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Concrete and Virtual Geoboard: Effects on Students' Geometry Performance

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Abstract
Aim: This study aimed to determine the effectiveness of concrete and virtual Geoboard on students' performance in Geometry among Grade 7 students of Toledo City Science High School for Third Quarter of SY 2017-2018.
Methodology: The study utilized the experimental method of research employing the pretest-posttest with control group design.
Results: The findings of the study revealed that (1) the levels of performance in Geometry in the pretest of both the control and the two experimental groups were Below Average; in the posttest, the control group and the second experimental group had an Average performance while the first experimental group had an Above Average performance, (2) both the control and the two experimental groups had significant mean gains from the pretest to the posttest in Geometry, (3) the first experimental group which was exposed to concrete Geoboard had the highest significant mean gain compared to the control group exposed to direct instruction and the second experimental group exposed to virtual Geoboard, (4) both experimental groups exposed to concrete and virtual Geoboard manifested a Positive attitude towards the use of manipulatives, (5) the first experimental group manifested a Very Positive attitude towards Mathematics because of the use of concrete Geoboard while the second experimental group exhibited a Positive attitude towards Mathematics because of the use of virtual Geoboard, and (6) there was no significant correlation between the student's attitude towards the use of manipulatives and their performances in Geometry for the experimental group exposed to concrete Geoboard. However, the attitude of the experimental group exposed to virtual Geoboard significantly correlated with their performance in Geometry.
Conclusion: Learning Mathematics through providing a concrete way for students to link new and abstract information to already solidified and personally meaningful networks of knowledge will allow students to take in the new information and give it meaning which are essential to the learning of Mathematics and related disciplines. It is important that teachers make use of methods that are most effective and materials that enhance concept formation. One such material that has met with considerable success through research is the use of concrete Geoboard, which is a major finding in this study. The study showed that the use of concrete Geoboard is a more effective vehicle in learning Geometry as evidenced by their greater performance in the subject. Thus, Lesh Multiple Representations Translations Model which states that the ability of making translations between and within modes of representations would reflect the student's understanding of concepts and Kolb's Theory on Experiential Learning which states that concrete objects can effect better learning, were affirmed in this study.

Keywords: Geoboard, Manipulative, Virtual, Concrete, Hands-on Learning

INTRODUCTION

The Philippines is the last country in Asia and one of the three countries in the world which still had a 10-year basic education program before president, Benigno Aquino Jr. signed the Republic Act No. 10533 or otherwise known as the Enhanced Basic Education Act of 2013 making the K-12 Education into law, thus adding 3 years to the existing basic education curriculum.

Prior to its implementation, Filipino learners and graduates were at a disadvantage in contending for employment, academic endeavors and other higher pursuits since longer educational cycle is seen to be critical and imperative in the global market.

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Moreover, this led to lagging behind a number of its international competitors in the areas of languages, mathematics and sciences as assessed by Southeast Asian Ministers of Education Organization – Innotech (SEAMEO-Innotech).

With the advent of the K-12 education, it aims to provide solutions to these insufficiencies and problems. Specifically, with the goals of Mathematics in the basic education level which are critical thinking and problem solving, it intends to shorten and hopefully, eliminate the increasingly growing gap between the current Philippine education and necessities of the global market. These two goals are to be achieved with an organized and rigorous curriculum content, a well-defined set of high-level skills and processes, desirable values and attitudes and appropriate tools, taking into account the different contexts of Filipino learners.

However, critical thinking and problem solving are skills which cannot be learned overnight. A learner does not become a critical thinker and a problem solver after an hour Mathematics class. It requires not only the awakening but more importantly, sustaining their interest for continuous learning which cannot be achieved through the conventional way of Mathematics teaching. Rather than just listening to teachers talk, the students need to be more actively involved in mathematics and do mathematical activities.

This brings us the idea of integrating concrete and virtual materials in the teaching of Mathematics. Manipulatives are concrete objects used to help students understand abstract concepts offering students the opportunity to explore concepts both visually and tactilely, often through hands-on experiences.

However, virtual manipulatives are interactive, web-based, computer-generated images of objects that learners can manipulate on the computer screen. Similar to the ways they slide, flip, rotate and turn a concrete manipulative by hand, children can use a computer mouse to slide, flip, rotate and turn a dynamic visual representation as if it were a three-dimensional object. Using virtual manipulatives, children can apply mathematical concepts and explore processes for representing the concepts.

It is in these perspectives that the researcher considered it advantageous to implement classes with concrete and virtual manipulatives. Furthermore, to determine the effectiveness of the concrete and virtual manipulative use in the form of Geoboard on the performance of Grade 7 learners of Toledo City Science High School in Geometry is the ultimate aim of this study. In the conduct of this research, the Grade 7 learners were going to be divided into three groups. The first group belongs to the control group where the teacher uses direct instruction without the use of manipulatives. The second and third groups are the experimental groups where the teachers utilize concrete and virtual manipulatives in the delivery of their instruction.

Numerous learning theories are contemplated as relevant to direct instruction and manipulative use. This study is anchored on Theory of Direct Instruction by Siegfried Engelmann which focuses on the use of direct instruction (explicit instruction) in the delivery of the discussion, Cognitive Theory of Multimedia Learning (CTML) by Richard Mayer which directs the usage of virtual manipulative as aid for better learning in the classroom and Lesh Multiple Representations Translations Model (LMRTM) by Richard Lesh and Constructivism by Jean Piaget which suggest the usage of a concrete manipulative.

Engelmann's Theory of Direct Instruction is a methodical approach in teaching which gives learners rigorous support through the guidance of the teacher during the early stages of learning. In the traditional classroom environment, teacher standing in front of the classroom presenting information was considered as a productive approach to learning because a large amount of information could be provided in a short period of time. Direct instruction (explicit instruction) is cited as one of the three evidence-based mathematics instructional strategy in an article published by The IRIS Center of the Vanderbilt University. They further specified the steps in using this method: (1) orientation of the lesson, (2) initial instruction, (3) teacher-guided practice, (4) independent practice, (5) check and (6) reteach.

In contradiction with the previous theory, CTML known as the "multimedia principle" states that people learn more deeply from words and pictures than from words alone. However, simply adding words to pictures is not an effective way to achieve multimedia learning. The goal is instructional media in the light of how the human mind works. It is focused on three assumptions: dual channels, which considered human to possess separate channels for information processing, an auditory/verbal channel and a visual/pictorial channel; limited capacity, which postulated that human working memory has limited capacity for information processing; and active processing, which means to be able to learn, one must actively filter, select, organize and integrate information based upon prior knowledge.

Moreover, according to NCTM, representations play an important and necessary role in the teaching and learning of mathematics. "The ways in which mathematical ideas are represented is fundamental to how people can understand and use those ideas." Representations have become one of the major aspects in the teaching and learning

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of mathematics as emphasized by many theorists. The concept of using representations as a means of communicating abstract mathematical ideas is a prominent focus of research in teacher knowledge and student learning.

Mental functions, such as representing thoughts in pictures and writing, develop through social interactions with "more knowledgeable others" and experiences in a child's life. Through these interactions, children come to learn their culture, such as speech patterns, written language, and other symbolic representations through which children gain meaning.

The use of technology in education is supported by constructivism promoted by Jean Piaget. In constructivism, knowledge is constructed by the learner; it cannot be supplied by the teacher. In a constructivist classroom, the role of the teacher is that of a facilitator and a coach. The teacher provides meaningful learning environment for the learners. This task can be simplified with the use of technology.

Constructivist researchers have contributed to the popularity of the use of mathematical representations. Piaget suggested that children do not have the mental maturity to truly grasp abstract mathematical concepts that were presented merely in words or symbols alone, and that children need many and a variety of experiences with concrete materials and graphics in order for learning to occur.

The theory of multiple representations which is called Lesh Multiple Representations Translations Model (LMRTM) has been proposed by Richard Lesh. He viewed both internal and external representations as crucial elements for understanding mathematical concepts and both are interrelated since "external (and therefore observable) embodiments of students' internal conceptualizations." This model argued that the ability of making translations between and within modes of representations would reflect the student's understanding of concepts. He described five distinct modes of representations that occur in mathematics learning and problem solving; they are "(1) real-world situations –in which knowledge is organized around "real world" events; (2) manipulatives –in which the "elements" in the system have little meaning but the "built in" relationships and operations fit many everyday situations; (3) pictures or diagrams –static figural models; (4) spoken symbols –it can be everyday language; (5) written symbols –in which specialized sentences and phrases take place." Building on the theories of Piaget, Bruner and Dienes, the Lesh model suggests that a deep understanding of mathematical ideas can be developed by involving students in activities that embed the mathematical ideas to be learned in five different modes of representation with an emphasis on translations within and between modes.

Moreover, manipulatives have been used by people since the olden days. Carving symbols on caves, stones and leaves and knotting on ropes and straps are done to represent numbers. As civilization started and progressed, people have learned that creating calculating devices could make their work easier and convenient. This led to the invention of various concrete devices such as abacus.

In the late 1800s, the value and importance of concrete objects for the teaching and learning of Mathematics was given a great emphasis by Johann Heinrich Pestalozzi. According to Pestalozzi, children must first deal with concrete ideas before moving to abstract ones. In the early twentieth century, the discovery of this method of instruction was established by Mari Montessori. According to Montessori, learning is processed through the sense and imagination. Children's senses recognize concrete concepts through the materials that they observe and manipulate. Montessori developed various mathematics materials that construct children's previous knowledge and guide them throughout a progressive sequence of activities that underline concepts while preparing the children for abstraction (Wilhelmi, 2009).

However, technology is becoming more and more visible in classrooms. Each new generation of learners has greater comfort and familiarity with computer programs and usage. The mathematics classroom is enhanced by taking advantage of the new platform that computer-aided instruction can provide.

Virtual manipulatives are powerful tools in that they constrain the learner's action and direct the learner to focus on the mathematics in the virtual environment. It successfully provides a bridge between the concrete use of manipulatives and the more abstract mathematical concepts they present. The exercise-structured framework of activities reinforces mathematics skills and will benefit those teachers who are not as comfortable with the NCTM emphasis on active exploration.

Additionally, several researches indicate that the proper use of manipulatives results in marked success in achievement and that manipulatives are particularly helpful in assisting students in understanding mathematical concepts.

In a study done by Perry (2014) regarding the usage of manipulatives in the middle school mathematics classroom, he interviewed teachers to gather relevant information on how and why they use it in the delivery of instruction. Conclusion on the analysis of the findings stated that all of the teachers incorporated manipulatives into their instruction of mathematical concepts with the goal of improving student understanding of those concepts. In

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addition to weighing the instructional benefit of using the tool, teachers also considered student engagement as part of their decision whether to use a manipulative.

Another study conducted by Pableo (2016) showed that the students who were exposed in the use of algebra tiles in teaching polynomial factoring in intermediate algebra reached the 75% standard criterion set by the school. This could be attributed to the use of manipulative which can offer support to concretize abstract concepts thus achieving an average performance in the posttest.

With the rapid advancement of technology in the recent years, an ICT – integrated classroom had gained prominence in the educational system due to its student-centered nature. One of which is the virtual manipulative.

Virtual manipulatives could be accessed in a desktop computer whether it be online or offline. Numerous apps had been created to answer the call for ICT-integrated lessons which make learning, not only informational, but also entertaining.

These had also become available on a new platform, touchscreen devices, as part of educational apps. These apps utilized the touch and multi-touch technologies that touchscreen devices of all sizes afford. Virtual manipulatives designed for use on the touchscreen platform had been programmed in many different languages for both Android and Apple devices. In short, virtual manipulatives were readily available at present in many different formats as a part of apps on a variety of different touchscreen devices and other media.

Hannan's (2012) study presented that the use of virtual manipulatives could stimulate the learner and provided extension work for children of all abilities. In a sense, it challenged learners by engaging them in higher order solving activities. Moreover, most virtual activities were used by groups and these types of activities stimulated mathematical discussion. This ensured social interaction and cooperation among students.

Villamora's (2014) results revealed that virtual manipulative (Virtual Geoboard Plus) was an effective tool in increasing the students' performance on area and perimeter of polygons on a set of Grade 7 students.

Lastly, Doias (2013) concluded that learning seemed more authentic, thus enabled the students to make real-life connections. These personal connections formed a much more stable foundation for student learning. Students retained the information more quickly, and the teacher spent less time reteaching.

Based on the review of theories, literature and studies which provided substantiation that classrooms utilizing concrete and virtual manipulatives have potential to improve Mathematics performance among learners which were the focus of this study. The subjects of the study were the Grade 7 learners of Toledo City Science High School. The learners were divided into three groups: one control and two experimental groups. Pretest and posttest scores were collected, presented and analyzed and from which, conclusions and pertinent recommendations were derived. Based on the findings and conclusion, instructional intervention was proposed to improve students' performance in Geometry.

Objectives

This study compared Geometry performance of Grade 7 students of Toledo City Science High School SY 2017-2018 who were exposed to direct instruction, concrete Geoboard and virtual Geoboard.

Specifically, this study aimed to answer the following:

1. What is the level of performance in the pretest and posttest in Geometry of the Grade 7 students of the:
   1.1 control group (exposed to the direct instruction approach),
   1.2 first experimental class (exposed to the concrete geoboard approach), and
   1.3 second experimental class (exposed to the virtual geoboard approach)?
2. Is there a significant mean gain in the performance of the Grade 7 students from the pretest to the posttest in geometry of the:
   2.1 control class,
   2.2 first experimental group, and
   2.3 second experimental group?
3. Is there a significant difference in the mean gains between the control and experimental classes?
4. Is there a significant difference in the students' attitudes before and after the use of manipulatives?
5. What intervention guidelines may be proposed to enhance students' performance in Geometry?

Hypotheses

This study sought to provide answers to the following hypotheses:

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HO1: There is no significant difference between the hypothetical mean and actual mean in the pretest and posttest performance in Geometry of the Grade 7 students of the:

HO1.1 control group (exposed to the direct instruction approach),

HO1.2 first experimental class (exposed to the concrete geoboard approach), and

HO1.3 second experimental class (exposed to the virtual geoboard approach).

HO2: There is no significant mean gain in the performance of the Grade 7 students from the pretest to the posttest in Geometry of the :

HO2.1 control class,

HO2.2 first experimental group, and

HO2.3 second experimental group.

HO3: There is no significant difference in the mean gains between the control and experimental classes.

METHODS

Research Design

This study was a quasi-experimental method which utilized a pretest-posttest control group design. This aimed to determine the effectiveness of concrete and virtual Geoboard on students' performance in Geometry. The research design is diagramed below:

G1	O1	X1	O2
G2	O3	X2	O4
G3	O5	-	O6

where: G_1 - was the first experimental group which will use the concrete geoboard,
G_2 - was the second experimental group which will use the virtual geoboard,
G_3 - was the control group exposed to the conventional lecture method,
O_1, O_3 and O_5 - were pretests in Geometry,
O_2, O_4 and O_6 - were posttests in Geometry,
X_1 - was the first experimental variable, the use of concrete geoboard, and
X_2 - was the second experimental variable, the use of concrete geoboard

Research Environment

This study was conducted in Toledo City Science High School situated at Ilihan Heights, Toledo City. It was founded to answer the call of the Department of Education in its project "Science Education Institute of the Department of Science and Technology" (SEI-DOST) to focus on Math and Science education from a regional to a provincial basis in 1996. At present, TCSHS caters to learners from Junior High School to Senior High School and with the K-12 program implementation this year, it offers 1 strand of the Academic track – Science, Technology, Engineering and Mathematics (STEM).

Research Subjects

The subjects of this study were the 66 Grade 7 students of Toledo City Science High School. Since there were only 2 sections and there should be 3 groups, they were divided into 3 groups randomly. The 3 groups were as follows: 1 group as control which focused on direct instruction and 2 groups for experimental which utilized the concrete and virtual Geoboard. Each group consisted of 22 students.

Data Gathering Procedure

This study was conducted during the Third Quarter of the School Year 2017-2018 which lasted for a total of 6 weeks. A letter of permit was presented to the Schools Division Superintendent of the Division of Toledo City and Principal of Toledo City Science High School to secure permission and approval for the data gathering of this study.

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Before the interventions were implemented, the learners took a pretest which was taken from the Mathematics 7 Learning Material (LM) distributed by the Department of Education to all public schools nationwide which served as a baseline data of the researcher. Since there were 2 sections only for Grade 7, they were grouped further into 3 to form the 1 control and 2 experimental groups of this study. Grouping of the 66 students were done randomly. To determine if there was no significant difference in the characteristic of each group, one-way ANOVA was used in their pretest scores. The 2 experimental groups underwent classes which utilized concrete and virtual Geoboard and the control group was taught using direct instruction. Since these were intact classes and they were allowed to be subdivided only during the Mathematics period, 22 students from both sections, which comprised the control group, did not join their classmates during their usual Mathematics schedule and stayed at the Computer Laboratory 1 to do their curricular and co-curricular tasks and had their Mathematics classes everyday at 11:40 – 12:00 and 4:30 – 5:00. After the 6-week period, the same test, in which the test items and its options will be shuffled, was administered to determine the learner's performance in the three groups.

Pedagogical Approach

The study was anchored on three pedagogical approaches: direct instruction which was employed in the control group, concrete manipulative (concrete Geoboard) which was used in the first experimental group and the virtual manipulative (virtual Geoboard) in the second experimental group. The allotted time and amount of instruction for the three groups was the same all throughout the conduct of this study.

Control Group

The control group consisted of 22 students taken from the 2 intact sections. In this class, lesson delivery was done by the teacher. It started with orientation of the lesson which served as preparatory activity for the learners. This was followed by the lesson proper which was done through lecture method. Then, through a drill, learners practiced and mastered the skill. Next, formative assessment was conducted to check for learners' comprehension and analysis of the lesson. Lastly, the result of the assessment was the basis if there was a need for reteaching if learner's performance was below average.

Experimental Groups

In the first experimental group, at most 2 days was allotted to explore and familiarize the use of the concrete Geoboard for the discussion. Then, lessons were discussed inductively starting with examples in which the manipulatives were utilized, practiced exercises in which learners were working collaboratively in an inquiry-based manner and abstractions in which generalization of concepts was formulated based on the learner's prior activities.

In the second experimental group, the same number of days was arranged for exploratory and familiarization of the virtual Geoboard. The procedures of the lessons would be the same; however, the only difference is that a virtual Geoboard will be used by the learners.

At the end of the intervention, an attitude questionnaire was given to measure the level of perception of students in using concrete or virtual Geoboard in learning the basic concepts of Geometry. Then, the three groups were administered a posttest to measure their learning achievement.

Research Instruments

The main instrument for the pretest and posttest was composed of 30 multiple choice items which covered 11 competencies as stipulated in the DepEd Math 7 Third Quarter curriculum guide. Sixty minutes was allotted for this assessment. These items were taken from the Mathematics 7 Learning Material (LM) distributed by the Department of Education (DepEd) to all public schools nationwide.

The other instrument that the study used was an attitude scale. This measured the attitude of students of the 2 experimental groups towards the use of concrete and virtual Geoboard in the learning process. The questionnaire was adopted from Maxima Ruyca, 1994 which is in the form of a Likert scale with the following indicators and its corresponding points: Strong Disagree – 1 point; Disagree – 2 points; Agree – 4 points and Strongly Agree – 5 points.

Statistical Treatment

This study analyzed and interpreted the results using the following statistical tools:

1. **t-test for single and small sample.** This statistical treatment measured the level of performance in the pretest and posttest of the learners in the direct instruction, concrete Geoboard and virtual Geoboard classes.

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2. **t-test for correlated samples.** This statistical treatment measured the significant mean gain of the performance of learners in the direct instruction, concrete Geoboard and virtual Geoboard classes.
3. **Analysis of Variance (ANOVA, F-test) One-Way**. This statistical treatment measured the significant difference in the mean gains in the direct instruction, concrete Geoboard and virtual Geoboard classes.
4. **Weighted Mean.** To determine the Grade 7 students' perception towards the use of manipulatives, the weighted mean using the five-point Likert Scale was calculated.

RESULTS AND DISCUSSIONS

Performance Level of the Grade 7 students in Geometry

The pretest and posttest administered to the Grade 7 students before and after the experimentation evaluated their performance level in Geometry.

Table 1 below shows the pretest performance level of the students in Geometry.

Table 1. Pretest Performance Level of the Grade 7 Students in Geometry

Group	*n*	$H.M.$	*A.M.*	*SD*	Difference between Means	Test Statistics			Qualitative Description
						Computed *t* value	Tabled *t* value	*p* value	
Control (exposed to direct instruction)	20	18	8.50	3.44	9.50	12.35*	2.093	0.00001*	Below Average
1st Experimental (exposed to concrete Geoboard)	20	18	8.50	3.68		11.55*	2.093	0.00001*	Below Average
2nd Experimental (exposed to virtual Geoboard)	20	18	8.50	3.09		13.77*	2.093	0.00001*	Below Average

Hypothetical mean is equal to 60% of the total number of points in the test
* Significant at $\alpha = 0.05$ with $n - 1$ degrees of freedom

Table 1 revealed that the control and the two experimental groups obtained actual means which were lower than the hypothetical mean. The control group obtained 8.50 (*SD* = 3.35), the first experimental group had 8.50 (*SD* = 3.58), and the second experimental group obtained 8.50 (*SD* = 3.00). The computed *t* values for the control and two experimental groups were 12.68, 11.87, and 14.16, respectively. These were greater than the tabled value of 2.093 at $\alpha = 0.05$ with 19 degrees of freedom. The *p* values were 0.00001 for the three groups. Both *t* and *p* values yielded significant results, hence, the rejection of H_{01}. All three groups exhibited Below Average performance in the Geometry pretest. The level of performance of the control group which was exposed to direct instruction, the first experimental group which was exposed to the use of concrete Geoboard, and the second experimental group which was exposed to the use of virtual Geoboard did not meet the standard criterion of 60% set by DepEd.

This below average performance of the Grade 7 students was reasonable because most of the topics covered in the pretest may have not been taken up yet when they were in Grade Six or may have been discussed with a level of difficulty appropriate for Grade Six students. Their prior knowledge of the concepts might have not been sufficient for them to pass the test since it was still a pre-assessment.

The level of posttest performance of the students in Geometry was analyzed and the results obtained were presented in Table 2.

Table 2. Posttest Performance Level of the Grade 7 Students in Geometry

Group	*n*	$H.M$	*A.M.*	*SD*	Difference	Test Statistics			Qualitative
						Computed	Tabled *t* value	*p* value	

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					between Means	*t* value			Description
Control (exposed to direct instruction)	20	18	16.45	5.09	1.55	1.361^{ns}	2.093	0.189439^{ns}	Average
1st Experimental (exposed to concrete Geoboard)	20	18	22.20	4.92	4.20	3.821*	2.093	0.001153 *	Above Average
2nd Experimental (exposed to virtual Geoboard)	20	18	20.35	4.09	0.20	2.567*	2.093	0.018866 *	Above Average

^{ns} Not Significant * Significant

Table 2 displayed that the control group obtained an actual mean of 16.45 (*SD* = 5.09). The computed *t* value of 1.361 was less than the tabled value of 2.093 with a *p* value of 0.189439 which is greater than $\alpha = 0.05$. Both values were not significant, hence failed to reject Ho_1. This meant that the performance of the control group in Geometry was Average in the posttest. Thus, this group reached the 60% standard criterion set by the Department of Education.

Conversely, the actual mean in the posttest of the first experimental group was higher than the hypothetical mean. The first experimental group had a mean of 22.20 (*SD* = 4.92), a computed *t* value of 3.821 which is higher than the tabled value of 2.093 and *p* value of 0.001153 which is less than $\alpha = 0.05$. These values were significant, thus, Ho_1 was rejected which means that the first experimental group exposed to concrete Geoboard obtained Above Average performance in the posttest manifested that they performed way above the 60% criterion.

This indicated that the students who were exposed to the use of concrete Geoboard reached the 60% standard criterion set by the Department of Education. This could be because manipulatives, such as a concrete Geoboard, can provide valuable support for student learning when teachers spend sufficient time with the students in building links between the object, and the symbol that represents it, thus, achieving an above average performances in the posttest.

Additionally, the second experimental group exposed to virtual Geoboard obtained a mean of 2.35 points greater than the 60% set by DepEd. With a computed *t* value of 2.567 which is greater than the tabled value of 2.093 and a *p* value of 0.018866 which is less than $\alpha = 0.05$, Ho_1 was rejected further indicating an Above Average performance in the posttest.

This result supported the findings of Villamora (2014) that virtual manipulatives has the ability to quickly upgrade and make necessary revisions, give opportunities for interaction between developers and users, accessible to special needs populations, such as enlarged print for sight-impaired users or voice activation for hearing-impaired users, and offer the users the ability to individualize the information or materials to suit their own needs or creativity which make it effective for Geometry instruction.

Mean Gain of the Grade 7 Students' Performance in Geometry

To check for improvement in students' performance from the pretest to the posttest in Geometry, the *t* test of correlated samples was computed and the results are presented in Table 3.

Table 3. Mean Gains in Students' Performance in Geometry

Group	*n*	Pretest	Posttest	$\bar{d}$	S_d	Test Statistic: Computed *t* value	Tabled *t* value	*p* value
Control (exposed to direct instruction)	20	8.50	16.45	7.95	6.29	5.655*	2.093	0.00001*
1st Experimental (exposed to	20	8.50	22.20	13.70	6.04	10.136*	2.093	0.00001*

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concrete Geoboard)								
2nd Experimental (exposed to virtual Geoboard)	20	8.50	20.35	11.85	4.67	11.345*	2.093	0.00001*

*Significant

Table 3 indicated that from the pretest to the posttest, the control group obtained a mean gain of 7.95 (S_d = 6.13), 13.80 (S_d = 5.89) for the first experimental group, and 9.75 (S_d = 4.55) for the second experimental group. The computed *t* values of 5.800, 10.478 and 9.534 for the control, first experimental, and second experimental groups respectively were greater than the tabled value of 2.093 at 5% level of significance with 19 degrees of freedom. Consequently, the *p* value of 0.00001 for each was less than $\alpha = 0.05$, hence yielded significant results. Thus, Ho_2 was rejected in all three cases. This meant that significant mean improvements for the control and two experimental groups in Geometry were obtained. Also, this meant that the direct instruction approach employed in the control group and the two interventions for the two experimental groups, namely: the use of concrete and virtual Geoboards, were effective in enhancing Grade 7 students' performance.

This significant improvement in student achievement of the control group could possibly be because in the direct instruction method, regardless of the teacher being the lone source of concepts and inputs during the delivery of instruction, substantial comprehension might have been evident in the students. It further implied that the teacher could have effectively discussed and delivered the lesson to the students hence resulting to the significant improvement in the achievement of the students.

This result supported the findings of the study of Doias (2013) in which teaching gives learners rigorous support through the guidance of the teacher during the early stages of learning. In the traditional classroom environment, teacher standing in front of the classroom presenting information was considered as a productive approach to learning because a large amount of information could be provided in a short period of time.

Likewise, the use of manipulative materials might have helped students explore mathematical concepts and convert symbolic representations to abstract mathematical ideas through concrete and virtual models. This could give a solid foundation in the analysis, synthesis and application of concepts in Geometry to the students.

This supported the findings of the study of Pableo (2016) in using concrete manipulatives in teaching Intermediate Algebra which revealed that a higher mean gain was obtained by the students who were exposed to the use of manipulatives than the conventional lecture method. Hence, further suggested that it was a more effective vehicle in learning the subject since students were actively involved in learning (Allen, 2007; Larbi & Mavis, 2016).

Moreover, Villamora (2014) affirmed in their studies that the exposure to a virtual manipulative increased the students' knowledge. This was evident through the obtained significant difference between the performance of students before and after the experimentation which could be attributed to their engagement on the manipulative and on free-play. The use of manipulative could arise the motivation of students since they manifested excitement and interest in learning the subject through exploring ideas and concepts with the use of technology. Students' interest in computers and the like and the accompanying motivation can be captured with virtual manipulatives and teachers can take advantage of their students' increasing ability to use this technology.

Comparison of the Mean Gains in Geometry among the Control and two Experimental Groups

Table 4 capsulizes the difference in the control and the two experimental groups in terms of their mean gains through analysis of variance.

Table 4. Analysis of Variance To Determine the Mean Gain Difference of the Three Groups

Source of Variation	Sum of Squares	d.f.	Mean Square	*F* ratio	Tabled Value
Between - groups	341.93	2	170.965	5.23*	3.15
Within - groups	1862.4	57	32.67		
Total	2204.33	59	203.635		

*Significant at $\alpha = 0.05$ with $(2, 57)$ degrees of freedom

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As shown in Table 4, using One-Way Anova, the computed F ratio of 5.23 was greater than the tabled value of 3.15, at $\alpha = 0.05$ with (2, 57) degrees of freedom. This was significant which meant the rejection of Ho_3. At least one of the means differed from the others.

To test where the difference in performance lies, a post-hoc Scheffe' test was conducted which is shown in Table 5.

Table 5. The Post-Hoc Scheffe' Test

Comparison	n	Mean	Test Statistic	
			F_s	Critical Value F'
Control (exposed to direct instruction) VS **1st Experimental** (exposed to concrete Geoboard)	20	7.95	10.48*	6.30
	20	13.80		
Control (exposed to direct instruction) VS **2nd Experimental** (exposed to virtual Geoboard)	20	7.95	0.94^{ns}	6.30
	20	9.70		
1st Experimental (exposed to concrete Geoboard) VS **2nd Experimental** (exposed to virtual Geoboard)	20	13.80	5.15^{ns}	6.30
	20	9.70		

^{ns} Not Significant * Significant

From the control group vs first experimental group, it can be seen in Table 5 that the computed Scheffe' test of 10.48 was greater than the critical value of 6.30, hence, significant. This meant that the use of concrete Geoboard in the first experimental group was more effective than direct instruction in the control group as evidenced by the students' performance.

Conversely, from the control group vs second experimental group, and the first experimental group vs second experimental group, the computed Scheffe' test of 0.94 and 5.15 respectively were less than the critical value of 6.30, thus not significant in both cases. This meant that the performance of the control group exposed to direct instruction was comparable to that of the performance of the second experimental group exposed to virtual Geoboard. Moreover, the performance of the first experimental group exposed to concrete Geoboard was also comparable to that of the second experimental group exposed to virtual Geoboard.

The result showed that among the three groups, the use of concrete Geoboard was the most effective approach in teaching Geometry for Grade 7 students. The first experimental group which was exposed to concrete Geoboard performed better compared to the control group exposed to direct instruction. This could be because the first experimental group was actively involved in learning. This type of learning involved trial and error. As students engage in hands-on tasks, they might have found out that some approaches work better than others. They might have discarded the methods that don't work, but the act of "trying" something and then abandoning it – ordinarily considered a "mistake" – actually might have become a valuable part of the learning process. Thus, students learn not to fear mistakes, but to value them.

The findings of this study supported the study of Perry (2014) which revealed that students who used concrete manipulatives typically outperformed those who did not use manipulatives on Geometry achievement tests. This benefit held across all grade levels, ability levels, and Geometry topics, provided that the manipulatives being used were appropriate for the topics being studied. The use of manipulatives also increased scores on retention and problem-solving tests.

Children learn best when learning begins with a concrete representation. Consequently, the use of concrete manipulatives makes learning Geometry interesting and enjoyable. Thus, Lesh Multiple Representations Translations Model which states that translations of concepts through the use of manipulatives, one of the five modes of representation, enhances acquisition and understanding of mathematical concepts and problem solving and Kolb's Theory on Experiential Learning which states that concrete objects can effect better learning, were both affirmed in this study

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Attitudes of the Grade 7 Students Towards The Use of Manipulatives

Table 6 revealed the attitude of the experimental group towards Geometry after using manipulatives.

Table 6. Attitudes of the Experimental Groups of Grade 7 Students Towards The Use of Manipulatives

Group	Mean	Qualitative Description
1st Experimental (exposed to concrete Geoboard)	2.98	Positive
2nd Experimental (exposed to virtual Geoboard)	2.82	Positive

3.26 - 4.00 - Very Positive
2.51 - 3.25 - Positive
1.76 - 2.50 - Negative
1.00 - 1.75 - Very Negative

It can be seen in Table 6 that students in the first experimental group had a mean attitude of 2.98 (*SD* = 0.46) while the second experimental group had a mean attitude of 2.82 (*SD* = 0.47). This meant that the students in both experimental groups exhibited a Positive attitude towards the use of concrete and virtual manipulatives in learning Geometry. This could mean that the use of manipulatives might have provided a meaningful experience to the students.

Moreover, Perry (2014) found out in his study that aside from increased Geometry achievement through the long-term use of concrete instructional materials (manipulatives), students' attitudes toward the subject improved when they had instruction with concrete materials provided by teachers knowledgeable about their use, hence, supported by the finding of this study.

This finding also was in agreement with Hannan (2012) who found out that for students, the appeal of the virtual manipulatives comes with the interactive, engaging and immediate feedback features of the tool. Letting students know immediately whether their answer is correct is not only helpful but also allows students to be more independent of the teacher. They can also work at their own pace with online virtual manipulatives and, if they have access to the Internet outside of school, can use these same tools to support their homework or studying.

Relationship Between the Attitude Towards Geometry of the Experimental Group and Their Performance in the Subject

The Pearson Product-Moment Coefficient of correlation r was computed to establish relationship between students' attitude and their performance in Geometry. Results were presented in Table 7.

Table 7. Correlation Between the Attitude Towards the Use of Manipulatives of the Experimental Groups and Their Performance in Geometry

Group		*n*	Mean	*SD*	Test Statistics: Computed *r*	Test Statistics: Description	Test Statistics: *p* value
1st Experimental (exposed to concrete Geoboard)	Attitude towards the Use of Manipulatives	20	2.98	0.46	0.316^{ns}	Low	0.174^{ns}
	Geometry Performance		22.30	4.91			
2nd Experimental (exposed to virtual Geoboard)	Attitude towards the Use of Manipulatives	20	2.82	0.47	0.479*	Substantial	0.033*
	Geometry Performance		18.20	4.92			

^{ns} Not Significant * Significant

Table 7 showed that for the first experimental group, the computed *r* (0.316) and *p* (0.174) values were not significant hence, failed to reject H_{04}. This implied that there was no significant correlation between attitude and

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performance. The attitude of the first experimental group towards the use of concrete Geoboard in Geometry had no bearing in their performance which meant that the performance of students were not attributed to their attitude towards the subject. Students who expressed a positive attitude towards the subject may have a high or low performance in the subject. Likewise, students who did not exhibit a positive attitude towards the subject might also have a high or low performance. Thus, the performance of the students toward the use of concrete Geoboard in Geometry could not be predicted through their attitude towards the subject.

Conversely, the second experimental group obtained a computed *r* (0.479) and *p* (0.033) value. These values were significant at $\alpha = 0.05$ hence, Ho_4 was rejected. This means that there was a substantial significant correlation between attitude and performance. The second experimental groups' attitude towards the use of manipulatives was a determinant factor on their performance in the subject.

This negated the result of some researchers' studies that a concrete, exploratory approach to Geometry instruction is the most effective in supporting positive attitudes towards Math (Pableo, 2016).

Conversely, this finding concurred with the findings of Hannan (2012) that on-screen (virtual) manipulatives help children to transit from the concrete to symbolic levels by facilitating the development of abstract understanding through representational forms making the learning experience more valuable thus, exhibiting a positive attitude towards Geometry.

Conclusions

Geometry is representation of ideas using points, lines, planes, angles, surfaces, solids and its relationships. Expressing mathematical thoughts in geometric language is the ability to read with understanding and reason logically., hence necessitates that learners make use of methods and materials that are effective and can enhance concept formation.

Based on the findings of the study, the use of manipulatives in the form of concrete Geoboard was the most effective vehicle in understanding Geometry concepts. Moreover, the manipulatives, concrete or virtual, proved to be meaningful and interesting materials for students' conceptualization and understanding Geometry as evidenced by their positive attitude. Finally, the virtual manipulative was found to be a powerful tool in providing a bridge between the use of concrete and abstract mathematical concepts as demonstrated by students manifesting a positive effect of attitude in the virtual learning environment to their performance in Geometry.

The findings of this study concurred with this view in the use of manipulatives to effectively enhance learning. It affirmed the Theory of Kolb's Experiential Learning which states that concrete objects can affect better learning and Lesh Multiple Representations Translations Model which states that a deep understanding of mathematical ideas can be developed by involving students in activities that embed the mathematical ideas to be learned in the different modes of representation with an emphasis on translations within and between modes.

Recommendations

Based on the findings and conclusions of the study, the following recommendations were suggested:

1. that manipulatives be included in Geometry teachers' repertoire of teaching methods;
2. that further research use a similar design to be conducted with a larger sample to further investigate the relationship between manipulatives, attitudes, and Mathematics achievement and use assessment instruments which allow manipulatives to be used during all or part of the assessment activity;
3. that professional learning communities be organized by the Department of Education, like workshops and trainings, to encourage the effective use of manipulatives in teaching Geometry as it will help students of different learning styles;
4. that more resources be provided by the Department of Education to increase not only the alignment between the content of the resource material and the use of manipulatives but also to give more choices to teachers for finding strategies that will fit their classroom situation;
5. that longer time for experimentation be used to gain more conclusive results of its effects.

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