BECAMEDO BOARD: IMPROVING STUDENTS' PERFORMANCE IN TRIGONOMETRY

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ABSTRACT

`This research aims to investigate the performance of learners in Trigonometry before and after the use of BECAMEDO Board. This study is a quasi-experimental research using one group pretest-posttest design. The performance of 98 STEM students was investigated using a fifteen-item solution-based test and open-ended questions on the perceptions of the use of BECAMEDO Board. Using a dependent t-test analysis, results showed that at a=0.05, there is enough evidence to show that the posttest mean score, (M=13.24, SD= 1.32), is significantly different from the pretest mean score (M=8.20, SD=2.17), t(97) = 19.90, p<0.001. This result implies that the use of the BECAMEDO Board improved the performance of learners in the posttest. To further investigate these results, the researcher analyzed the textual responses of learners targeted on students' perception of the use of BECAMEDO Board using quantitative content analysis. Results revealed that majority (65%) of the respondents admitted that the game improved their knowledge and understanding of the fundamental trigonometric functions, especially the values of the special angles, its multiples at a particular quadrant helping them in simplifying trigonometric expressions; more than half (51%) of the respondents found the game fun; and nearly half (45%) found the game useful in their learning of Trigonometry. The researcher concluded that the BECAMEDO board is a promising manipulative tool in Trigonometry and recommends its wide use in Mathematics classrooms.
Keywords: Trigonometry, BECAMEDO Board, mathematical games, quasi experimental research, quantitative content analysis

Introduction

In a Trigonometry quiz conducted to Baybay City Senior High School Grade 11 sections Einstein, Darwin and Newton students involving topics about simplifying trigonometric expressions, the researcher noted that 95% of students got low scores in the quiz, averaging 8 of 15 items. This has been a common phenomenon as observed by the researcher in her classes since 2016. These Einstein, Darwin and Newton sections belong to the Science, Technology, Engineering and Mathematics (STEM) classes of which are presumed to be more literate in the sciences and mathematics and, therefore, capable of tackling more advanced science subjects (Cruz, 2014). In this contention, the researcher decided to embark on a formal study on the improvement of learners' knowledge in the competency using a game board that the researcher designed and created.

Trigonometry is one of the contents in Precalculus, a specialized subject for STEM students. It used to be a separate subject in collegiate mathematics covered for one whole semester. However, in the full blast implementation of the K to 12 program in the Philippines, Trigonometry has been embedded in Precalculus together with Analytic Geometry and Mathematical Induction, covered for one semester only.

As arithmetic and logical reasoning are the basis of science and technology, Mathematics is regarded as a fundamental subject (Yeh, Cheng, Chen, Lia, & Chan , 2019). Trigonometry like any Mathematics subject requires spatial skills among learners. There are strong evidences on spatial and mathematical connections linking transfer from spatial interventions to mathematical understanding (Young, Levine, & Mix, 2018). Moreover, mathematical manipulatives such as game boards can improve learners' spatial ability. A study conducted among grade 9 learners on the influence of board games on mathematical spatial ability found that board game teaching improves students' learning effectiveness of spatial ability and that board game teaching improves students' learning interest in

spatial ability (Young, Levine, & Mix, 2018). Studies conducted by Hartshorn and Boren (1990) and Stein and Bovalino (2001) were among the earliest which identified board games as key in providing effective, active, engaging lessons in the teaching of mathematics. The use of a manipulative help students in honing their mathematical thinking skills. There is a growing literature on the positive effects of educational games in the classroom settings and numerous foreign researchers in different countries have increasingly published game-based learning researches in science journals. However, a study published in 2007 revealed that although there is positive association between games and mathematical learning, an unexpectedly high proportions of negative attitudes of learners toward games used as a vehicle for learning mathematics was also found (Bragg, 2007). This explains the need for mathematics teachers to be creative enough to think of ways to engage learners especially when using games in improving performance in mathematics.

Learners' mathematics performance is influenced by a variety of factors. In the context of Mindanao for example, a study using meta-analysis revealed that mathematical skills, attitude, and self-efficacy are found to be the predictors of students' mathematical achievement underlining the need for teachers to utilize varied teaching strategies so that students would develop interest and positive learning attitudes towards mathematics (Callaman & Itaas, 2020). Another study conducted in Central Visayas revealed that there is significant relationship between learner's self-concept and academic performance in Mathematics raising the need for stakeholders to come up with a performance enhancement plan for adoption and evaluation (Emerson , et al., 2020). Another study conducted in the Philippines on the personality type and learning styles of high and low performing students in mathematics showed that although personality types of learners largely vary, both high and low performing students in mathematics prefer visual learning (Quintillan-bugas, 2010), making gamification of mathematics and using game boards an effective way of improving learners' mathematical performance.

One of the most widely used game board in the elementary and junior high school mathematics is the Damath Board game. Damath is a board game which can be used for basic numeracy exercises which contributed techniques for educators to improve numeracy skills among students, specifically on primary and secondary education in the Philippines (Huenda, 2010; Mshai, 2013). In a Jox Technology post in 2009, DAMATH board is described as a manipulative educational board game where players have to do mathematical computation whenever they capture an opponent's chip. However, no variation for a Damath game has been created for Trigonometry.

Since there is no Damath board game designed for senior high school, the researcher decided to create a board game that will be used to help improve the skills of students in simplifying trigonometric expressions. The researcher took inspiration and combined the rules of the Damath board and chess board games and called the innovation the BECAMEDO Board.

Action Research Questions

This action research aims to improve the performance of students in Trigonometry using a BECAMEDO Board, in particular, topic on simplifying trigonometric expressions.

This action research aims to answer the following questions:

1. What is the pre-test and posttest mean score of students?
2. Is there a significant difference between the pre-test and post-test mean scores of students?
3. What are the students' perceptions on the use of BECAMEDO Board?

The results of this investigation will aid fellow Trigonometry teachers in helping STEM students improve their performance on simplifying trigonometric expressions using the BECAMEDO board. This game can enhance and strengthen students' knowledge and make immediate recall of the fundamental circular functions and their values.

Theoretical Underpinnings

This study stands on the premise of theorists such as Piaget (1971), Dewey (1938), Bruner (1960), and Dienes (1969) as cited by Post (1981) that concepts are formed by learners through a reconstruction of reality and not through imitations of it, that knowing is a process and not a product and that learners need to build or construct their own concepts from within rather than having those concepts imposed upon them. All of these entail a provision on firsthand experiences of learners which can best be done through a manipulative.

According to Post (1981), Mathematics programs that are dominated by textbooks are inadvertently creating a mismatch between the nature of the learners' needs and the mode in which content is to be assimilated. This implies that a manipulative is important in delivering mathematics content. This also shows how important a manipulative is in the teaching and learning process in Mathematics. This is supported by Lesh (1979) (as cited by Durmus & Karakirip, 2006) who says that manipulative materials can be effectively used as an intermediary between the real world and the mathematical world; Stein and Bovalino (2001) saying that the use of a manipulative help students in honing their mathematical thinking skills; and Hartshorn and Boren (1990), who said that a manipulative can be key in providing effective, active, engaging lessons in the teaching of mathematics.

Innovation, Intervention, Strategy

The innovation used in this action research, the game board, is a researcher designed game board called the BECAMEDO Board, which name is taken from the first syllables of the researcher's name. It used an eight by eight squares on a 12inches by 12 inches board shaded alternately. The side of the board facing the players are labeled, from left to right, $\pi/6$, $\pi/4$, $\pi/3$, π, 2 π, $\pi/3$, $\pi/4$ and $\pi/6$, symbolizing the first three angles in the first quadrant and the half and one full revolution. While the vertical sides are be labeled, from bottom to top, Q1, Q2, Q3, Q4, Q4, Q3, Q2 and Q1, symbolizing the four quadrants in a Cartesian Coordinate System.

The chips are arranged from the first row, closest to the players, to the second and third rows in this manner; all sin θ for the first row, cos θ in the second row, and alternate sin θ and cos θ in the third row. The players alternately move their chips and capture opponent's chip. During capture, the following operations will be used in order, in a loop, addition-subtraction-multiplication-division. The angle θ is determined according to the location of the chip, with the abscissa as θ and the ordinate as the location of θ or its equivalent multiple in the unit circle.

Each game runs in three levels; simple checker moves with rotating operations and timer (level 1), checker moves with time and operation choice (level 2), and checker moves with operation choice and consumable time per player (level 3). The players will alternately move their chips capturing opponent's chip. For Level 1 game, both opponents will decide on a sole operation to be used in the game. For level 2 and 3, the following operations will be used in order, in a loop, addition-subtraction multiplication-division.

When a player's chip reaches the opponent's end of the board, the chip will be called the "BIDA". A BIDA chip is worth twice its value and can move just like any ordinary dama chip in the checker board game.

To win the game, a player must score higher in total points than the opponent.

In recording the run of the game, the moves need not be recorded except during competitions. The scores may be recorded cumulatively. Upon the agreement of both players, the scores may not be recorded cumulatively and will be summed up after the game.

For level one game, the game should run for 45minutes or until all the chips of the opponent are taken by the other player. For Level 2 games, the game will run for 30 minutes only or up until one

player loses all chips before the given time limit. In cases where the time runs out and extra chips remain in the board for one or both players, the value of these chips will be added to their scores with the BIDA chip taken double its value. Level 3 games will be played like a chess match where each player has 20minute time allowance and game ends when one of the players time is all used up needing the use of a chess clock.

Methodology

This study is a quasi-experimental research which utilized the one-group pre-test-post-test research design.

Prior to the conduct of the study and upon learning the very low mean percentage scores of learners after the given quiz, the researcher secured permission from parents regarding the participation of the learners on the conduct of the study.

The respondents of this study were students from the three intact groups, Newton, Einstein and Darwin of Grade 11 STEM classes. The sampling technique employed in this study is total population sampling. A total of 98 students served as respondents to this action research.

The researcher recorded the scores of students in the 15-item quiz as the pre-test. The researcher presented to the students the BECAMEDO board and explained how it is played. Students played with their classmates in their respective classrooms every 4:00-5:00 pm from September to October of 2019 and during their vacant times, with different opponent each time. The researcher monitored the students everyday checking on their use of the game board. Every Friday, a one round competition is held per class, rotating players, in which score sheets were collected. A learner was also required to submit at least two clean scoresheets with different opponents from the other sections in the said duration of time. All scores from the games were not included as part of the graded performance scores of the leaners.

The pre-test and post-test items which learners answered before and after the use of the intervention was taken from the Grade 11 Text Book readily provided by DepEd.

Four open-ended questions were also asked during the posttest. These were used to determine the perception of learners on the use of the BECAMEDO game board. Questions were based on a previously conducted study in the school about perception of learners on an evaluation program. Responses to the question on perception generated three global themes; advantage, disadvantage and general comments about the use of the evaluation program. The choice of basing the open- ended questions on the global themes of the said study was further validated by the mathematics supervisor. The researcher also included a question on learners' suggestions on how to improve the game. The collection of textual data was done due to the short exposure of the learners to the board game.

After the duration of the use of the intervention, the researcher conducted a 15-item post-test using a set of parallel questions. During the post test, students answered the open-ended questions aimed at finding their perceptions on the use of the board game.

The test scores were recorded and analyzed. Descriptive analysis was used to analyze the pre and posttests while dependent t-test was used to determine whether a significant difference between means exists at a=0.05. The textual data was analyzed using quantitative content analysis.

Results and Discussions

Upon collection and checking of learners answer sheets, results were immediately analyzed.

The following table presents the descriptive analysis of the pre and post test results.

Table 1
Descriptive analysis of the pre and post test results.

Test	N	Range	Mean	*SD*
Pretest	98	11	8.20	2.17
Posttest	98	7	13.24	1.32

Based on table 1, results showed that the pre-test mean score of learners, (M=8.20, SD=2.17), is lower compared to the post test, (M=13.24, SD= 1.32). This result implies that the students have more correct answers and solutions during the posttest than in the pre-test.

To determine if a significant difference exists between means, the researcher conducted a dependent t-test at a=0.05. The following table shows the result.

Table 2.
The T-test results between the pretest and posttest means.

Test	N	*M*	*SD*	t-stat	t-crit	p-value
Pretest	98	8.20	2.17	19.90	1.98	<0.001
Posttest	98	13.24	1.32			

Based from table 2, there is enough evidence to show that the posttest mean score is significantly different from the pretest mean score, t (97) = 19.90, p<0.001. This result implies that indeed, the use of the BECAMEDO Board improved the performance of learners in the posttest.

The following table shows the qualitative responses of learners on the questions targeting learners' perception of the game.

Table 3
The quantitative content analysis of responses to the open-ended questions pertaining to students' perception of the game.

Questions	Response	Percentage
1. What can you say about the BECAMEDO Board?		
	The game is fun.	51.02
	It is a very useful game in Trigonometry.	44.89
	The game is challenging.	26.53
	It is very interesting.	23.46
		13.27

	It is not easy.	10.20
	Others	
2. What are the advantages playing the BECAMEDO Board?		
	It improves knowledge and understanding of the fundamental trigonometric functions, especially the values of the special angles, its multiples at a particular quadrant.	65.30
	It helps us improve our thinking and problem-solving skills.	29.59
	It helps us memorize the values of special angles in a quadrant, and playing helps us for immediate recall.	11.22
	The game helps us develop game strategy.	11.22
	Others	10.20
3. What are the DISADVANTAGES playing the BECAMEDO Board?		
	Students who find it hard to memorize and understand trigonometric functions losses the game	44.90
	No disadvantage at all.	22.44
	Time duration is too short with the solutions and solving that are required.	13.26

	Careless players need to be extra careful and mindful in their moves and in writing the solution.	12.24
	Others	8.16
4. What are your suggestions to improve the game and why?		
	No suggestion, no change needed.	40.82
	Improve game style.	22.45
	Increase time for one game.	18.37
	Make it more entertaining.	16.33
	Others	15.31

Based from Table 3, students' general comments of the game were divided into two, positive and negative comments and is taken as learners' general perception of the game. These comments were based on the students' point of view of the importance, how the game affects them, and the use or benefit of the game to them, as students learning Trigonometry, specifically, simplifying trigonometric expressions and its solutions. Multiple responses were allowed, thus the sum of all responses for each question pertaining to perception do not necessarily sum up to 98, which is the total count of responses. Responses with multiple thoughts or ideas were also recorded separately or were given separate counts. Responses which did not answer the question and were out of context were counted under the response "Others", found at the bottom of each grouped of responses.

Among the positive perceptions include more than half (51%) of the respondents revealing that the game is fun and nearly half (45%) of them saying that the game is very useful in their learning of Trigonometry. Majority (65%) of the respondents also admitted that the game improves their knowledge and understanding of the fundamental trigonometric functions, especially the values of the special angles, its multiples at a particular quadrant. There is also a moderate number (30%) of participants who said that the game helps improve their thinking and problem-solving skills. Equal percentage (11%) of respondents agreed that playing BECAMEDO helped develop strategy and immediate recall of the trigonometric function values.

On the other hand, nearly half (45%) of the respondents revealed that careless players need to be extra careful and mindful in their moves and in writing the solution. This response, although falling under the "disadvantages" response, is actually a positive opinion about the game as it reveals that learners who were not careful in their moves, might somehow learn a couple of lessons about mindfulness and presence of mind because of their engagement with the game.

As part of the learners' personal perception on how the game can become better, a number of responses (22%) suggested that the game style must be improved in order to avoid the players from getting bored. As the researcher went over these types of responses, it was found out that what learners meant by the phrase "getting bored" is when they find the solution very hard that they started to not enjoy the game anymore or when the solutions were coming back again and again and they don't find the game challenging at all. The descriptions can be divided into two; improving the game such that it becomes more challenging, or improving the game such that the solutions that students have to make are easy and achievable, at least for level. Nevertheless, a significant number of responses (40%) said that there is nothing to change about the game and its rules as those were already clear and very easy to follow. These slight contradictions in the responses can be attributed to two reasons, (1) the learners might have a lack of understanding or might have found extreme difficulty in memorizing the values of the trigonometric functions which are the basic sin this game; and (2) the players do not really understand the objectives of the game that is why, they become bored when the same items to solve and solutions are coming back again and again. These made the researcher realize the need to check on how the orientation of the game was done and how can this orientation process be improved in the implementation of the project in the field. This is one learning that the researcher can take away from this study.

Thus, reading from the response and based from the percentages of answers in table 3, the researcher concludes that, indeed, the learners were really able to learn from the game and the game has truly improved the learners' performance in the post test.

Conclusion and Recommendations

Based from the results, the researcher concluded that the BECAMEDO Board game improved the performance of learners in Trigonometry on the topic simplifying trigonometric expressions, a promising intervention that holds a great potential in the field of gamifying mathematics.

Based from the conclusion, the researcher carefully lays out the following recommendations: (1) in connection with the significant difference among the pre-test and posttest mean scores of learners, the researcher recommends that the BECAMEDO game be utilized by other teachers teaching Trigonometry in the division; (2) the researcher also recommends further exploration of the game's potential to be used in gamifying topics in elementary and junior high schools; and (3) encourage teachers to design their own Mathematics game board by studying how this BECAMEDO game encourages learners to have fun with Mathematics.

References

Bragg, L. (2007). Students' conflicting attitudes towards games as a vehicle for learning mathematics: A methodological dilemma. *Springer Mathematics Education Research Journal* , 29-44.

Callaman, R., & Itaas, E. (2020). Students' mathematics achievement in Mindanao context:. *Journal of Research and Advances in Mathematics Education*, 148-159.

Chung, C.-C., Yen-Chih, H., Yeh, R.-C., & Lou, S.-J. (2017). The Influence of Board Games on Mathematical Spatial Ability of Grade 9 Students in Junior High School. PEOPLE: *International Journal of Social Sciences*, Vol. 3, 120-143 https://doi.org/10.20319/pijss.2017.31.120143.

Cruz, I. (2014), The STEM strand. Retrived from http://www.philstar.com/education-and-home/2014/07/03/1341906/stem Damath Board Game, 2009, November 2). Retrieved from http://www.joxtechnology.com/damath-board-game/.

Durmus, S. & Karakirip, E. (2006). Virtual manipulatives in mathematics education: a theoretical framework. Retrieved from http://files.eric.ed.gov/fulltext/ED496007.pdf.

Emerson , P., Gamboa , A., Etcuban, J., Dinauanao, A., Sitoy, R., & Arcadio, R. (2020). Factors Affecting Mathematics Performance of Junior High School Students. *International Electronic Journal of Mathematics Education.*

Hartshorn, R. & Boren, S. (1990). Experiential learning of mathematics: Using manipulatives. ERIC Digest. Retrieved from https://eric.ed.gov/?id=ED321967

Huenda, J. (2010, March 3). Damath learning math the pinoy way. Sorsogon UNITED. Retrieved from https://sorsogonunited.wordpress.com/2010/03/03/damath-learning-math-the-pinoy-way/

Mshai, (2013). Damath board game. Retrived from https://www.teacherspayteachers.com/Product/DaMath-Board-Game-250791.

Stein, M. & Bovalino J. (2001). Manipulatives: One piece of the puzzale. ERIC Digest. Retrieved from https://eric.ed.gov/?id=EJ668835.

Post, T. (1981). The Role of Manipulative Materials in the Learning of Mathematical Concepts. In Selected Issues in Mathematics Education (pp. 109-131). Berkeley, CA: National Society for the Study of Education and National Council of Teachers of Mathematics, McCutchan Publishing Corporation. Retrieved from http://www.cehd.umn.edu/ci/rationalnumberproject/81_4.html.

Quintillan-bugas, R. (2010). Factors Affecting Math Performance. Philippine E-Journals v.10.

Yeh, C., Cheng, H., Chen, Z.-H., Lia, C., & Chan , T.-W. (2019). Enhancing achievement and interest in mathematics learning through Math-Island. RPTEL 14, 5.

Young, C. J., Levine, S. C., & Mix, K. S. (2018). The Connection Between Spatial and Mathematical Ability Across Development. Frontiers in Psychology Vol. 9

Financial Report

The following are the incurred costs in the conduct of this study.

Table 2
Cost estimates

Activities	Materials Needed	Cost Estimates
Preliminaries Research proposal preparation	Ink, bondpaper	P500.00
Securing consent from the school head and approval from the division office	Ink, bondpaper	P500.00
Implementation Stage Orientation to parents and signing of consent	Ink, bondpaper, snacks (parents 104)	P2,000.00
Conduct of the study	Bondpaper (for the scoresheets), illustration boards for the BECAMEDO board, chips, ink	P5,000.00
Monitoring and Technical Assistance	Ink, bondpaper	P500.00
Analyses and Evaluation of Results	Ink, bondpaper	P500.00
Preparation & submission of report	Ink, bondpaper, binding services	P500.00
Post Implementation Stage Presentation of Research Results to Co-teachers in the school and district and in a research conference	Ink, bondpaper, snacks	P500.00
	TOTAL	**P10,000.00**