Relationship Between Game-Based Learning and Mathematics Achievement of Grade Seven Students in a Middle Secondary School in Bhutan
ความสัมพันธ์ระหว่างการเรียนรู้ผ่านเกม และผลสัมฤทธิ์ทางการเรียนวิชาคณิตศาสตร์ ของนักเรียนเกรด 7 ในโรงเรียนมัธยมศึกษาตอนต้นในประเทศภูฏาน

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บทคัดย่อ

การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อหาความสัมพันธ์ระหว่างการเรียนรู้ผ่านเกม (Game-based learning) และผลสัมฤทธิ์ทางการเรียนวิชาคณิตศาสตร์ (Mathematics achievement) ของนักเรียนเกรด 7 ในโรงเรียนมัธยมศึกษาตอนต้นในประเทศภูฏาน การวิจัยครั้งนี้ได้ดำเนินการในปี พ.ศ. 2558 ในโรงเรียนมัธยมศึกษาตอนต้นแห่งหนึ่งในประเทศภูฏานเป็นระยะเวลา 2 เดือน โดยใช้แบบวิจัยแบบกึ่งทดลอง (Quasi-experimental design) นักเรียนที่เข้าร่วมการวิจัยในครั้งนี้เป็นนักเรียนเกรด 7 จำนวน 2 ห้อง รวมทั้งหมด 70 คน โดยกำหนดให้ห้องหนึ่งเป็นกลุ่มตัวอย่างทดลอง (Experimental group) และอีกห้องเป็นกลุ่มตัวอย่างควบคุม (Control group) กลุ่มตัวอย่างทดลองมีการเรียนรู้โดยใช้วิธีการเรียนรู้ผ่านเกม ขณะที่กลุ่มตัวอย่างควบคุมเรียนรู้โดยใช้วิธีการสอนแบบเดิม (Traditional teaching approach) การวิเคราะห์ข้อมูลได้ใช้โปรแกรม SPSS 21.0 ส่วนการคำนวณแต่ละกลุ่มตัวอย่างได้ใช้ค่าเฉลี่ยเลขคณิต (Arithmetic means) และค่าเบี่ยงเบนมาตรฐาน (Standard deviations) ผลการวิจัยแสดงให้เห็นว่าผลสัมฤทธิ์ทางการเรียนของนักเรียนกลุ่มตัวอย่างทดลองดีกว่ากลุ่มตัวอย่างควบคุมมาก โดยค่าเฉลี่ยความแตกต่าง (Mean difference) ของกลุ่มตัวอย่างทดลองอยู่ที่ระดับ 9.29 ขณะที่กลุ่มตัวอย่างควบคุมอยู่ที่ระดับ 3.40 ซึ่งมีค่าสูงกว่ากลุ่มตัวอย่างควบคุมมาก ข้อมูลที่ได้ยืนยันว่ามีความสัมพันธ์อย่างมีนัยสำคัญระหว่างการเรียนรู้ผ่านเกมและผลสัมฤทธิ์ทางการเรียน ทั้งนี้การวิจัยเกี่ยวกับเจตคติที่มีต่อวิชาคณิตศาสตร์เป็นระยะเวลา 2 เดือนได้ผลลัพธ์คล้ายคลึงกัน นักเรียนส่วนใหญ่มีเจตคติที่ดีต่อการใช้รูปแบบการเรียนรู้ผ่านเกม ก่อนการทดลอง ค่าเฉลี่ยของกลุ่มตัวอย่างทดลองเท่ากับ 2.06 และหลังทดลองค่าเฉลี่ยเท่ากับ 4.61 ปรากฏว่าค่าคะแนนเฉลี่ยสูงขึ้น 2.55 แสดงให้เห็นว่าการเรียนรู้ผ่านเกมมีผลเชิงบวกต่อเจตคติในการเรียนวิชาคณิตศาสตร์ของนักเรียน ผลจากการวิจัยแสดงให้เห็นว่าควรสนับสนุนให้ผู้บริหารโรงเรียนในประเทศภูฏานและประเทศอื่น ๆ นำวิธีการเรียนรู้ผ่านเกมมาประยุกต์ใช้ในการสอนวิชาคณิตศาสตร์ของนักเรียนระดับมัธยมศึกษาตอนต้น

คำสำคัญ: การเรียนรู้ผ่านเกม ผลสัมฤทธิ์ทางการเรียนวิชาคณิตศาสตร์ เจตคติที่มีต่อวิชาคณิตศาสตร์

Abstract

The aim of this study was to determine the relationship if any, between Game-Based learning and mathematics achievement of grade seven students in a middle secondary school in Bhutan. The research using quasi-experimental design, was carried out in 2015 in one of the middle secondary schools in Bhutan over a two-month period.The participants consisted of 70 seventh graders in two classes. One class was assigned to be the experimental group and the other the control group. The experimental group learned using game-based learning approach, while the control group learned using a traditional teaching approach. The data obtained in the study were analysed by the computer program SPSS 21.0. Arithmetic means and standard deviations were calculated for each group. The result showed that the learning achievement of the students in the experimental group was significantly better than that of the students in the control group. The mean difference for the experimental group over the two month period was 9.29 which is significantly higher than that of control group which was 3.40. These data confirm that there is a strong relation between game-based learning approach and mathematics achievement. With respect to attitudes toward mathematics there was a similar result over the two-month period. Most of the students revealed quite positive attitudes toward the use of the game-based learning approach. The mean in the pre-test of the experimental group was 2.06 and 4.61 in the post-test. The mean score had increased by 2.55 which indicated that game-based learning had a positive effect on student attitudes towards mathematics.These results should encourage school leaders in Bhutan and elsewhere to consider adopting Game-Based learning approach for the teaching of mathematics for middle school age students.

Keywords: Game-based Learning, Mathematics Achievement, Attitude Toward Mathematics

Introduction

Mathematics is a fundamental skill in our daily life. Humans have been using mathematics knowledge for over a thousand years. Moreover, Von referred to mathematics as the queen of sciences (Von, 1856), which implied the importance of Mathematics. Bhutan embraced the modern system of education in the early 1960s and Mathematics was introduced as one of the major subjects; to provide children with critical thinking and problem-solving skills along with the knowledge and values. However, the Department of Curriculum and Research Division points out, "Learning Mathematics is considered to be important and essential in every aspects of life, but learning mathematics is still a nightmare for many children in Bhutan".

Moreover in 2008, the Education Sector Review Commission (2008, p.15) states "Concern has been expressed at all levels of society over a perceived decline in standards of education, with student performance particularly worrisome in mathematics…" and the report further indicates "a high level of children who are not mastering the curriculum. Alarmingly, mean test scores in literacy and numeracy are very low…" (p.7). It is evident that Mathematics subject is difficult for the Bhutanese school going children.

Bhutanese students and students all over the world have considered Mathematics as a difficult and challenging subject. Bhutan Board of Examinations (2004, p.31) pertaining to grade 6 students points out "Equations are the most difficult for a third of the students, with algebra separately named as difficult for a further two fifths."Bhutan Board of Examinations further supplements "… in syllabus terms, class 6 children are being made to study too much too soon, especially when their relatively poor performance on high-level word-based problems is considered" (p.25).

The very reason for the poor performance in Mathematics could be lack of hands on experience due to the huge syllabus that the teacher has to cover in a limited time. Very limited space is provided to the students to explore and create. Udeinya and Okabaib (1991) blamed the poor performance of students in Mathematics on inappropriate methods and approaches to teaching which has reduced the level of achievement. Harbor and Peter (2001) asserted that the issue of poor performance in Mathematics examination was due to the problem of teaching methods. According to Bhutan Board of Examinations while teaching Mathematics, teaching methods like discussion were used less, project work was used very less, and field trips were not used at all. Teachers were found not using a variety of teaching methods (2004). Furthermore, there has been an increasing awareness that the conventional methods of teaching Mathematics, has not been very successful. Thus, to make Mathematics an interesting and fun subject, the instructional design needs to be changed.

Game-Based Learning (GBL) refers to teaching using games, where students explore mathematical problems using games. The game can be found in textbooks and also games are designed by teachers. It is based on the core premise that learning should be based on doing some hands on experiment and activities rather than just listening passively. There are several theories that are recognized as being relevant to the game-based learning approach, such as cognitive theory and situated learning theory. Cognitive theory emphasizes that learning processes are progressive and move from simplicity to complexity; moreover, games that are adopted need to stimulate students' learning motivation and make learning more fun (Gagné, 1985). Situated learning theory states that learners should enter learning scenarios to acquire knowledge. Therefore, establishing a rich learning scenario enables learners to gain practical problem-solving abilities via observation and behavioral exploration, and a well-designed game is able to provide such a learning scenario (Kim, Park, &Baek, 2009).

Games have been recognized as being a good tool to promote learners to actively participate in learning activities (Baid& Lambert, 2010). Researchers believe that games can help children develop problem-solving skills (Chuang & Chen, 2009). Terrell and Rendulic (1996) stated that using games for learning in elementary schools can increase the internal motivations and learning achievement of students. These games can also enhance students' learning motivation (Klawe, 1998; Nussbaum, 2007). Caroll (1982) also stated that games are able to boost motivation owing to such characteristics as; adventure, challenge and freshness. Several studies have demonstrated the ease of use and usefulness features of games by applying the game-based learning approach to a variety of learning activities (Bourgonjon, Valcke, Soetaert,

&Schellens, 2010). Researchers have indicated that Game-Based Learning could be the best way to trigger students' learning motivation (Dickey, 2010). In addition, game based learning approach might provide a good chance to stimulate children's abstract thinking during the process of cognitive development, and further foster their higher order thinking ability (Carbonaro, Szafron, Cutumisu, & Schaeffer, 2010).

Some researchers believe that even the best teaching materials and techniques are not as good as having children learn happily via games (Norman, 1981). Compared with other media, games are closer to the children's world and are easily accepted by them (Kafai,1995). Many researchers tried to promote students' mathematical learning achievement by using Game-Based Learning. In addition, these studies also investigated whether Game-Based Learning is beneficial to all students with various abilities. The results demonstrated that this approach yielded better outcomes than paper-based setting in students' learning achievement and confidence. Past studies found that games had potentials to enhance students learning achievement (Radford, 2000). Therefore, embedding games into Mathematics' learning may be a possible solution to enhance students' learning motivation, learning performance and improve their attitude towards this particular subject.

Thus, having seen the 'difficult' perception of Bhutanese students and the decline in their performance in Mathematics, this study intended whether games can be adopted to enhance students' learning performance and improve students' attitude toward learning Mathematics.

Research Objectives

The study aims to find out if there is difference in achievement in Mathematics between students who studied using game-based learning and those who did not and to find out if game-based learning approach is an effective teaching strategy towards improving student attitudes towards mathematics.

Research Methodology

Research Design

The research was a quasi-experimental with two groups' pre-test-post-test design. It is a quantitative method. In the study, achievement test was administrated to both the groups once before and once after teaching to find out the students' learning achievement after incorporating Game-Based Learning. A questionnaire was used before and after with the experimental group to check if there is any improvement in the attitude of students after teaching with GBL approach

Subjects

The participants in this study included seventy seventh graders of a middle secondary school in southern Bhutan. The students were divided into two equal groups. One group was used as experimental group and another as the control group. In order to avoid influences caused by different instructors, the two classes were taught by the same instructor. Both the groups were taught the same topic 'Measurement.'Both the experimental and control group had thirty-five students. The study lasted for the duration of two months.

Instruments

Achievement Test: To measure mathematics achievement, an achievement test comprising of 20 questions was used. The questions were adapted from national textbook prescribed by the Ministry of Education, Bhutan. The test was administered to both the groups once before the experiment and once after the experiment. The test scores of pre-test and post-test of individuals was compared using t-test to see the level of achievement in mathematics at the end of the experiment. The Kuder-Richardson reliability of the test was 0.71, the item discrimination values were higher than 0.25, and the item difficulty values ranged from 0.4 to 0.8 showing the good reliability of the instrument.

Questionnaire: To measure students' attitude towards mathematics as a result of game-based learning, a questionnaire developed byFenneme-Sherman was modified and adopted. It consisted of twenty items on a five-point Likert scale. The Cronbach's alpha value of the questionnaire was 0.75, showing good reliability in internal consistency. It was administered to experimental group once before and after the experiment.

Learning Activities

The games were designed based the topic 'Measurement'. Following is the sample of game which was used during the experiment.The game was designed to allow students to practice calculating areas of rectangles.

Instruction

Play in groups of 2 or 3. You need a 22 cm-by-18 cm grid and a pair of dice. Each player needs a different colored pencil.

Take turns. On your turn:

• Roll two dice.

• The product of the numbers you roll is the area of a rectangle.

• Try to color a rectangle with that area on the grid. If you cannot, you lose your turn.

  It cannot overlap any area already colored.

The game is over after each player has had 5 turns or there is no area left to color. The player with the most colored squares wins the game.

For example:

• On the grid below, Player A is using grey and Player B is using black.

• Player A has colored a 20 cm².rectangle, a 2 cm².rectangle, and a 15 cm² rectangle.

• Player B has colored a 20 cm².rectangle and a 1 cm² rectangle.

It is Player B 's turn and she has rolled a 2 and a 4. Since 2 cm x 4 cm = 8 cm²., she should look for rectangles of these dimensions:

- 2 rows by 4 columns
- 4 rows by 2 columns
- 1 row by 8 columns
- 8 rows by 1 column

Only three of the choices (2 by 4, 4 by 2 and 8 by 1, as shown by the dashed or dotted lines) are available.

Results of the Study

The results of the study are reported in the order of the research objectives as follows:

Pre-test – Post-test Comparison (within the groups)

Firstly the pre-test and post-test scores of each group were compared. The mean in the pre-test of the experimental group was 6.6 and the standard deviation was 3.00. In the post-test the mean was 15.89, an increase of 9.29. The standard deviation was 2.59. In the control group the mean of pre-test was 6.63 and the standard deviation was 3.07. The mean of the post-test was 10.03 and the standard deviation was 3.48. The mean had increased by 3.40. (See Table 1.1)

From the result of the comparison, the data show that there was an increase in the mean scores of the post-test of both the groups. The data show that there was a significant increase in achievement in mathematics. The mean difference out of 20 for the experimental group over the two months' time period was 9.29 which was significantly higher than that of control group which is 3.40, showing that game-based instruction can effectively increase students mathematics achievement.

Table 1.1 Pre-test and Post-test Comparison

Group	Experimental Group		Control Group	
	Pre-test	Post-test	Pre-test	Post-test
Mean	6.6	15.89	6.63	10.03
Standard Deviation	3.00	2.59	3.07	3.48
Mean difference	5.89 - 6.6 = 9.29		10.3 - 6.63 = 3.40	

Pre-test-Pre-test and Post-test-Post-test comparison

The data show that the pre-test mean of the experimental group was 6.60 and the mean of the control group was 6.63. It was noted that they were almost equal and the 2-tailed significance value was 0.96 which indicated that there was no significant difference between the pre-test means of the two groups. Thus, it indicated that the two groups had equal learning abilities in the beginning of the experiment. (See Table 1.2).

The post-test mean of the experimental group was 15.89 and 10.03 for the control group. The 2-tailed significance was 0.00 which indicated that the learning achievement of the experimental group was significantly higher than that of control group.

Table 1.2 Pre-test-Pre-test and Post-test and Post-test comparison

Test	Group	Mean	SD	N	Mean difference	t-value	Df	p-value
Pre-test	Experimental	6.6	3.00	35	0.03	0.04	34	0.96
	Control	6.63	3.07	35				
Post-test	Experimental	15.89	2.59	35	5.86	8.36	34	0.00
	Control	10.03	3.48					

Significance level :> 0.05- not significant, < 0.05-significant

Analysis of Questionnaire on Learning Attitude of Students

The second research objective of the study was to find if there were any improvement in attitudes toward Mathematics after experiencing the game based learning approach. The attitude questionnaire comprised of four sub-categories. They were; (a) Utilitarian (of Math), (b) Enjoyment (of Math), (c) Learner confidence (in Math), (d) GBL (Attitudes toward GBL). The mean was computed for the four sub-categories. Five point Likert scale was used to evaluate the learning attitude of the students towards mathematics as a result of game-based learning approach.

This study showed that in general, the participants had positive attitudes toward mathematics as a result of game-based learning. They enjoyed mathematics (M = 4.64), were confident about their ability to do mathematics (M = 4.49), saw the value of mathematics (M = 4.55) and considered game-based learning approach as an effective strategy (M = 4.76)

Table 1.3 The Mean Scores of Students' Attitude toward Mathematics

Components of Questionnaire	Mean 1 (Pre)	Mean 2 (Post)
Utilitarian (of Math)	2.68	4.55
Enjoyment (of Math)	2.12	4.64
Learner Confidence (in Math)	2.32	4.49
GBL (Attitude towards GBL)	1.12	4.76
Total	2.06	4.61

In the first sub-category of the student's attitude questionnaire, 'Utilitarian (of Math)' all the students strongly agreed that Mathematics is an important subject. The total mean before the experiment was 2.68 and total mean after the experiment was 4.55 Data further indicated that the students considered lesson learned in mathematics classroom not only applicable to their real lives but also helped in solving problems in other areas.

In the second sub-category of the student's attitude questionnaire, 'Enjoyment (of Math)' almost all the students strongly agreed that they enjoy learning mathematics. The total mean before experiment was 2.12 and the total mean after experiment was 4.64. In addition, findings indicated that the students liked mathematics more than other subjects.

In the third sub-category of the students' attitude questionnaire, 'Learner Confidence (in math)', most students have agreed with almost all the statements with the total mean score of 2.32 before experiment and 4.49 after the experiment. Data indicated that students get a great deal of satisfaction from solving mathematics problems and developed greater self-confidence. Moreover, students agreed that they were now learning mathematics easily.

In the fourth sub-category of the students' attitude questionnaire, 'GBL (Attitudes toward GBL)', all the students strongly agreed with all the statements. The total mean was 1.12 before the experiment and 4.76 after the experiment. Data indicated that learning mathematics through games helped students not only like and enjoy the subject but also comprehend the topics better.

The overall mean before experiencing GBL was 2.06 and the overall mean after experiencing GBL was 4.61. The result indicated that there was an improvement in students' attitudes toward mathematics as a result of GBL approach.

Discussion and Conclusions

The results of the study revealed that GBL approach increased the learning achievement and improved students' attitudes toward mathematics of seventh grade students in mathematics. Many other studies supported these findings. Ke& Grabowski (2007); Owston, Wideman, Ronda & Brown (2009) all found out that students who played games had a better math performance than those who received paper-based drills. Similar studies conducted by Papastergiou (2009); Suh, Kim & Kim (2010) indicated that the inclusion of GBL approach in learning not only increased the academic achievement but also improved the attitude of students and fostered positive learning atmosphere and therefore, a positive attitude in students towards learning.

The first finding of the study was that game-based learning approach increased the learning achievement of the students. This was evident from the achievement test result which showed the mean difference of 9.29 in the pre-test and post-test of the students in the experimental group. The scores in the pre-test were almost equal in both groups, representing same ability of students in both the groups. When the post-test and post-test scores of both the groups were compared, the mean of the experimental group was significantly higher than that of control group with 2-tailed significant value of 0.00.

Randel, Morris, Wetzel and Whitehill (1992) referred that using games during mathematics' teaching can improve students' attitude and performance during lessons. The active student's participation during the games is the need for better understanding and memorizing of taught mathematical knowledge. In this study, students were mostly engaged in learning themselves and most of the class time was used in games

that allowed students to discuss, share ideas and learn through fun. Another reason to account for increase in the test score could be due to the non-threatening learning atmosphere created by GBL approaches.

Dale's (1946) theory of learning which states that student's retention rate increases with the amount of student involvement also supported the gain in test scores in the experimental group. The researcher planned interesting games at the beginning and at the end of the lesson to make them involve with flow of the lesson and to comprehend the lesson taught more easily. These showed that entertaining mathematics games made liveliness of the GBL lesson which increased their zeal and interest in learning mathematics. Another reason could be due to the pleasure and satisfaction students derived from understanding the concepts.

The second finding from the study revealed that, game-based learning approach improved student's attitudes toward learning mathematics. The questionnaire was used only by the students in the experimental group since traditional teaching method was used in the control group. The overall mean which is 4.61 indicated that all the students strongly agree with almost all the statements with regard to learning mathematics incorporating game-based learning approach.

The data revealed a significant increase of the attitude between the pre-test and the post-test of experimental group students. These results indicated that the experimental group students' attitude gained improvement after experiencing with GBL approach.

The result of the attitude of students towards learning mathematics was found positive as suggested by rating scale. Most of the statements were rated strongly agree. The possible reason for such result is that games have specific goals, which provide the opportunity of attaining a winning state for students in the experimental group and then provide the experimental group students with a sense of success. Successfully completing a task improved students' attitude toward the future mathematics learning tasks. Another reason could be the learning environment where the learning was student centered where students were allowed freedom to play games in their groups. While in groups, they experimented the things on their own and felt responsible for their work. This findings echoes the theory of Mastery experience (Bandura, 1997), which argues that people who repeatedly gain the successful experience due to their effort can become confident when performing related tasks and hence enhances positive attitude towards learning.

Based on the findings, some recommendations have been made. First, the current research was conducted for a period of two months and with a population of 70 students for studying the relationship between game-based learning and Mathematics achievement of seven grade students' in Bhutan. The amount of time and the size of population were limited. It is recommended that further study be carried out with a larger population of, say, middle secondary children to see if that age group would benefit to the same degree as this present study has shown.A further recommendation is to replicate the study in an urban school to see if there is difference in learning achievement and attitude of students towards mathematics as a result of GBL approach.

Second, teachers in training should become acquainted with GBL and its effects in achievement as well as motivation. In addition, teachers who are already in teaching mathematics should be informed about the result of this study and encouraged to become familiar with the Game-Based learning approach for possible adoptions.

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