

Effectiveness of Manipulatives within the Algebra 1 Classroom

by Andrea Wingett

Submitted in Partial Fulfillment of the Requirements for the
Degree of Master of Education

July 2019

Graduate Programs in Education

Goucher College

Table of Contents

List of Tables	i
Abstract	ii
I. Introduction	1
Statement of Problem	2
Hypothesis	2
Operational Definitions	2
II. Review of the Literature	4
Historical Approaches to Teaching Math and their Impact on Present Math Education	4
Best Practices and Student Attitude Towards Mathematics	7
Current Research on Manipulatives	11
Summary	13
III. Methods	14
Purpose	14
Participants	14
Instruments	15
Procedures	16
IV. Results	18
V. Discussion	19
Results	19
Implications	19
Threats to Validity	20

Comparison of Results to Literature	21
Future Research	22
Conclusion	22
References	23

List of Tables

1. Algebra Test Results for Classes Using or Not Using Manipulatives	18
--	----

Abstract

The purpose of this study was to determine whether the use of manipulatives, which include Algebra tiles, improve student performance in Algebra 1 students who have failed Algebra 1 at least one semester. The measurement tool was an Algebra 1 team made test. This study used the pre/post test design to compare the data before and after the intervention. The experimental group was taught two targeted skills with the use of manipulatives (intervention), while the control group received instruction on the two targeted skills without the use of manipulatives. This study lasted three weeks and took place over the course of six, eighty-five minute class periods. The results of the experimental group, when compared to the control group, showed no statistically significant differences; Thus acceptance of the null hypothesis. Further implications, threats to validity, and suggestions for future research are discussed within this paper.

CHAPTER I

INTRODUCTION

Math instruction in the United States has changed and adapted over time in an attempt to prompt students to become leaders and assist in the United States' pursuit to be the best in the areas of science, technology, engineering, and math (Maccini & Gagnon, 2000). The increase in rigor and the emphasis on abstract and problem-solving skills in the math classroom leads one to question what teaching practices are effective for teaching students' mathematical concepts that are difficult to understand. Education reform in the math classroom has specifically focused on allowing students to participate in inquiry, sense making, and problem solving within the classroom (Loveless, 2001).

Studies have found that students' attitude towards mathematics drops and becomes increasingly negative with each grade level in middle school and high school (Wilkins & Ma, 2003). In order to improve students' attitudes towards math and increase performance, many researchers have studied interventions and best practices for teaching mathematics (Maccini & Gagnon, 2000). Some of these practices involve embedding problem-solving mathematical situations within real world context, calculators, collaboration, and the use of the CRA model (concrete, representational, abstract) to teach students through the use of hands on manipulatives. Some examples of manipulatives in mathematics include fraction strips, geoboards, pattern blocks, and algebra tiles (Satsangi, Bouck, Taber-Doughty, Bofferding, & Roberts, 2016).

The researcher of this study is a special educator who teaches self-contained and co-taught Algebra 1 and supports students who have disabilities and documented deficits in the area of mathematics. Students within the Algebra 1 classroom are typically ninth graders, and consequently, the students who struggle with Algebra 1 curriculum continue to struggle with the

mathematical concepts required of them the rest of their high school career. Students in Anne Arundel County who fail to earn their credit of Algebra 1 are required to take the class outside of regular day school and must receive the credit in an alternative placement, such as Evening High School. The Algebra 1 course is a graduation requirement for students who are diploma bound. The researcher is looking for ways to best support students within the Algebra 1 classroom and increase student performance on skills necessary for success in other mathematics classes.

Statement of the Problem

This study was conducted to determine whether the use of manipulatives, which include algebra tiles, improve student performance in Algebra 1 students who have failed Algebra 1 at least one semester.

Hypothesis

Manipulatives, including algebra tiles, will not improve secondary students' math skills.

Operational Definitions

The following variables and concepts for this study are defined below.

The *Targeted Skill 1* for this study is the ability to add and subtract polynomials.

The *Targeted Skill 2* for this study is the ability to multiply binomials.

The *Concrete, Representational, Abstract* model (CRA) involves teaching students the targeted skill using algebra tiles first, then having the them draw out and label the tiles on paper, and finally having them write the abstract math terms/concepts that the tiles represent.

Manipulative instruction in this study refers to teaching the targeted skill using algebra tiles and the CRA model.

Non-manipulative instruction in this study will refer to teaching the targeted skill without the use of algebra tiles and only teaching the mathematical concepts and process to achieve skill.

Improved math skills for the purpose of this study will refer to students who perform the targeted skill with 75% accuracy or higher.

The *Comparison Groups* will be two different Algebra 1 Evening High classes in which one class will receive manipulative instruction and the other group will receive non-manipulative instruction.

Pre-Assessment will refer to a department-made warm up, which will assess student ability to multiply binomials.

Post-Assessment will refer to a department-made assessment that will be given to students after receiving instruction on the targeted skill.

CHAPTER II

REVIEW OF THE LITERATURE

The following literature review explores the impact of historical events, research-based best practices, and the use of tangible math manipulatives on the instruction of mathematics in the United States. The review is broken into three sections. The first section of this review describes the historical events that have had an impact on education in the United States and the instruction of mathematics. Section two is a discussion of research-based mathematical best practices, as well as the impact of student attitude on their achievement in mathematics. Section three reviews the current research on the use of manipulatives in the secondary math classroom.

Historical Approaches to Teaching Math and their Impact on Present Math Education

Math instruction is constantly evolving and changing to meet the needs of students. To help one understand why math is taught the way it is presently, it is important to look to the past and explore how historical events have shaped math instruction in the United States today. In the 1900's, the economy and education were built around farming (Loveless, 2001). Schools were local, independently run institutions that students typically only attended through eighth grade. Very few students continued education through high school and even fewer went on to college.

During the 1900's, students were taught arithmetic (Loveless, 2001). Students were taught enough math skills to be able to buy or sell groceries and purchase land. For the select group of students who did enter into high school, they were taught Algebra and Geometry. The even smaller group of students who went to college were taught trigonometry, analysis, and precalculus. The typical student received the most basic of math instruction needed to function in society. As cities grew larger and industrialism increased, the education system in the United States began to receive scrutiny. World War I and II began to shed a light on the deficiencies in

the math knowledge of Americans as many of the male Army inductees were unable to pass basic math fluency assessments (Permuth & Dalzell, 2013). World War I and II opened the eyes of a lot of women who advocated for changes to the United States education system (Loveless, 2001). Much of the math instruction taught to students was taught in a traditional manner where teachers demonstrated a skill, and then students practiced the skill. There was little room for students to explore math concepts. Students were taught how to do the skill and were to memorize the steps to complete the skill with few abstract connections drawn.

During the 1950's, the United States was in a race to launch into space, and there was a shift in mindset of Americans (Loveless, 2001). Students were expected to compete high school, where they received Algebra 1, Geometry, Algebra 2, and Trigonometry instruction. When the Soviet Union successfully launched SPUTNIK in 1957, experts believed that the United States education system was failing, as the launching was predominantly seen as a science and math effort (Permuth & Dalzell, 2013). During this time, mathematicians were approached to enter into educational leadership roles to help improve math and science programs. In the 1960's, the School Mathematics Study Group began to introduce "new math," which attempted to challenge students, with the focus of putting a man on the moon. This new math was not successful for most students, so instruction returned to the basics where students practiced on pages of manipulation problems. Mastery of math skills was based on performance towards specified outcomes.

The 1980's brought about the National Council of Teachers of Mathematics (Loveless, 2001). This council produced documents providing guidance for teachers to drive math instruction. This organization formed a foundation for change in math curriculum, teaching, and assessment of students. The NCTM strove to shift instruction from teaching only math skills to

teaching students to use math knowledge in order to problem solve. NCTM believed that student thinking and analyzing should be the platform for learning. During this time, there was also a change in the way assessment was used. Instead of using assessment as an end of unit test, the assessments were used to drive instruction and to tailor the learning process to the needs for the students. NCTM reformed math education where curriculum resulted in inquiry, sense making, and problem solving.

The Third International Mathematics and Science Study results were released in 1990, which compared the results of more than half a million participants from forty-one different countries (Permuth & Dalzell, 2013). The participants of this study were in the fourth, eighth, and twelfth grades. The results of this study indicated that fourth graders in the United States were above the international standard in science and math. However, the eighth-grade results indicated barely average results in science and math, and twelfth grade results were well below the international standard in both areas. As a result of these tests, standards-based education became the foundation of the math reform seen today. Instruction started to consist of more concrete material to increase student motivation (Loveless, 2001). Teachers began to scaffold instruction to increase students understanding and content strands began to be integrated.

In the early 2000s, under the Bush Administration, No Child Left behind was initiated. Bush put an emphasis on STEM (science, technology, engineering, and math) education and careers (Permuth & Dalzell, 2013). The federal and state government began to take action and play a bigger role in education, which led to nationwide achievement testing. These tests held students, and teachers, accountable in the areas of science, reading, and mathematics.

In 2009, Common Core was adopted in the United States that attempted to set standards to be met in content areas, including math. The Common Core Standards set for math were an

attempt to address key issues in math proficiency (Permuth & Dalzell, 2013). These standards are still in place today, and forty-two of the fifty states have adopted these standards. In 2013, the National Assessment of Education reported that only 26% of twelfth graders scored at proficient or high in the area of mathematics (Bouck & Park, 2018). In 2015, NAE reported that only 33% of eighth graders reached proficiency or above, 28% were reported as basic, and 29% were well below proficiency in the area of math. Although organizations such as NCTM and the educational standards of Common Core are in place to increase student performance in mathematics and other subject areas, the United States has seen students continue to struggle in the area of mathematics. Therefore other factors that could negatively affect student performance in math must be considered.

Best Practices and Student Attitude Towards Mathematics

Student attitude towards math may be just as important as the mathematical content taught. According to authors Wilkins and Ma (2003), “Researchers and educators have reported that a positive mathematical disposition is an important part of one’s being quantitatively literate” (52). For a person to be quantitatively literate they must possess a functional knowledge of math content, an ability to reason mathematically, recognize that math has a value and impact in society, and a general understanding of the historical development of math. Reports show that student motivation towards mathematics becomes increasingly negative each grade level in middle school and high school. Students who have learning disabilities in mathematics tend to have low confidence in math. These students usually have difficulty with the problem-solving aspect of math and the interventions used with these students is typically working on low skills, such as memorization of multiplication facts and simple equation procedures (Marita & Hord, 2017).

Wilkins and Ma (2003) found that there are certain factors and experiences that can positively or negatively impact a student's attitude towards mathematics. Their research found that providing students with positive experiences towards math in the classroom and home can positively impact student motivation towards math. Students who have teachers who set high expectations for them have been found to have more positive attitudes towards mathematics, as well as placing a higher value on mathematics.

Research has shown that teachers can increase student motivation and attitude towards mathematics by instructing students using research-based practices (Loveless, 2001). Studies show that students cannot learn math by simply listening and imitation. Effective instruction has been found to be instruction in which students construct their own understanding based on new experiences, which provide opportunities for students to increase their intellectual framework where new ideas can be created. Additionally, students are more successful when they see math as a worthwhile endeavor where they are able to make sense of curriculum through exploration, reflection, and discussion. As mentioned earlier, the National Council for Teaching Mathematics has had a major impact on math instruction. The NCTM outlined expectations and standards for best practices for teaching mathematics. These standards include providing students with opportunities for problem solving, communicate mathematics, reason mathematically, and mathematical connections (Maccini & Gagnon, 2000).

Researchers Fung, Tan, and Chen (2018) studied how students' engagement impacted student achievement in math. In their study, they broke engagement down into three areas: affective engagement, behavioral engagement, and cognitive engagement. The researchers characterized affective engagement as student emotions or attitude towards the learning process, and they noted that it is especially important to factor this type of engagement in the math

classroom as math is often perceived as being less enjoyable than other contents. Behavioral engagement refers to students' behavior during class and in school, especially noting if they attend regularly. Finally, cognitive engagement was defined as students' ability to persevere in the math problem solving process and not give up when struggles occurred. This study found that cognitive engagement was the most important factor in student achievement, and that if students were not able to persevere when problems were tough, their level of achievement decreased.

One practice for opening the door to the above outlined experiences is through the use of manipulatives (Satsangi et al., 2016). The use of manipulatives has been found to be highly effective in teaching students with learning disabilities and can be used to accommodate learners who are struggling with particular concepts. Manipulatives are defined by Maccini and Gagnon (2000) as, "concrete objects that students can physically arrange or group to represent an array of mathematical relationships" (p. 8). Manipulatives, such as base ten blocks, fraction strips, geoboards, pattern blocks or algebra tiles, allow students to visualize and physically represent mathematical situations. Manipulatives should be used in three stages: concrete, representational, and abstract. The three stages allow opportunities for students to use the manipulatives, pictorially represent the manipulatives, and lastly use the appropriate abstract math process to solve problems.

Research has also found that calculators can increase achievement and attitude towards math for students who have learning and emotional disabilities that impact their abilities in mathematics (Maccini & Gagnon, 2000). Calculators prove to be an effective tool when students are explicitly taught how to use the calculator to check answers, compute problems, and use the calculators to problem solve. Students who have difficulties with math calculations and fluency can use the calculator to alleviate those difficulties, and it allows them time to focus on the

problem-solving aspect of mathematics. Maccini and Gagnon (2000) found that providing these students with a calculator allows them to spend time making sense of the curriculum and dive deeply into math, which is where students are truly able to understand and retain information, instead of being caught up in the calculations.

Another best practice for mathematics instruction is to activate student's conceptual knowledge of mathematics through real world connections and context (Maccini & Gagnon, 2000). Teachers who embed mathematical problem-solving within real world contexts are able to activate students' prior knowledge, which is effective in students retaining and making sense of the information presented to them. Other best practices that should be incorporated into the math classroom, and across classrooms of other content, include cooperative learning and effective instruction. Cooperative learning allows students to voice their thinking and engage in discussion that can help them make sense of math concepts.

A recent study took a look at the nature of activities performed in math classrooms across the United States (Maccini & Gagnon, 2000). The study found that students in the United States spend 96% of their time in the classroom performing seatwork activities where they are practicing routine procedures and only spent 1% of their time where they were working on problems that required them to problem solve, create new solutions, and engage in activities where they were creating meaning for themselves. Research shows that the type of instruction that is occurring most often in the United States is not effective, so mathematicians and teachers have been working together to fix this mindset. Research shows that teachers who provide students with opportunities to problem solve, make connections to the real world, and build their own meaning see greater retention and achievement than teachers who present information and expect students to mimic the process through practice problems.

Current Research on Manipulatives

Bouck & Park (2018) define manipulatives in mathematics as “concrete objects that can be used to help students understand and solve mathematics problems” (p. 66). Today, manipulative can refer to non-concrete resources as well, such as virtual online manipulatives or apps on a mobile device. However, little research has been done to study the impact of virtual manipulatives versus concrete manipulatives (Satsangi et al., 2016). Larbi & Marvis (2016) found that manipulatives reduce the abstract nature of math. Manipulatives, such as algebra tiles, help learners visualize concepts that may seem abstract, such as the process of distribution. The use of manipulatives as an instructional approach has been endorsed by the National Council of Teachers of Mathematics and is consistently used to support students struggling in math (Bouck & Park, 2018).

The use of manipulatives has been met with resistance from instructors. Kontas (2016) reports that some educators are resistant towards the use of manipulatives because they are unaware of how to use the tools and would require instruction or training on how to properly utilize the manipulatives. Teachers have expressed that they do not have enough time to teach concepts with the use of manipulatives, and they feel that manipulatives can create confusion for students if the manipulatives are not used correctly. Researchers Larbi and Marvis (2016) advised teachers to teach concepts with manipulatives using the concrete, representational, and abstract model (CRA) to ensure that students make the connection between the concrete and symbolic mathematics. Larbi and Marvis warn that if students are not taught to use manipulatives using the CRA model, students may see math as two different worlds: concrete and symbolic.

Manipulatives used in mathematics have limits for application. Most manipulatives are only applicable for certain problems and are not able to be used for all problems (Satsangi et al., 2016). For the most part when using manipulatives, the problems need to contain small numbers because of the availability of the manipulative pieces per student. Educators have also expressed concerns that the manipulative can become time consuming for teachers to set up and may contain multiple plastic parts that can be confusing to put together. Despite the perceived drawbacks, research has found benefits to using manipulatives available in the classroom to help students visualize mathematics (Bouck & Park, 2018). Manipulatives do not need to be items that are specifically designed for the instruction, such as algebra tiles (Larbi & Marvis, 2016). Any object that can provide students with an opportunity to learn hands on and visualize a mathematical concept can be beneficial to different learning styles.

Many researchers have studied the impact of manipulatives on student achievement in mathematics. One study, a meta-analysis studying the effect of manipulatives on students without disabilities in kindergarten through twelfth grade, found that there was a small to moderate impact on students' achievement in mathematics (Bouck & Park, 2018). Researchers found that manipulatives have a positive impact on achievement when used with students who are identified as having a disability and when the CRA model (concrete, representational, abstract) was implemented. The use of manipulatives has shown to have less of an impact when the CRA model is not used. Another study showed a positive impact on teaching students the distributive property through the CRA model and algebra tiles. This study found that students who were taught to distribute using the algebra tiles had a higher level of achievement of the skill, by comparing pre and post test results, than students who were taught to distribute without the use of algebra tiles (Larbi & Marvis, 2016).

Summary

History has defined the way education and the math classroom looks today. Comparison of the United States to other countries has shed a light on deficiencies in the mathematical education of students in the United States, and therefore government implementation of acts such as No Child Left Behind and the Common Core have put an emphasis on standardized testing, resulting in the identification of students as proficient or below proficient with their math skills. With the constant monitoring of students today, researchers have focused on studying best practices for teaching mathematics, including providing opportunities for students to make their own meaning of mathematics, communicate mathematics, and reflect on their learning.

The research reviewed revealed that the traditional way of learning math, by means of direct instruction, memorization and recitation, is not effective. This review also discussed the effective use of math manipulatives to introduce mathematical topics when taught using the concrete, representational, and abstract model. There are many different student learning styles and abilities in the math classroom, and to meet these learner's needs, best practices need to be implemented.

CHAPTER III

METHODS

Purpose

The purpose of this study was to determine whether the use of manipulatives, which include Algebra tiles, improve student performance in Algebra 1 students who have failed Algebra 1 at least one semester.

PARTICIPANTS

The participants of this study are students who attend Anne Arundel County evening high school. The evening high school program is an alternative high school instructional program. Students who did not complete their high school education can earn a high school diploma through this program. Credits that students have already earned in previous schools may be applied toward graduation requirements for obtaining a high school diploma in Maryland. The Spring 2019 Anne Arundel County Evening High consisted of 281 students, 161 males and 120 females. Of the 281 students, 49 students were identified as having a disability and 23 students were English Language Learners. The population of students consisted of White, African American, Hispanic, and Multi-Racial students. The classes offered include the core subjects of English, Math, Social Studies, and Science, as well as the elective courses of Criminal Justice, German, Psychology, and others. Students enrolled in evening high classes who have an Individualized Education Plan receive their accommodations and services during evening high through Special Education resource teachers. Each evening high class meets for 85 minutes, two times a week.

This study was composed of ten students who were enrolled in Anne Arundel County evening high at North County High School and have failed to earn the required Algebra 1 credit.

The two groups of students participated in a pre- and post- test of a targeted skill (multiplying binomials). The first group of students were taught using the targeted skill without the use of Algebra tiles, and the second group of students were taught the targeted skill with the use of manipulative using the concrete, representational, abstract model. The performance of both groups was recorded to determine whether the group receiving the intervention improved significantly more than the group that did not receive the intervention.

The group that received instruction using the Algebra tiles was composed of five students (two male and three female), which included two white/Caucasian students, two Hispanic students, and one multi-racial student. Three of the students in this group receive free or reduced meals, and one of the students has an Individualized Education Plan. The group receiving the instruction of the targeted skill without the use of manipulatives was composed of five students (three male and two female), which included one English Language Learner, one student with an Individualized Education Plan, and two students who receive free or reduced meals. This group was made up of one Hispanic student, two African American students, and two White/Caucasian students.

Instruments

A department-made pre-assessment was given to both groups before any of the students had received instruction on the targeted skills. The purpose of the pre-assessment was to assess any prior knowledge that the students had of the targeted skills. After receiving initial instruction of the skill, both groups completed a county-made independent practice of the skills. For targeted skill 1, students completed a county-made worksheet, and for targeted skill 2, students completed a county made gallery walk. Finally, the students were given a department made post assessment to assess their performance of the targeted skill.

Procedures

Both groups of students took the department-made pre-assessment prior to receiving any instruction on the two targeted skills. The experimental group received the intervention over the course of three weeks (classes occurred two times a week), which included six, ninety-minute sessions. The first session using the manipulatives was spent instructing the students on what each of the tiles represents and practicing teacher guided problems where the students were using the tiles to add and subtract polynomials. During sessions two and three of the intervention, students independently practiced adding and subtracting polynomials by participating in activities that were scaffolded to lead students to independence and less reliance on the physical tiles. These activities included guided practice with teacher, whiteboard practice with a collaborative group, and an independent practice worksheet. By the end of the third session, students were expected to draw out the tiles and solve the problems by writing out the Algebra terms that the tiles represented.

During sessions four and five of the intervention, students within the experimental group received instruction on multiplying binomials using the Algebra tiles and instruction was scaffolded to allow for students to go through the CRA process. Students completed guided practice problems with their teacher, completed a gallery walk of multiplying binomials, and completed an independent decoder activity. By the end of session five, students were expected to be able to solve problems where they were multiplying binomials by writing the abstract Algebra terms that the tiles represented, rather than physically using the tiles. On day six of the intervention, students were given mixed practice of the two targeted skills as a review for their post-assessment. Students had access to the physical tiles, but students were expected to write the

Algebra terms on their paper. Students were given the post assessment of the two targeted skills at the end of session six.

Students in the control group received instruction of the two targeted skills, adding/subtracting polynomials and multiplying binomials, without the use of manipulatives and using the abstract Algebra terms. Students in the control group completed the same practice activities and problems as the students in the experimental group. Students in the control group spent two days receiving instruction and practicing adding and subtracting polynomials, two days receiving instruction and practicing multiplying binomials, and two days practicing mixed review of problems. During the sixth session, students in the control group took the post-assessment.

CHAPTER IV

RESULTS

The purpose of this study was to determine whether the use of manipulatives, which include algebra tiles, improve student performance in Algebra 1 students who have failed Algebra 1 at least one semester.

The pre and post scores on an algebra test for a class taught using manipulatives and a class that did not use manipulatives were analyzed using a t-test for independent groups. The results are presented in Table 1.

Table 1.

Algebra Test Results for Classes Using or Not Using Manipulatives

Test	Manipulatives	Mean	N	Standard Deviation	t	Significance
Pretest	Yes	7.6	5	11.24	1.51	0.17
	No	0.0	5	0.00		
Posttest	Yes	75.2	5	31.87	0.28	0.79
	No	70.0	5	26.16		

The null hypothesis that manipulatives, including algebra tiles, will not improve secondary students' math skills is accepted.

CHAPTER V

DISCUSSION

The purpose of this study was to determine whether the use of manipulatives, which include algebra tiles, improve student performance in Algebra 1 students who have failed Algebra 1 at least one semester.

Results

The results of the experimental group, when compared to the control group, showed no statistically significant differences. On the pretest, the experimental group's mean was 7.6 mean while the control group's was 0.0. On the posttest, the experimental group's mean was 75.2 in comparison to the 70.0 mean of control group.

Implications

Based on the results of this study, students using the manipulatives of algebra tiles had higher test scores than students who did not use manipulatives. The researcher observed that the students in the experimental group were initially resistant to the manipulatives, but the student attitude towards the manipulatives changed once they were able to make the connection between how the tiles were a concrete representation of an abstract skill.

The researcher also observed one student, who often seemed unengaged in instruction, be engaged in instructional when the physical tiles were being used. Of the five students who were in the experimental group, the researcher observed that four of the students seemed to be using and benefitting from the tiles, while one student understood how they worked, but preferred the abstract method as opposed to the concrete method using algebra tiles.

The researcher will continue to use manipulatives, specifically algebra tiles, to introduce and teach abstract topics. Although the use of the tiles did not produce statistically significant

results, the researcher, as well as the Algebra 1 curriculum writers of Anne Arundel County, finds value in the visual and concrete representation that manipulatives provide and will continue to teach certain topics utilizing manipulatives. The researcher observed manipulatives to be beneficial to students who are visual and hands on learners.

Threats to Validity

During this action research, there were some factors that may have created a threat to the validity of this research. One of the threats occurred from the small class sizes. This research consisted of five students in the experimental group and five students in the control group, which may have yielded different results had the groups been bigger.

The composition in the groups also created a threat to the validity of this research. The students within both groups all had previously failed Algebra 1 and consisted of students who were currently enrolled in other math classes, such as Geometry and Algebra 2. Also, based on the results from the pre-test, as well as observations made by the researcher, the experimental group seemed to include students who were higher performing in mathematics compared to the control group.

Another threat to validity that the researcher observed was that the intervention only lasted six classes that spanned over a three-week period with classes only meeting on Mondays and Wednesdays. A study lasting longer than three weeks, with a group that met on a more frequent basis, may be more beneficial for studying whether this intervention was effective. It should also be noted that this study did have some mortality within both groups which resulted in incomplete scores for some students who were originally chosen for one of the two groups.

Comparison of Results to Literature

Although the outcome of this research did not result in statistical significance, the results are consistent with current research. Current literature and studies consider best practices to include using problem-solving mathematical situations embedded within real world contexts, calculators, collaboration, and the CRA model (concrete, representational, abstract) to teach students using manipulatives (Satsangi et al., 2016). During this action research, the researcher observed that hands on manipulatives were beneficial to a majority of students in the class, the tiles were not the best practice for all students, and that another best practice, such as collaboration or real-world contexts, may have been a better strategy for other learners.

The literature used in this study discussed how students' attitude towards mathematics becomes increasingly negative with each grade level in middle school and high school (Wilkins & Ma, 2003). The researcher of this study observed this within the class, especially since the class was made up of students who had previously failed the course. The researcher observed that students within the experimental group, who had a previously negative attitude towards math, appeared to have a more positive attitude towards math once the manipulatives were introduced and used.

Research done through a meta-analysis studying the impact of manipulatives on students without disabilities in kindergarten through twelfth grade found that there was a small to moderate impact on students' achievement in mathematics (Bouck & Park, 2018). This research was consistent with the findings from this study of the specific manipulatives of algebra tiles.

Future Research

If this study was to be conducted once again by the researcher, they would change several aspects of this study. One change that the researcher would make would be to have larger control and experimental groups, as the sample size for this research was very small, and a large size group may yield different results. The researcher would also consider conducting the research in a class that of students in the same grade only enrolled in one math class, as this research study was done within an alternative placement in the evening containing students who were enrolled in multiple math classes.

The researcher would also like to administer the intervention for a longer period of time to gain a better picture of the impact, or lack thereof, of manipulatives within the math classroom. The researcher would like to introduce multiple manipulatives, not just algebra tiles, to study the effects of other manipulatives within the math classroom.

Finally, the researcher would suggest taking a few weeks to get to know students' ability levels and learning styles before creating groups and performing intervention to create groups that are composed of similar learners to create more valid test results.

Conclusion

The results of this study found that manipulatives, specifically algebra tiles, did not have a significant impact on student achievement within an Algebra 1 alternative placement for students who had previously failed the course in regular day school. The experimental group did have better post-test results when compared to the control group; however, the results were not statistically significant. Students who normally were not engaged in mathematics, appeared to be more engaged when hands on manipulatives were used. The researcher concluded that larger groups should be studied for a longer period of time.

References

- Bouck, E. C., & Park, J. (2018). A systematic review of the literature on mathematics manipulatives to support students with disabilities. *Education & Treatment of Children, 41*(1), 65-106. Retrieved from <https://goucher.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=128468305&site=ehost-live&scope=site>
- Fung, F., Tan, C. Y., & Chen, G. (2018). Student engagement and mathematics achievement: Unraveling main and interactive effects. *Psychology in the Schools, 55*(7), 815-831. Retrieved from <https://goucher.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1184102&site=ehost-live&scope=site><http://dx.doi.org/10.1002/pits.22139>
- Kontas, H. (2016). The effect of manipulatives on mathematics achievement and attitudes of secondary school students. *Journal of Education and Learning, 5*(3), 10-20. Retrieved from <https://goucher.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1097429&site=ehost-live&scope=site>
- Larbi, E., & Mavis, O. (2016). The use of manipulatives in mathematics education. *Journal of Education and Practice, 7*(36), 53-61. Retrieved from <https://goucher.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1126428&site=ehost-live&scope=site>

- Loveless, T. (2001). *The great curriculum debate: How should we teach reading and math?* Washington, D.C.: Brookings Institution Press. Retrieved from <https://goucher.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=91926&site=ehost-live&scope=site>
- Maccini, P., & Gagnon, J. C. (2000). Best practices for teaching mathematics to secondary students with special needs. *Focus on Exceptional Children*, 32(5), 1. Retrieved from <https://goucher.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=2955657&site=ehost-live&scope=site>
- Marita, S., & Hord, C. (2017). Review of mathematics interventions for secondary students with learning disabilities. *Learning Disability Quarterly*, 40(1), 29-40.
doi:10.1177/0731948716657495
- Permuth, S., & Dalzell, N. (2013). Driven by history: Mathematics education reform. *International Journal of Educational Reform*, 22(3), 235-251. Retrieved from <https://goucher.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1044766&site=ehost-live&scope=sitehttps://rowman.com/page/IJER>
- Satsangi, R., Bouck, E. C., Taber-Doughty, T., Bofferding, L., & Roberts, C. A. (2016). Comparing the effectiveness of virtual and concrete manipulatives to teach algebra to secondary students with learning disabilities. *Learning Disability Quarterly*, 39(4), 240-253.
doi:10.1177/0731948716649754
- Wilkins, J. L. M., & Ma, X. (2003). Modeling change in student attitude toward and beliefs about mathematics. *Journal of Educational Research*, 97(1), 52-63.
doi:10.1080/00220670309596628