Section: Research Paper

Development and Connecting Research Using Manipulatives: The Geometry Teaching Setting

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Abstract. The development of the teachers and students' competencies is part of their professional development, but this could be enhanced by the advancement of the teaching process inside the classroom with various activities such as analysis and construction of geometric ornaments. In this study, it focuses on the effect of manipulative Mathematics in the form of teacher-made square and triangle tiles on solving the perimeter and area of polygons. Specifically, it aimed to compare two techniques, the manipulative style and the conventional method, in solving the perimeter and area of polygons based on the following: the performance of students in terms of accuracy and correctness of their quiz results and the student's evaluation of the quizzes in terms of level of confidence and difficulty. The participants in the study were 92 college freshmen. They were divided into groups representing their specific section and handled separately by different instructors. The teacher-made square and triangle tiles as a concrete instructional model were simultaneously introduced in a conventional manner for each lesson during regular class sessions that lasted for eight (8) weeks. The result showed that the performance of each group taught using either method on correctness and accuracy in solving both perimeter and area did not differ significantly. The students using manipulative style had significantly more correct answers in solving both perimeter and area, but in terms of accuracy, it was not significantly different using the two methods. For the level of confidence, students in each group were significantly more confident using manipulative style in solving perimeters, but only one group expressed higher confidence using the technique in solving areas. The results suggest that using the manipulative style in solving the perimeter and area of polygons contributes to better performance and higher confidence among the students. Moreover, it was observed that participation and interaction between and among the students and instructor were enhanced using manipulative instruction. Hence, this teaching scheme could be integrated as a learning activity in teaching geometry.

Keywords: connecting, development, geometry, manipulatives, research

Introduction

It is a very important approach to making the learning atmosphere for learners in solving the perimeter and area of polygons more interesting and motivating. There are several approaches like a line; it could be optical, symbolic representations, or physical manipulation. A physical manipulative is an object that is designed so that a learner can perceive some concept by manipulating it. It is valuable and easy to use and can be purchased or constructed by the teacher (Cotter, 2000; Clements & Battista, 1990). Research in mathematics instruction revealed that

students' mathematical understanding is more effective if manipulative materials are used. It is one way of making mathematics learning more significant to the students, as the materials are designed to represent explicitly and concretely abstract mathematical ideas (Stein & Bovalino, 2001). Manipulatives as cognitive tools that provide a concrete, hands-on experience, which focuses attention and overall increases motivation; senses are brought into learning; students can touch and move the objects to make visual representations of mathematical concepts (Durmas and Karakirik,2006).

Some manipulative materials are objects designed to explicitly and concretely represent abstract mathematical ideas. They have both visual and tactile appeal and can be manipulated by learners through hands-on experiences. Manufacturers advertise manipulatives as materials that will make the teaching and learning of mathematics 'fun' and promote their products as catalysts for engaging students in mathematical learning. Because students' abstract thinking is closely anchored in their concrete perceptions of the world (Thompson, 1992).

In addition, according to Thompson (1992), in his study using augmented reality (AR)-based virtual manipulatives, children in the control group who used physical manipulatives learned a lot compared to the other group. The instruction lasted for a period of four weeks at a public primary school in Turkey with 72 children aged five and six years old. A comparison of their understanding of geometric shapes was based on their scores from pre-test and post-test measures of the Geometric Shape Recognition Task instrument. Analysis of the collected data revealed no statistically significant difference between the groups in the circle recognition task, while statistically significant differences were found between the groups in the recognition tasks for triangle, rectangle, and square shapes in favor of the experimental group. Although there was an increase in the total scores of both groups, the results showed a statistically significant difference in test scores in favor of the experimental group.

Using manipulative is intended for elementary and middle grades, it is also interesting to try this instructional method to college students especially to those who are taking education courses. Its value and relevance could be fully understood and experienced by the students who might find it useful in their profession later.

Objectives

The main objective of this study is to determine the development and connecting research in teaching Mathematics using manipulative like the form of teacher-made square and triangle tiles in solving area and perimeter of polygons as part of the subject Fundamentals of Mathematics.

Methodology

The participants of the study were 92 college freshmen students enrolled in the subject Fundamentals of Mathematics at Bohol Island State University, Calape. They were divided into three groups, each representing a specific section, and handled separately by different instructors. Two methods, manipulative style and conventional, were used for each lesson during regular class sessions that lasted for 8 weeks. The use of teacher-made square and triangle tiles as concrete instructional models was introduced. The tiles have dimensions of 1 x 1 inch. The students were asked to count the number of tiles used along the sides of the figure to obtain its perimeter and the number of tiles used altogether in the figure to obtain its area. For the

conventional method, the formula for finding the perimeter and area was used. After every lesson of using one specific method, a quiz was given to the students applying the exact method that they had learned.

The results of the quiz, which contained three problems, were evaluated in terms of accuracy and correctness. Accuracy is the correct and precise process employed in getting the correct answer to the problem, while correctness is simply the right final answer to the problem. After the quiz, the students rated the level of difficulty of the quiz and their level of confidence in answering it using either method through a semi-structured questionnaire. The weighted mean of the scores and ratings was obtained, and a t-test was employed to determine the significant difference in the respondents' performance and ratings on the two methods in each group. The F-test was also used to determine the overall performance and rating of the three groups. Descriptive ratings were assigned to determine the levels of the four domain: for accuracy in calculating problems; fair (8.00-9.00), good (9.01-10.00), very good (10.01-11.99), excellent (12.01-13.00); for correctness: fair (0.01-0.75), good (0.76-1.5), very good (1.51-2.25), and excellent (2.26-3.00); for level of confidence: very strong (5), strong (4), moderate (3), low (2), very low (1); for the level of difficulty: very difficult (5), very difficult (4), moderate (3), easy (2), and very easy (1).

Results and Discussion

The students' accuracy scores in calculating the perimeter and area of the convex polygon are shown below. The mean scores were slightly higher using the manipulative style but not significantly different from the results of the other method. The highest mean score for accuracy was attained by the students from Section 1 at 11.74; the highest possible score for accuracy is 13. In terms of the correctness or actual correct final answer, likewise, using the manipulative style, mean scores were slightly higher but not significantly different from the results of the other method. Generally, students using manipulative style had significantly higher correct scores in solving both perimeter and area, but in terms of accuracy, it was not significantly different using the two methods.

Table 1. Accuracy mean scores of the students for each group using two different methods in finding the perimeter and area of polygons. Means with letter difference indicate significant difference between treatment ($p<0.05$)

Section	Method	Mean Rating Perimeter	Descriptive Value	Mean Rating Area	Descriptive Value
1	Manipulative	3.01[a]	Moderate	3.05[a]	Moderate
	Conventional	2.91[a]	Moderate	2.63[a]	Moderate
2	Manipulative	3.03[a]	Moderate	2.82[a]	Moderate
	Conventional	2.93[a]	Moderate	2.62[a]	Moderate
3	Manipulative	2.92[a]	Moderate	2.71[a]	Moderate
	Conventional	2.87[a]	Moderate	2.53[a]	Moderate

For the level of confidence, students in each group were significantly more confident using the manipulative style in solving perimeters, but only one group expressed higher confidence using

the technique in solving areas. Moreover, all three groups rated the level of difficulty as moderate in solving both area and perimeter using either method. However, one group perceived that using the conventional method was significantly more moderate, almost approaching the easy range.

The results suggest that using the manipulative style in solving the perimeter and area of polygons contributes to better performance and higher confidence among the students. Moreover, it was observed that participation and interaction between and among the students and instructor were enhanced using manipulative instruction. Hence, this teaching scheme could be integrated as a learning activity in teaching geometry.

Table 2. Correctness means scores of the students for each group using the two different methods in finding the perimeter and area of polygons. Means with different letters indicate significant differences between treatments ($p<0.05$)

Section	Method	Mean Rating Perimeter	Descriptive Value	Mean Rating Area	Descriptive Value
1	Manipulative	3.05[a]	Moderate	2.91[a]	Moderate
	Conventional	2.95[b]	Moderate	2.48[b]	Moderate
2	Manipulative	3.08[a]	Moderate	2.82[a]	Moderate
	Conventional	2.86[b]	Moderate	2.42[b]	Moderate
3	Manipulative	2.93[a]	Moderate	2.77[a]	Moderate
	Conventional	2.78[b]	Moderate	2.53[b]	Moderate

Table 2 data shows that the development and integration of research on manipulatives in teaching geometry are effective. Data shows that using manipulatives from the 3 sections significantly increased compared to using conventional ways of teaching geometry. The intervention is very effective.

Table 3. Consolidated accuracy and correctness mean scores of the students for each group using the two different methods in finding the perimeter and area of polygons. Means with different letters indicate significant differences between treatments ($p<0.05$)

Method	Accuracy		Descriptive Value	Correctness		Descriptive Value
	Perimeter	Area		Perimeter	Area	
Manipulative	11.05	11.02	Moderate			Moderate
Conventional	10.03		Moderate			Moderate

The consolidated accuracy and correctness are a good indicator that the mean score of the students increases and, therefore, greater knowledge is gained from the instruction given. There is a great difference between the use of conventional methods and the use of manipulatives.

The current study also showed that the children had difficulty in categorizing geometric shapes when their attributes were changed, therefore providing different forms of geometric shapes to children is very important for improving their conceptual understanding.

Table 4. Students rating the quizzes of each group using the two methods (manipulative and conventional) in terms of level of confidence. Means with different letters indicate significant differences between treatments (p<0.05).

Section	Method	Mean Rating Perimeter	Descriptive Value	Mean Rating Area	Descriptive Value
1	Manipulative	2.45[a]	Moderate	2.41[a]	Moderate
	Conventional	2.80[b]	Moderate	2.32[a]	Moderate
2	Manipulative	2.06[a]	Moderate	2.10[a]	Moderate
	Conventional	2.28[b]	Moderate	2.34[b]	Moderate
3	Manipulative	2.05[a]	Moderate	2.16[a]	Moderate
	Conventional	2.47[b]	Moderate	2.37[a]	Moderate

Table 5. Students' rating of the quizzes of each group using two methods (manipulative and conventional) in terms of level of difficulty. Means with different letters indicate the significant difference between treatments (p<0.05)

Section	Method	Mean Rating Perimeter	Descriptive Value	Mean Rating Area	Descriptive Value
1	Manipulative	3.66[a]	Moderate	3.58[a]	Moderate
	Conventional	3.46[b]	Moderate	3.43[a]	Moderate
2	Manipulative	4.09[a]	Moderate	3.98[a]	Moderate
	Conventional	3.74[b]	Moderate	3.74[b]	Moderate
3	Manipulative	3.97[a]	Moderate	3.80[a]	Moderate
	Conventional	3.64[b]	Moderate	3.84[a]	Moderate

Both Table 4 and Table 5 results showed a remarkable impact on the research integration of teaching geometry using manipulatives. The data implies that 3.66, 4.09, and 3.97 are significantly higher compared to conventional teaching, which has only 3.46, 3.74, and 3.64 for the rating in their respective quiz scores.

Conclusion

Teacher-made square and triangle tiles are useful concrete instructional models for solving the perimeter and area of polygons. Hence, the use of this manipulative instructional scheme could be integrated as a learning activity in teaching geometry.

References

Clements & Battista, 1990. Constructivist and Teaching. https://www.researchgate.net/publication/258932205_Constructivist_learning_and_teaching

Durmas, Soner and E. Karakirik, 2006.Virtual Manipulatives in Mathematics Education: A Theoretical Framework. Turkish Online Journal of Educational Technology.

https://www.semanticscholar.org/paper/Virtual-Manipulatives-in-Mathematics-Education%3A-A-Durmu%C5%9F-Karakirik/4cf7074c501e4c49f714bde839bad4c34393da19

Stein, Mary Kay, Bovalino, Jane, W. 2001. Manipulatives: One Piece of the Puzzle. Mathematics Teaching in the Middle School, V6, n6 p356-59 Feb 2001. https://eric.ed.gov/?id=EJ668835

Thompson, A. G. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics* (pp. 127–146). Macmillan Publishing Co, Inc.