-test scores (quick check, quiz, and form scores) between the group exposed to memory games and the group that was not. The Mann-Whitney two-sample rank-sum test is a non-parametric alternative to the independent samples t-test and does not share the independent samples t-test's distributional assumptions. This is a more suitable statistical test for the study since the post-test scores were not normally distributed.

The form score mean rank of the group exposed to memory games was 103.04 while the mean rank of the regular group was 101.99. The Mann-Whitney Test revealed

insufficient evidence to show a statistically reliable difference between form scores of Grade 10 students who had memory games incorporated in Science class discussions and those who had regular Science class discussions (U = 5146.000 p = .899).

The quiz score mean rank for the group exposed to memory games was 99.75 while the mean rank for the regular group was 105.14. The Mann-Whitney Test revealed insufficient evidence to show a statistically reliable difference between quiz scores of Grade 10 students who had memory games incorporated in Science class discussions and those who had regular Science class discussions (U = 4925.000 p = .514).

The quick check score mean rank for the group exposed to memory games was 110.94 while the mean rank for the regular group was 94.38. This suggests that the distribution of quick check scores for the regular group was significantly different from the distribution of quick check scores for the group exposed to memory games, with the game-based learning group having a mean rank higher than that of the regular group(U = 4356.000 p = .045). Table 3 shows the ranks of the two groups while Table 4 presents the Mann-Whitney Test results.

Table 3. Group Ranks

	student_game_exposure	N	Mean Rank	Sum of Ranks
TOT_QUIZ	Regular	104	105.14	10935.00
	Game-based Learning	100	99.75	9975.00
	Total	204		
TOT_F	Regular	104	101.99	10606.50
	Game-based Learning	100	103.04	10303.50
	Total	204		
TOT_QC	Regular	104	94.38	9816.00
	Game-based Learning	100	110.94	11094.00
	Total	204		

Note: TOT_QUIZ = Total Quiz Scores, TOT_F = Total Form Scores, TOT_QC = Total Quick Check Scores

Table 4. Mann-Whitney Test Results

	TOT_QUIZ	TOT_F	TOT_QC
Mann-Whitney U	4925.000	5146.500	4356.000
Wilcoxon W	9975.000	10606.500	9816.000
Z	-.653	-.127	-2.003
Asymp. Sig. (2-tailed)	.514	.899	.045

Note: TOT_QUIZ = Total Quiz Scores, TOT_F = Total Form Scores, TOT_QC = Total Quick Check Scores

There were 100 students in the group exposed to memory games and 104 students in the regular group. There was no significant difference found between quiz and form

test scores of the regular group and the game-based learning group based on results from the Mann-Whitney Test.

However, it is observed that the form score mean ranks of the game-based learning group were slightly higher than that of the regular group. On the other hand, it is observed that the quiz mean score ranks of the regular group were slightly higher than that of the game-based learning group.

One factor that might have contributed to these slight differences in quiz and form test results is the difference in pacing of discussion. Pacing of classroom discussions is highly dependent on the number of questions generated by each class, thus, greatly varying the length of time allotted for a particular topic. Another factor could have been the allocation of time for the game in the case of the game-based learning group. Some discussion time is spent on the execution of the game and processing of the game results, while the regular classes had a lengthier discussion time for the topics. Another factor could have been that some of the games were used as a motivational activity rather than a review game. Subject matter in some of the motivational activities was trivia-related and not aligned with the competencies being checked by the post-tests.

Interestingly, the quick check mean rank of the game-based learning group (M = 110.94) was significantly higher than the regular group (M = 94.38). This is somewhat consistent with the findings of Rondon et.al. (2013) that Speech-Language and Hearing pathology undergraduate students who received the game-based method performed better in a post-test assessment focusing on a particular topic. However, they concluded that game-based learning is comparable to the traditional learning method in general and in short-term gains, while the traditional lecture still seems to be more effective in improving students' short and long term knowledge retention. In their study, the game-based method was limited to the use of computer assisted instruction with minimal lecture classroom discussions. This is in contrast with the definition used in this study, wherein game-based learning is defined as the integration of review games in traditional lecture discussions. The difference in definition of game-based learning, where review games are coupled with traditional lecture discussions, resulted in more positive results for game-based learning, in general. This is supported by the findings of this study that results of summative tests (form and quiz scores) of both groups are comparable to each other (as shown in Table 4).

As a review technique, games seem to be more effective than the traditional lecture review in improving students' ability to recall terms, concepts, processes, or ideas during the short-term post-tests (quick checks), usually administered immediately after the execution of the game, rather than long-term post-tests (forms and quizzes), which are administered a few days or weeks later. These findings are consistent with the results of Ke and Grabowski's study (2007). They compared Math post-test results of three groups of fifth grade math students employing three different review techniques (competitive gameplay, cooperative gameplay, and pen-and-pencil review). Their results showed that there was no significant difference in math performance between the cooperative game-playing group and the competitive game-playing group but both performed significantly higher than the control group (pen-

and-pencil). Incorporation of games, whether competitive or cooperative, seems to result in better performance in short-term post-tests.

Implications of the Study

The classes that were exposed to game-based learning showed more interest in the subject matter, with a greater percentage of the class consistently participating in class discussions than the first term. This could mean that increased interest in the subject led to a slightly improved performance in the short-term post-tests but not the long-term post-tests.

Results of the study imply that:

• games should be used to supplement traditional lecture discussions since the findings of this study suggest that incorporating games in certain lessons is effective in improving short-term post-test results;
• different game-related applications must be introduced to and explored by teachers for lesson integration
• incorporation of games in particular lessons should be based on its appropriateness for the nature of the lesson;
• lesson planning should take into consideration the length of time necessary to execute the game, leaving enough time for covering the scope of the lesson; and
• perceived improvement in participation in class discussions by the game-based learning group suggests that there could have been unexplored and undocumented positive outcomes beyond the scope of the study like increased intrinsic motivation, improved interest, and development of a positive attitude towards the subject matter.

Conclusion

The Mann-Whitney two-sample rank-sum test revealed a statistically reliable difference between the quick check scores of the Science 10 regular group and game-based learning group. On the other hand, the Mann-Whitney two-sample rank-sum test revealed insufficient evidence to show a statistically reliable difference between quiz and form scores of the Science 10 regular group and the game-based learning group. These findings suggest that incorporating games in certain lessons might be effective in improving short-term post-test results. However, the results were inconclusive regarding the effect of game-based learning on improvement of long-term post-test scores.

Recommendations

1. **Documentation of Engagement in Class Discussions.** The improvement in participation of the game-based learning classes also suggest increased engagement in class discussions. However, this was not properly documented during the research. This was just based on the teacher's observation.

2. **Implementation of a Pre-Test – Post-Test Research Design.** If given the chance to improve the method of administering the study, the researchers recommend using the pre-test – post-test research design instead of the post-test only research design.

This method will be more effective in measuring the improvement in performance after exposure to game-based learning.

3. **Conducting a Science Interest Survey.** Adding a survey or means of measuring the increase in interest in Science could also be added to better support claims of the study.

4. **Alignment of Game Subject Matter with Competencies Measured by Post-Tests.** To make game-based learning more effective, subject matter included in the games must be aligned with competencies to be measured during the post-tests.

5. **Utilization of Other Game Types.** Since this study focused on review games, future studies could look into the effect of incorporating other types of games in improving retention of terms, concepts, processes, and ideas. Appropriateness of games and/or game types for specific topics could also be studied. Further studies on tournament game technique, wherein students' individual scores are collectively weighed against another group's score, could be pursued. Games in this format have been shown to increase personal accountability and engagement that lead to better performance (Salam, 2015).

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