BINGO Number Tower Game: Acceptability and Effectiveness in Enhancing Math Learning Performance among Male and Female Children

Potenciano D. Conte, Jr.

Pangasinan State University Lingayen Campus, Lingayen, Pangasinan, Philippines, borntobeaneducator@gmail.com

Abstract – Researchers from various places in the world observed a gender difference in mathematics performance among children favoring the male sex. With literature on the positive effects of educational games in the classroom setting continues to grow, contributing for the improvement of Math scores among Filipino children, through introducing an educational game and measuring its acceptability and effectiveness was the goal of this study. This study used a one-group pretest-posttest design with the 30 fourth-grader pupils in Lingayen, Pangasinan, Philippines. A five-point Likert Scale utilizing four constructs were used to determine the level of acceptability of the game among the male and female participants.The pupils showed a very high level of acceptability of the Number Tower Game in learning Mathematics. Results also showed a significant improvement on the learning performance of the pupils in Mathematics after utilizing or playing the game for weeks. A significant difference does not exist on the level of acceptability and test scores between the male and female participants.

Keywords – number tower game, BINGO in Mathematics, educational game, gender difference in mathematics achievement

INTRODUCTION

Gender difference on mathematics performance among children is observed in various places in the world. There is an extensive collection of literature reporting gender difference in Math performance favoring the male sex regarding problem-solving (Zhu, 2007). Math as a "male" subject is currently understood as the leading factors behind girls' low levels of engagement and poor performance in mathematics worldwide. In African schools, gender inequity in mathematics and science education found that girls received lesser quality and quantity of education than their male counterparts in the subjects Math and Science (Asimeng- Boahene, 2006).

In Tanzania, girls scored lower in the subjects Science, Math and Technology (Jones, 2016). The low participation and performance of girls in this country was attributed by gender-stereotyping as a significant factor. There is the belief that girls and women cannot excel in SMT areas (Jones, 2016). In the United States, math-gender stereotyping happens in formative years (Cvencek, Meltzoff, & Greenwald, 2011). A cultural stereotyping among Americans, that math is for boys emerged when gauged. Data on the result of mathematics competition suggested a huge gender gap between high math achievers in America (Ellison, G., & Swanson, A., 2010).

The report of the Trends in Mathematics and Science Study or TIMSS 2003 for the eighth-grade performance says that boys had higher achievement in Mathematics in countries like the United States, Italy, Hungary, Lebanon, Belgium, Morocco, Chile, Ghana, and Tunisia.

In the Philippines, college students' beliefs about mathematics and mathematical problem solving were measured by administering the self-report questionnaire and analyzed possible significant differences in mathematics-related beliefs related to gender, year level, and field of specialization (Giovanni, 2010). Results showed that Filipino students valued the effort in increasing one's mathematical ability and considered mathematics as useful in their daily lives. However, Filipino students believed that an easy step-by-step procedure could solve word problems. Statistical tests revealed that gender difference in positive beliefs that effort can increase mathematical ability and in the usefulness of mathematics is significant.

The analysis of the Programme for International Student Assessment (PISA), an international survey

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assessing the skills and knowledge of 15-year-old students, suggests a lesser to a disappearing gender gap in countries with more gender-equal culture. (Guiso, et al., 2008). That might be the reason, for the countries like Philippines, Moldova, Cyprus, Serbia and among others, where girls had significantly higher average achievement than boys in the eighth-grade math as reported in TIMSS 2003.

The Global Gender Gap report in 2017 ranked 10th of the 144 countries based on four categories: labor force participation, educational attainment, health and survival, and political empowerment.

However the education system in the Philippines underperformed among peers in East Asia and the Pacific according to the World Bank using the country's tests cores from 2013.

The Philippines, alongside Indonesia, Malaysia and Thailand scored below average in international exams under the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS). In 2003, Filipino students ranked 36th out of 38th performing countries.

An increasing literature on the advantages of educational games in the classroom is published on renowned science journals. Liu and Chen (2013) told the increasing publications of the educational game in major journals associated with technology and learning. The positive effects of educational games serve as the impetus for creative and innovative educators to develop new games for better students' learning performance. Various skills of children are developed by playing various educational games. There's a game that improves critical thinking skills (Wood and Stewart, 1987), test aptitude skills (Lorenzen and Chang, 2006), teach to recognize and remember certain configurations (Gobet and Campitelli, 2006), teach deductive logic (Neller, et.al., 2006), to teach propositional logic and computer programming (Neller, et. al, 2006), or to teach financial principles (Shaklin and Ehlen, 2007) or memorization skills (Conte, 2016).

Papert and Harel (1991) constructionism view in education is: to do is to learn-- a way of equipping students with new knowledge and skills. Students' mind is set free from the tedious classroom lectures or instructions. The use of board games is similar to playing lego which frees the thinking ability and provides advantages to children. Liu and Chen (2013) developed a card game "Conveyance Go," and studied its effects on students' scientific knowledge of transport and energy; their finding showed a significant increase of learning performance among the participating students. A higher educational institution and district schools had collaboratively launched a project aimed at teaching a math board game as a learning tool to motivate learners in the subject math in various ways (Jimenez-Silva et al., 2010). Conte (2016) designed a board game "Larong Akademiko (L-Akad) para sa Pilipino" and the education students majoring the Social Studies program had very highly accepted said board game. On the effect of the game, the finding showed a significant increase of learning performance in the subject Economics among the participating students.

Siegler and Ramani (2008) found a significant increase in knowledge in four different areas of math among 124 pre-schoolers. Within two weeks, the respondents were given 15-20 minutes to play a board game per sitting. Seigler and Ramani (2008) had even suggested that with lesser chance to play number games in their childhood, might have resulted in the lack of skills among children from low-income households.

To possibly contribute to the improvement of Math scores among Filipino children, the researcher has developed an educational game and measured its effectiveness. BINGO is a gambling game in the form of a lottery originated in Italy and was brought to United States of America where it got its first name "Beano"(History, B., 2007). The game uses 75 tiles drawn randomly and announced by a caller during the game. Every player needs to mark his BINGO card/s accurately for the declared number. The randomly selection of numbered tiles continues until one or more players claim BINGO. Then the game for that round has to stop, the numbers are validated and the prize is given to the winner (BINGO Rules).

In this study, the researcher used the BINGO tiles and designed-cards for instructional purpose. The game is called "BINGO Number Tower Game" since it uses the BINGO numbered tiles. The researcher has developed the game mechanics, and copyright was secured by the researcher at the National Library of the Philippines, with the hope to enhance the learning performance of pupils in Mathematics.

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METHODS

Research Design

This is a quasi-experimental research which used a Pretest-Posttest design. The level of knowledge of the participants on grade four Mathematics was measured before the intervention was implemented and after it is implemented.

Research Participants

The study purposely chose grade four pupils from a small public school in Lingayen, Pangasinan, Philippines. Fourth graders were selected because the primary graders--Grade 1-3 students-- are taught using the vernacular language or local dialect. And since Mathematics in higher grades is prepared using the English language, the game is designed to use the English language. A total of 30 pupils—14 males and 16 females-- participated in the study. They belonged to the first section.

Procedure

After the permission was granted by the school principal to conduct the research, the researcher explained to the classroom adviser the purpose of the study. The researcher had requested the adviser to administer a 30-item test for the fourth graders. The examination tried to measure the level of knowledge and skills of the participating pupils on basic Mathematics concepts such as odd/even numbers, ascending/descending order of numbers, multiples, factors, prime and composite numbers, addition, subtraction, multiplication, division, PMDAS, exponents, perfect square numbers and simple problem solving.

The game mechanics of the BINGO Number Tower Game (NTG) was explained among the participating pupils with the presence of the classroom adviser. The class was divided into groups with five members, and were given the materials—BINGO tiles numbered one (1) up to 75 and NTG cards. Each pupil in a group equally and randomly divided the BINGO tiles among themselves and instructed them to arrange the numbered tiles faced up, in ascending or increasing order. However, the researcher used only one set of NTG cards for the six groups for teaching or demonstration.

The researcher then, draws an NTG card and read out loud what is written on it. The card drawn states "All multiples of 7". So each of the players were instructed to separate those numbered tiles which are multiples of "7". These tiles are activated and were piled one after the other by each player forming a tower BINGO tiles. Piling was done in chronological order. For example, after putting the number "7" BINGO tile at the center of the play area, the player who has the BINGO tile number "14" piled next, and so on. A player may pile consecutively if he/she has the succeeding numbered BINGO tiles. If all activated tiles are successfully piled up or without the tower collapsing, another NTG card will be drawn, and the same procedure is repeated. But if for example, the tower collapses as a player piles a BINGO tile, the tiles which fell will be given to that player, adding more tiles to his possession. Piling stops temporarily and activated tiles not piled will be de-activated. Another card will be drawn again and the process of activating and piling of BINGO tiles continues.

The researcher instructed the pupils that the goal of the game per round is to use up all the tiles of the player. But for a timed game, meaning if a set time is reached (say for example, after 20 minutes), the player with the least number of tiles wins.

When the participating pupils got the hang of it, they play on their own. The researcher and classroom teacher assisted the participating pupils in the event they had questions. The pupils played 15-20 minutes on day 1 (Monday). The pupils were given a chance to play for 15-20 minutes for day 2 (Wednesday), for day 3 (Friday) and another three days the following week.

A survey questionnaire using a 5-point scale was administered to the pupils to measure their acceptability on the first week. Then, a post-test exam was given to them at the end of the second week.

Design of the BINGO Number Tower Game

The BINGO Number Tower Game is developed with the desire to enhance the number and math skills and appreciation of students especially those in basic education. The BINGO NTG can be played by two to five players. For children, their patience and control in building a tower and their interpersonal skills are hoped to be improved. The game is ideally played on a smooth floor or a sturdy unmovable table. Before the game starts,

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the players may agree on the length of time to play, say 20 minutes. After 20 minutes, the player with the least number of NTG tiles will be declared the winner. Without time set by the players before the game starts, the player who uses all his/her NTG tiles without making the tower collapsed after his/her latest tile will be declared as the winner.

The game materials can be easily found. A set of BINGO tiles is available on most bookstores. The cards can be printed or made by the teacher who may put any math conditions or equations he/ she desires to depend on the Math lessons he/she wants his/her learners to master.

Statistical Analysis

The researcher employed a five-point Likert scale to measure the level of acceptability of the game based on the students' perception, from the scale of 1 (not acceptable) to 5 (highly acceptable). There were four constructs with five statements for each--perceived usefulness, ease of use, attitude towards usage, and intention to use. Such constructs used to evaluate the degree to which students accepted the educational game was developed by Davis, Bagozzi, & Warshaw (1989), as also utilized by Liu and Chen (2013) and Conte (2016). T-test analysis was also employed to determine if a significant difference exists between the boys' and girls' level of acceptability.

A pre-test duly validated by fourth grade Math educators was administered to the participating pupils to determine the effectiveness of the BINGO NTG in the learning performance in grade four Mathematics. Then after playing the games for weeks, a post-test was administered. T-test analysis was used to test the mean difference of the scores using a 0.05 level of significance to determine significant improvement in their test scores.

RESULTS

The acceptance of pupils towards the educational game along the different areas by the mean score for each construct of the satisfaction scale was presented in table 1. The respondents gave positive responses for all the four constructs.

Table 1. Mean scores in the student acceptance scale
n = 30

Construct	Sex	Mean	Average Mean	t	p
Perceived usefulness	Boys	4.6167	4.60	.326	.747
	Girls	4.5833			
Perceived ease-of-use	Boys	4.6833	4.70	-.389	.700
	Girls	4.7167			
Attitude towards usage	Boys	4.6500	4.64	.154	.879
	Girls	4.6333			
Perceived intention to use	Boys	4.7833	4.76	.507	.616
	Girls	4.7333			

Intention to use and ease of use and received high scores in particular. That indicates 'very high acceptance.' The pupils agree that the game mechanics were simple and easily understandable. Game materials can be easily produced and can be played anytime. This is shown by the average mean for both the sexes of 4.76 and 4.70, respectively. For these two constructs, their level of acceptability has no significant difference ($p = .616$; $p = .700$)

The perceived usefulness and attitude towards usage were also very highly accepted by the participants who felt that they could enjoy learning and re-learning Math concepts with the game. These results show that the game-based learning aroused student interest in numbers as they cooperatively learned while playing. The pupils even hoped to share the game with their friends and siblings. Regarding sex, the mean score of the boys, and girls do not differ much and no significant difference exists for all the constructs.

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Effect of educational game on Mathematics learning achievement among the pupils

An independent sample t-test was performed using SPSS to examine whether the participants' improvement in their learning performance after playing the game 15-20 minutes on alternate days within two weeks. The results imply that the post-test scores of the students with a mean of 24.40 and standard deviation (SD) of 2.17 are significantly higher than the average pre-test score of 15.43 with an SD of 2.06 as shown in Table 2. According to these results, we can infer that the Number Tower Game designed in this study, can assist students in gaining knowledge and skills in Mathematics. The p-value of .000 indicates a significant improvement in the learning performance of the pupils.

Further, on gender difference on Mathematics achievement, Table 3 shows that in the pre-test and post-test score, boys and girls score has no significant difference, as indicated by the p-value of 0.967 and 0.397, respectively.

Table 4 shows the effectiveness of the game for individual group. For the pre-test and post-test score of males, the p-value of .000 indicates a significant improvement. This is also supported by the mean difference. Same result for the group of females is shown by table 4.

Table 2. Results of paired sample t-test on Mathematics assessment for the Grade IV Pupils

	Mean	Std deviation	t	p
Pre-test	15.43	2.06	-16.384	.000
Post-test	24.40	2.17		

*** p<0.01*

Table 3. Result of T-test on Pre and Post-test scores between male and female pupils

	Sex	t	p
Pre-test	Male Female	.042	.967
Post-test	Male Female	-.862	.397

*** p<0.01*

Table 4. Result of T-test on Pre and Post test scores of male and female pupils

	Test	Mean	t	p
Male	Pretest Post-test	15.40 23.87	-11.232	.000
Female	Pretest Post-test	15.47 24.60	-11.82	.000

DISCUSSION

This study aimed to measure the acceptability of the game and whether this game-based learning using BINGO tiles and number tower cards could assist fourth-grade pupils in the acquisition and mastery of knowledge related to the subject Mathematics. It also aimed to know if gender difference exists towards their performance.

The participants exhibited positive attitudes in playing the game. They rated the game with a 'very high' level of acceptability. Both the boys and girls enjoyed playing, and their level of acceptability has no significant difference. It could have supported the TIMSS report that, in countries such as ours with lesser or disappearing gender gap, math performance among pupils does not significantly vary or sometimes girls outperformed boys.

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The research has tended to determine the effectiveness of the game introduced to the students. It appears that the educational game has contributed to their improved learning performance in grade four Mathematics, as measured by their pre-test and post-test scores. Further, the use of the game might have enhanced the learning motivation and learning effectiveness among the pupils. Again, both the boys and girls scores for pre-test and post-test have no significant difference.

Unlike in African countries, Filipino children are given equal opportunities in learning mathematics subject. Boys and girls have the ability to appreciate mathematics and no gender-stereotyping, similar to the U.S. is suggested by the result of this study. The gender gap report of 2017 ranking Philippines on top seems to hold true among pupils in the elementary level.

The researcher would suggest that future studies should be conducted using higher Mathematics concepts among learners in a higher grade or year level.

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