Studying the Effectiveness of Physical Manipulatives on the Math Achievement of 5th Graders

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Abstract

The stereotype exists that males outperform females in math. This stereotype is supported with facts revealing that males outnumber females in careers that employ high level math skills. However, some studies show that at an early age there is no difference in math scores between the two genders. To provide additional evidence for the presence or absence of a gender gap, sixteen fifth grade students from a suburban elementary school were selected to participate in a math intervention program. In this study half of the sixteen students (4 males and 4 females) received math intervention incorporating the use of physical manipulatives in addition to their daily classroom math lesson. Results from the pre- and post-assessments showed that the students who received the intervention had greater improvement and on the average a higher post-assessment score. However, a statistical analysis of these results revealed no significant difference in gender scores. In addition, all the students participating in the study were then given a math interest survey, which examined their belief and interests about continuing their education in math. These survey results showed no significant difference between the males and females.

Introduction

Achievement gaps refer to the inconsistencies in academic performance among different groups of students (Editorial, 2011) with gender, race, and ethnic backgrounds being the target of most studies. These achievement gaps manifest themselves in various educational platforms such as school subjects, grades, dropout rates, standardized test scores, and college completion rates. In order to bridge the achievement gap in a specific group, it is imperative to first identify at what age the gap initially appears. The lower achieving students can then receive additional assistance and/or intervention to boost their academic performance before continuing on to higher grades in school.

In terms of academic performance in math, research shows that by the end of second grade there is little difference between males' and females' performance scores in math (Ngware, et al., 2012). However, by third grade there is a slight difference in math scores with males scoring higher, and these differences can lead to diverse career choices later in life (Gorman, 2006). Students who struggle in math can benefit from interventions targeting math concepts. One such intervention is called Response to Intervention which is a program that identifies potential students who are struggling and require additional assistance through focused interventions (Gersten et al., 2009). This program consists of eight different math recommendations for the intervention, and each is ranked (strong, moderate, and low) based on the research findings regarding their effectiveness (Hinton, 2013). The program goal is to incorporate many of these recommendations into a single intervention in order to boost the academic achievement of the student.

Math achievement gaps have been studied profusely in both the United States and in Europe (Ngware, 2012); however, the research is often debated as to whether these achievement gaps really exist. For example, males perform better than females on standardized math assessments throughout elementary grades (McCormick, 2015). On the other hand, females tend to have an advantage in the classroom possibly related to the high quality relationship females tend to form with their teachers (McCormick, 2015). Ngware (2012) discovered in Kenya that females tend to start school [kindergarten] with a lower math level than males, which is why males continually outperform females. Additional research studies have reaffirmed that there is no difference in average performance of math related assessments between males and females. After studying over seven million students between second grade and eleventh grade, Hyde et al. (2008) found that there is no difference in the standardized test scores between males and females. In addition, no significant gender difference with regards to math skills was seen in grades one through three. In another research study, Azar (2010) argues that the achievement gap is small in younger grades and that the gap only accounts for differences in math performance at higher grade levels. There is insufficient research to draw a conclusion that one gender outperforms the other in math achievement.

The intervention selected for this project incorporates the use of manipulatives. Manipulatives are models that involve mathematical concepts and can be touched and moved around by the learners (Heddens, 2005). Physical manipulatives provide a tactile way of learning for students and are often referred to as hands-on learning. According to Durmus (2006), hands-on learning is more effective for teaching students basic math concepts. The use of these manipulatives provides students with more concrete models of thought in preparation for abstract thinking. The manipulatives (MasterPieces) selected for this study are available from

Teach4Mastery and published in the following curriculum: *Perception: Changing the Way You Think.* They are similar to base-ten blocks, which are commonly used by elementary teachers to teach basic operations. In order for the physical manipulatives to be successful, each student needs the opportunity to learn the numerical value of each block and practice manipulating them.

Hypothesis 1

In comparing the post-assessment math scores of the students participating in the study, there will be a higher average post-assessment math score for those students who receive the intervention as compared to those students who do not receive the intervention.

Hypothesis 2

In comparing the post-assessment math scores of female and male students participating in the study, there will no significant difference between the average post-assessment math score for males as compared to the average post-assessment math score for females.

Hypothesis 3

The math interest survey will show that there is no difference between the future goals of males and females regarding their plans for obtaining a higher education in math.

Method

Participants

Sixteen students (9 females and 7 males) were recruited from a single 5th grade classroom in a suburban school district as participants for this study. Parent permission forms along with student assent forms were collected from all sixteen students and their parents prior to the start of the study. Permission forms from the 5th grade teacher as well from the principal were also collected before starting the study. Eight students were identified (4 females and 4 males) for the intervention (experimental) group based on their performance scores from the math portion of

the *Smarter Balance Test* (Missouri State Assessment Program), which was administered in the spring of 2015. The remaining eight students (5 females and 3 males) made up the control group and received no intervention.

Procedure and Measures

Sixteen students from a 5th grade classroom were selected to participate in this study. Eight of the sixteen students received the intervention and were part of the experimental group. These students were identified based on their performance from the math portion of the *Smarter Balance Test* (Missouri Stats Assessment Program) administered in the spring of 2015 along with teacher recommendations. The remaining eight students did not receive the intervention and served as the control group. The *KeyMath Diagnostic Assessment, Form A*, was administered as a pre-assessment to all sixteen students in the 5th grade classroom to acquire a baseline score for each student. This test is administered individually to measure a student's understanding of math related concepts and their applications. There are three general math content areas, but only the section on operations was used in this study. The results of the *KeyMath* assessment identified potential weaknesses in any of the following areas: basic concepts, operations, and applications. Once weaknesses in basic operations, specifically division, were identified, an intervention was implemented for four weeks (seven total lessons), two to three times a week. The intervention was taught using the *Perceptions: Changing The Way You Look At Math* for basic operations in division. The curriculum is normally arranged to cover sixteen-weeks. The intervention focused on a specific math topic area (division) and used physical manipulatives to aid in teaching the eight students. Lesson-by-lesson video instructions along with the physical manipulatives (MasterPieces) were used to train each student on their proper usage. At the end of the intervention period (four weeks, seven lessons), the sixteen

students were given a post-assessment using the *KeyMath Diagnostic Assessment, Form B,* to evaluate the efficacy of the intervention and determine if the intervention had a significant effect on the students' math achievement.

A math interest survey, which examined personal beliefs, personal interests, and situational interests was distributed to the students after completing the post-assessment to examine student's perceptions of math and their thoughts about taking any future math classes. Examples of the personal belief survey questions include “How good are you in math?” and “How have you been doing in math this year?” These questions were on a five-point Likert scale with 1 indicating very bad and 5 indicating very good. Examples of the personal interest survey questions include “Math is enjoyable to me” and “I think math is exciting”. These questions were on a five-point Likert scale with 1 indicating strongly disagree and 5 indicating strongly agree. Examples of the situational interest survey questions included “I look forward to math class” and “I like math this year”. These questions were also on a five-point Likert scale with 1 indicating strongly disagree and 5 indicating strongly agree.

Results

Pre-Assessment and Post-Assessment Results

A paired samples t-test was conducted to determine whether students’ pre-assessments or post-assessments had higher scores. Results revealed that from the pre-assessment (M= 8.25; SD= 1.69) to the post-assessment (M= 11.00; SD= 2.53), $t(15)$= 4.20, p= .001 scores significantly increased for all 16 students. Another paired samples t-test was conducted to examine the differences between the pre-assessment and post-assessment scores for just the intervention group. Results from comparing the pre-assessment (M= 7.38; SD= 1.41) to post-

assessment (*M*= 11.75; *SD*= 2.49), *t*(7)= 5.19, *p*= .001 revealed that scores from the intervention group increased significantly.

Figure 1 shows the difference in the overall growth from pre-assessment to post-assessment between the intervention and control group. The scores from both groups increased when comparing the pre-assessment to the post-assessment; however, the scores from the intervention group increased significantly higher than the control group's score.

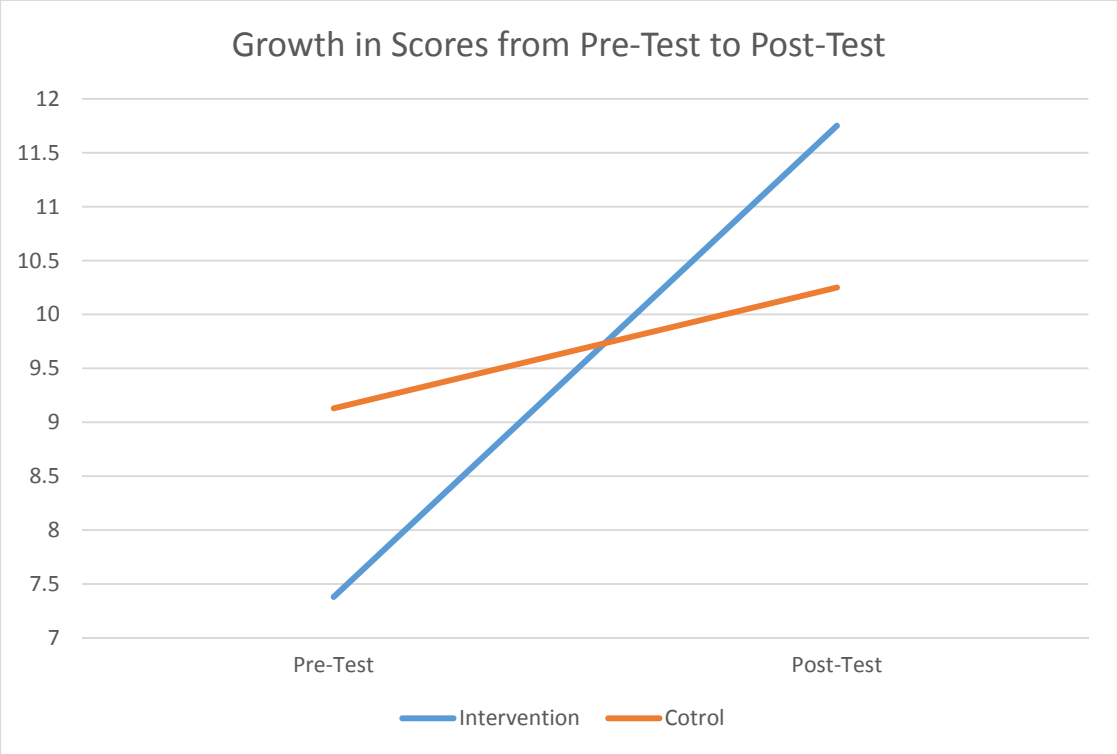

Figure 1

A mixed ANOVA was conducted to assess whether there were overall gender differences between pre-assessment and post-assessment scores, however, there were no significant difference. This supports previous research studies that a gender gap does not exist.

Math Interest Survey Results

Cronbach alphas were run on all three sections of the math interest survey (personal beliefs, personal interests and situational interest) and were all about the excepted .7 value (.7,

.88, and .7 respectively) proving the math interest surveys were reliable. The overall Cronbach alpha was .88. An independent samples t-test was conducted to examine whether males or females differed on their personal beliefs and future math plans. The results revealed that no significant difference was evident between males and females. This suggests that gender differences regarding future math plans do not start as early as 5th grade and perhaps begin in a later grade such as junior high school or high school.

Discussion

The present study intended to examine the efficacy of a math intervention using physical manipulatives on fifth grade students and to disprove the gender stereotype that males outperform females in math. The first hypothesis predicted that average post-assessment math scores for students who receive the math intervention will be significantly greater when compared to average post-assessment math scores for students who do not receive the intervention. The second hypothesis predicted that there will be no significant difference between the average post-assessment math scores of male students and the average post-assessment math scores of female students. Lastly, the third hypothesis predicted that the math interest survey will show no difference between the future goals of males and females regarding their plans for obtaining a higher education in math. The results of the study supported all three hypotheses. The mean post-assessment math scores for the students, who were in the intervention group, had greater significance than the mean post-assessment math scores for the students, who were in the control group. In addition, there were no significant differences between pre-assessment and post-assessment scores of males and females. The results from the interest survey indicated that math interest between males and females do not differ in 5th grade.

A noted strength of the study is that the intervention provided additional math instruction for the students, especially those struggling in math. The intervention provided a tactile, hands on mode of learning in addition to the visual mode of learning taught by the teacher in the classroom. The math curriculum, *Perceptions: Changing the Way You Look at Math,* is fairly new; it was introduced in 2014, yet the results from this study reaffirm previous research studies that physical manipulatives are excellent tools for increasing the math achievement of struggling students and should be use more often in schools. Lastly, the reliability of the combined interest surveys has strong reliability coefficients and were developed in the mid-1990s and have been used extensively in education.

There are many strengths as a result of this study, yet it is important to acknowledge that there are limitations. One notable limitation involved the brevity of the study. Originally, the researcher intended to conduct the study over eight weeks and implementing 15 lessons. The researcher was only able to implement seven lessons over the course of four weeks. It would be beneficial for future studies to implement the intervention for a minimum of 18 weeks, which is equivalent to one semester. In addition, future research involving physical manipulatives should include all basic operations including addition, subtraction, multiplication, and division, not just division, which was the focus of this study. Next, there were issues with external validity because the results could only be generalized to suburban elementary school in the St. Louis area. Future studies should work with an entire grade level, not just one classroom. It would be beneficial to compare the performance of students in other elementary schools or in different grade levels. Future research studies should explore the use of manipulatives earlier in grade schools so students are already familiar with using the manipulatives prior to the start of any study. Virtual manipulatives are available in conjunction with the physical manipulatives.

Future research studies should focus on using virtual manipulatives to augment the use of physical manipulatives, which validates the concrete-representational-abstract technique for teaching math concepts. Lastly, students participating in the study exhibited a short attention span. This was an issue when administering the pre-and post-assessments, which may have altered the baseline scores resulting in not capturing their full potential on the assessments.

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Appendices

Children's Belief About Math Ability Questions

		1=very bad				5= very good
1.	How good are you in math?	1	2	3	4	5
2.	How have you been doing in math this year?	1	2	3	4	5
3.	How hard do you try in math?	1	2	3	4	5
4.	How important is it for you to do well in math?	1	2	3	4	5
5.	Would you take more math if you did not have to?	1	2	3	4	5
	Personal Interest	1= strongly disagree				5=strongly agree
6.	Math is enjoyable to me	1	2	3	4	5
7.	I have always enjoyed studying math in school	1	2	3	4	5
8.	I think math is relaxing	1	2	3	4	5
9.	I think math is exciting	1	2	3	4	5
	Situational Interest	1= strongly disagree				5=strongly agree
10.	Our class is fun	1	2	3	4	5
11.	I look forward to math class	1	2	3	4	5
12.	Our class is dull	1	2	3	4	5
13.	I like math this year	1	2	3	4	5
14.	I don't find anything interesting about math	1	2	3	4	5
15.	My other classes are more interesting that math	1	2	3	4	5

Demographics

Gender: Male_____ Female_____

How old are you? _____

Ethnicity/Race (Please circle): White Black or African American Other