

USING MANIPULATIVES TO SUPPORT MATHEMATICAL CONCEPT
UNDERSTANDING AND SKILL IMPROVEMENT IN SIXTH GRADE STUDENTS

A Research Paper Submitted
in Partial Fulfillment of the Requirement
for EDMA 5683

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Masters in Teaching Program
July 2013

Abstract

Using Manipulatives To Support Mathematical Concept Understanding And Skill Improvement In Sixth Grade Students

This action research report investigates the question of whether the targeted use of manipulatives with small groups of sixth grade students, who are struggling with math, will improve their skill and understanding. A second point of study is whether the intervention will be most effective with girls or boys. The study took place at a private elementary school with sixth grade students from two single-gender math classes. The groups were given a pretest at the start of the study, followed by four 20 – 25 minute targeted manipulative concept support sessions, a posttest, and a survey to complete about their experience. The tests were scored and evaluated by comparing group test score means by gender groups and a means comparison of pretest and posttest scores. The girls' group scored consistently better on the tests than the boys' group, though all of the students improved from their pretest scores to posttest scores. Because there was no control group, the students were drawn from a convenience sample of students struggling in math, and the number of students in the study were small (11 total), the results of this study are not transferable to other populations. Small numbers in the study also make any statistical analyses results suspect. However, this study appears to have been effective in supporting the learning needs of a specific population. The girls in the study expressed that being in a single gender group was beneficial to their experience. The boys indicated working in an all male group was helpful, but working with students who were focused and supportive would be more important than gender.

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Introduction

Initially this research was intended to be a study in single gender education. How is single-gender learning perceived by students, their parents and teachers? Do they feel it has been helpful and what are the benefits they have noticed? The opportunity while student teaching to work with students who experienced single gender education, at least in the core subject of mathematics, gave rise to the interest in studying this dynamic more closely. The lead teachers were on board and interested in the outcomes of research on this topic as well. However, potential redirection in future school program focus changed administrative interest in the topic as time to begin drew near. Attention being focused on the current program was discouraged, which meant parent and student interviews on this subject was discouraged. After consultation with the teachers and principal, a solution was presented. Male and female small groups would be formed as part of a math study focused on helping struggling students, thus their single-gender experience could be noted and discussed as an element of their math learning. The new main focus would be on the use of math manipulatives to aid and strengthen concept understanding in sixth grade students, who are also working in single gender groups. No interviews would be conducted, but surveys and testing could be used with these students.

According to Boggan, Harper and Whitmire (2010), “when students manipulate objects, they are taking the first steps toward understanding math processes and procedures,” (p.4). The authors also state, “educational research indicates that the most valuable learning occurs when students actively construct their own mathematical understanding, which is often accomplished through the use of manipulatives,” (p.2). It was with this understanding in mind that the sixth grade teaching team agreed on a study

with two small, single gender groups to determine if guided interaction with manipulatives would increase concept connection and math performance for these students.

Literature Review

Gender Research Done Before No-Child-Left-Behind Legislation

Klebosits and Perrone (1998) studied “the effects of like-gender grouping versus random grouping” in discussions and for projects “on students’ academic performance” (p.1). The target subjects were junior high math and high school Spanish in two middle-class schools located in suburban districts of a large city. One class of each subject worked cooperatively in single-gender groupings, and the other class of each subject worked in mixed-gender groupings. Students filled out a survey after each group project, were evaluated on their group interactions by their teacher, and tracked by project grades. Klebosits and Perrone (1998) found that, though single-gender groupings were the most cooperative and successful in their projects, all of the students benefitted by the group projects through increased social skills, task delegation, participation, shared effort and interpersonal communication.

C. Chmelynski’s (1998) reported on financial grants offered by the Superintendent of Public Instruction to get single-gender education started in California in the late ‘90s. The concept struck a chord with many communities that saw the opportunity to increase confidence and self-esteem in their children, as well as improve focus on the academic needs of struggling students with targeted instruction. State officials hoped to encourage students to pursue college. Separate single-sex academies

and subject area gender splits were established in several cities. Single-gender programs and schools were provided with the exact same instructional equipment, curriculum and supplies provided and enrollment was voluntary to avoid accusations of gender inequality by the ACLU. Despite the successes, the program had to stop after a few years due to discontinued state funding.

Dorothy Valcarcel Craig's research, "A League of Their Own: Gender, Technology, and Instructional Practices" (1999), noted that girls' perception of their ability to perform well in science, math and technology is heavily influenced by culture – through media, their family, friends and teacher interactions – rather than by intelligence. In her study Craig (1999) studied 52 girls, 5th through 8th grade, in single-gender groupings during a two-week math, science and computer camp. She gathered information using surveys from before and after the camp as well as videos of the teachers and students during computer projects to track behaviors and changes. The author noted that, according to what they expressed in the closing survey, the girls' belief in their ability as females to succeed in math, science and technology significantly improved from the initial survey responses. She noted that much of the attitudes of the students correlated to how the camp teachers treated them, as evidenced on the video recordings. Some teachers encouraged the girls to do their own projects with support when requested, some did the projects for the girls and gave them minor tasks to do instead, while the remainder dictated the girl's every move to complete the projects. Craig (1999) concluded that, though girls grew more confident about their abilities in a single-gender setting, teacher behavior and instruction played an even greater part in the girl's attitudes.

In her article, "Research on Same-Gender Grouping in Eighth Grade Science Classrooms" (2006), Jennifer Friend did research in the Midwestern public middle school where she was the principal. Some problems that led to her doing the research included (a) a gap between males and females on achievement testing in science; (b) the preponderance of males seeking careers in science over females relative to the equal numbers of the genders in the general work force; (c) concern that males appeared to be becoming the disadvantaged gender in current school dynamics while; (d) the numbers of male students interested in science were on the decline. The author postulated that in order to lessen the gender gap in the field of science, the female students would need increased confidence in their ability in science classes while the male students would need reengagement in interest regarding science as a subject. The mixed-methods study lasted one school year. Data collected included control and subject classroom test scores, student questionnaires, observations and teacher interviews. All of the classes used the same instruction material and format. The teachers received no specific training. One male teacher taught both the mixed and same-gender boys classes while one female teacher taught the mixed and same-gender girls classes. The results of the research were that the differences in the achievement and behavior between the same-gender classes and the mixed-gender classes were not statistically significant. The researcher concluded that separate gender classes alone would not solve the problems due to the unrealized gender biases of students, parents and teachers. Instructional training, development of curriculum targeted to the learning needs of each gender and establishing social parity would be essential to single-gender education that avoids perpetuating inequality.

“Until the late 19th century, education in the United States was single-sex education” (Vincent A. Anfara, Jr & Steven B. Mertens, 2008). Anfara and Mertens (2008) present philosophical research on the history of gender as it relates to education, including that public coeducation began not far from the start of the 20th century due mainly to economic reasons. It was cheaper to combine students into mixed groups rather than supply two sets of buildings, teachers, furniture, books, supplies, and so forth. Single gender schools did continue on a smaller scale, but only in private school settings (Anfara & Mertens, 2008). Equal federal funding for all public education was mandated through Title IX in 1972. Public opinion began to believe in the essential socialization between genders in school to promote harmony between the sexes, citing a necessary balancing effect boys and girls had on one another. Most of the research on single-gender versus coeducational education has been conducted in other countries up to that point. Anfara and Mertens (2008) noted that there is compelling evidence on both sides of the issue. The coeducational experience can be distracting for young people more interested in dating, athletics and social clubs. Academics can be deemed as less important of a priority in the lives of children and youth. Still, single-gender educational research can be said to lack strong validity due to the lack of balance in the type of families and students that choose those programs, namely the more academically serious people who can afford the private schools that offer the option. The authors conclude that the learning interventions and adaptations used by successful single-gender programs could be used to equally good effect in improving mixed-gender schooling. This would include reduction in student to teacher ratios, creative lesson planning, instructional support and active parent involvement.

According to authors Nancy Smirl Jorgensen and Catherine Pfeiler (2008), sometimes the transition to single-gender programs starts out on a small scale to meet a specific need and expands later. In Germantown, Wisconsin, Kennedy Middle School started an all-male gender program to rebuild academics and student engagement due to problems with boys acting out inappropriately and achieving poor reading test results. The school continued to have mixed-gender classes as well, with the single-gender reading and social studies classes as options. Other schools in the area cautiously began single-gender programs to specifically meet needs of struggling students, following research by Leonard Sax's brain research. Jorgensen & Pfeiler (2008), high school music teachers, wanted to help boys interested in choir to get the training and support they need. The school already had an all girls choir, due to the larger number of girls in music, and started a class for freshman and sophomore boys to learn the basics of music that were difficult for them to follow in a mixed choir. The program was successful, partly due to older boys in the program mentoring the younger ones and partly due to focus in the class on their specific areas of weakness to grow their skill. The male and female choirs often sang together for events as well. The first year started with 39 boys in the Baritone Chorale. The second year numbers jumped to 90 boys joining the choir class. The success of the choir program inspired the school to initiate single-gender biology and English classes, which were similarly popular, while still maintaining coeducational class options for those who preferred them. Jorgensen & Pfeiler (2008), saw the positive effects in the areas of leadership, lack of embarrassment, improved focus and willingness to engage that was fostered by the single-gender choices for student learning – not as exclusion but in encouraging students take ownership of their learning.

Francis R. Spielhagen's research article, "It All depends...": Middle School Teachers Evaluate Single-Sex Classes (2011), "explored the effectiveness of single-sex class arrangements according to the key stakeholders in this educational reform - the teachers who were assigned or hired to teach in these classes and schools" (Spielhagen 2011). In it he gave a history of Title IX legislature enacted to end race and gender inequalities and the subsequent NCLB policy which opened the door again to single-gender instruction. Many believed single-gender education held promise for improved student success by targeting specific learning styles. The research focused on an urban school district whose administration proposed to rework one failing school into two single-gender programs. Students from the original school could choose to stay, while teachers were hired specifically for male or female only classrooms. The first teachers hired were provided initial training. These teachers were excited about the potential for the student improvement they anticipated. Though there were many positive results from the project, the lack of ongoing training and support for the teachers in this new format of teaching led to diminished teacher satisfaction by year's end. District administration did not understand the different needs of the single-sex classrooms and demanded district wide instructional conformity, as opposed to covering the same curriculum with tailored methods. Despite the problems, teachers saw improvement in student participation and focus on learning. They felt the option of single-gender classrooms should remain open for parents to choose for their children.

In 2009 South Carolina was leading the country in single-gender education and doing it very well. According to J. Rex and D. Chadwell (2009), "Public schools are offering more choices because educators increasingly have come to believe that a broader

instructional menu brings positive results for everyone involved” (p.28). The very successful program in South Carolina was due primarily to the state hiring a full time coordinator, whose was available to do training, design programs, help get school planning started, be a support, find the answers, and whatever else was needed to maintain quality programs. The whole procedure, from evaluation of need to implementation of program, was streamlined to provide the optimal program and training to meet student needs. Parents, principals, teachers and administrators worked together to meet student needs. The level of support and helpful infrastructure in place impressed those who came from other states to observe their program and attend training to take back and share. In 2009 Rex and Chadwell’s data showed drops in discipline referrals, decreased instance of failing students and increases in stated assessment scores. In addition, 76% of parents were satisfied with their school’s program and stated they had observed improvements in their child’s confidence and abilities. The three key success factors were: supportive teacher training, careful analysis of student learning needs and helping parents with the information they needed to make decisions for their child’s education.

Gender Differences and Brain Anatomy

An important consideration in determining the educational needs of boy and girls can be found in brain research. Virginia Bonomo (2010), researched the order and magnitude of brain development in males and females. She highlighted some interesting findings that could give guidance to teachers in best methods of education for each gender. Bonomo (2010) noted that the male brain tends to be larger and generally more developed in the spatial and mathematical reasoning area. She also stated that female

brains show more cross-brain connections and develop the side of the brain responsible for language and skills for writing before boys do, so they generally have a head start on communication (p 257). Boys tend to develop better gross motor control first, while girls usually have earlier fine motor skills. Boys are drawn to watch movement and tend to visually prefer colors such as blues, blacks and grays while girls like to look at faces and often prefer warmer colors because of differences in vision translation structures, (Bonomo, 2010, p. 259). According to this author, girls and boys experience the world differently from temperature to hearing, listening skills and reactions to stress. Awareness of brain process differences of boys and girls may more effectively guide teachers in classroom environment and presentation that could enhance student learning in single or mixed gender classes.

K, Piechura-Couture, E. Heins, & M. Tichenor (2011), in their research article about the over-representation of boys in special education, also discussed the brain differences of boys from girls and how their responses to stimulus can lead to inappropriate behavior for a classroom setting. If an entire class has the same gender make up, then it would be more likely to be welcoming and conducive to that gender's learning. Often boys are penalized for their outbursts and lack of focus, but those may be more related to processing than behavior. Girls can get caught up in relational chatting or bickering and lose focus on the lesson, but both genders can also pull together and support the community of learners. Offering separate classes for students by gender, in all or only some subjects, can help schools accommodate student needs while helping boys and girls learn effectively in community.

Shifting Focus: Literature on the Use of Math Manipulatives

What are Manipulatives? Before discussing the literature on the use of math manipulatives, first the term should be defined. According to Lira and Ezeife:

Concrete materials, or manipulatives as they are commonly referred to in math literature, are defined as “objects designed to represent explicitly and concretely mathematical ideas that are abstract. They have both visual and tactile appeal and can be manipulated by learners through hands-on experiences” (Moyer, 2001, p. 176). Some examples of these materials include tangrams, base ten blocks, algebra tiles, connecting cubes, pattern blocks, playing cards, etc. Teachers use them to teach abstract mathematical concepts that ordinarily may be difficult for students, such as adding and subtracting integers, solving equations, and determining the value of fractions. (Lira, J., & Ezeife, A. N., 2008, p. 2).

In recent years, the category of manipulatives has expanded to include interactive digital representations as well now that computers and interactive whiteboards are available for use in many schools. Lira and Ezeife explain that though many educators use manipulatives mainly with primary students as learning support during their concrete operational stage of learning, intermediate students have often not all transitioned to formal operational thinking. These students continue to benefit from instructional support with manipulatives to make the concepts of increasingly abstract math more meaningful (2008, p. 3). Moyer (2001) agrees that “students’ abstract thinking is closely anchored in their concrete perceptions of the world; actively manipulating these materials allows learners to develop a repertoire of images that can be used in the mental manipulation of abstract concepts” (p. 176).” Sixth grade students who are struggling with math may indeed still be transitioning in their thought processes and need concrete concept anchors

for the abstracts of fractional math.

According to D'Angelo and Iliev (2012), "Students should have as many hands-on interactions with manipulatives as possible since the use of manipulatives enables students to clarify mathematical concepts" (p.2). These authors trace the use of physical items used for the purpose and support of mathematics through history. People have used clay tablets, sand in stone trays, knotted cords, and abacuses in the past. In the mid 1800s Friedrich Froebel, and in the early 1900s Maria Montessori, envisioned tools to help children learn abstract mathematical concepts. Similar items are available to make the abstract ideas of math more approachable today. The use of items to aid in counting has progressed with time to the many and various representations of today that help people to visualize the concepts behind the abstract symbols of mathematics, including concrete and virtual manipulatives. D'Angelo and Iliev believe that "all students at any age will benefit from the use of manipulatives especially English Language Learners, low ability students, students with learning disabilities, etc.," (2012, p. 3). However, the items themselves will not impart the necessary understanding without instructional understanding, support and guidance in using the manipulatives for targeted objectives.

A strong and persistent thread throughout many of the articles indicates manipulatives have to be used purposefully and with understanding in teaching. Boggan et al. believe, "incorporating manipulatives into mathematics lessons in meaningful ways helps students grasp concepts with greater ease, making teaching most effective," (2010, p. 5), and "studies also suggest that manipulatives improve children's long-term and short-term retention of math" (p. 4). However, the manipulatives chosen must be appropriate for the age and abilities of the students using them while care should be taken

to insure items used lead to meeting the learning objective, according to Boggan et al. (2010, p. 3).

What the teacher thinks about manipulatives and their use makes a difference in student willingness to use them. “Students pick up on what teachers verbal and body language tells them very quickly, particularly when it effects overall self-esteem and confidence” (Kelly, 2006, p. 191). According to Kelly, “If teachers send messages to students that “only less able students need manipulatives” or “you don’t need those anymore, do you?” students will begin to devalue and stop using manipulatives, reducing their own chances for success in mathematics overall,” (Kelly, 2006, p. 191). The author believes that students will prefer to use what is most helpful to aid their understanding of math concepts as long as they are encouraged to do so. Teachers should use manipulatives to instruct their students if those tools are effective to promote understanding. The age of students using them should not be a factor as long as the tools work to promote concept understanding, because all ages can benefit from using manipulatives. Problem solving in daily life often involves the use of tools – telephones, thermometers, measuring devices, utensils, etc. – therefore, mathematics instruction should include tools as well, along with the steps for using them to solve problems. “Helping students make connections and see real-world learning applications is essential in creating and instilling the desire for life-long learning” (Kelly, 1999, p. 3). Kelly insists that using math manipulatives as tools encourages problem solver mentality in children and builds confidence over time (2006, p. 187).

“Not all teachers use manipulatives, and those who use these tools do not necessarily use them the same way. How teachers design their classroom activities

involving manipulatives will ultimately affect the success of their use on student understanding” (Uribe-Flórez & Wilkins, 2010, p.364). Uribe-Flórez and Wilkins (2010) investigated how manipulatives were used in elementary classrooms and what relationship a teacher’s background, grade levels taught and beliefs about the effectiveness of manipulatives had to their instructional habits. Similar to other researchers, they found that manipulatives were used most often in the primary grades and declined in frequency moving toward the upper grades. However, experienced teachers used them more often than teachers with less experience. Teachers they studied who used manipulatives to teach math had students who were performing in the top 15% of math students in their schools.

Manipulatives need not be expensive or fancy to be effective. The article “Playdough Math” (Caswell, 2007) explains a manipulative exploration and learning that centers on the use of dough circles and working with fractional pieces of dough. The tangible nature of Playdough makes the abstract concepts of fractional manipulations visible, the texture and colors make it interesting to students, and the ease of use makes it accessible to use for investigation. Playdough is also easy to reuse and store for using in multiple lessons. “Once the solution (of a particular equation) is gained, the challenge starts (among the students) to create a diverse range of improper fractions and mixed numbers using play dough. Any shapes can be represented and students frequently move around the classroom to view each other’s ideas and share their own thinking” (Caswell, 2007, p. 15). Thus, once again, encouraged and guided use of a hands-on tool over time led to creative and confident problem solving in students. As Kelly stated, “Teachers may want to vary the delivery of mathematics to include inquiry, inquisitiveness and

questioning, communication, real-world application and value in the child's world" (Kelly, 1999, p. 12).

The use of concrete representational tools, called manipulatives, for supporting mathematical conceptual understanding has a long history in education. They have been and are used most often with younger students who have less abstract concept understanding. However, they continue to be helpful to students of all ages when used with purpose. Manipuatives on their own do not educate, teacher direction and guidance are necessary to reach the learning objectives, but the tactile interaction with the objects engages the brain more than listening and observing alone. The teacher's comfort with, understanding of, and training in the use of math manipulatives makes a difference in how often they are used in a classroom and how effectively for student learning. As they grow older, boys and girls are often distracted by the other gender. Boys try to impress the girls, girls fear appearing too smart or looking foolish to the boys. Single-gender, small group instruction may be most effective for instructional support of students struggling with math, particularly when combined with math manipulatives to focus on specific concepts.

Research Questions

Does targeted use of manipulatives support mathematical concept understanding and skill improvement in sixth grade students? Secondly, if change was perceived, was the change more pronounced in one gender over the other? Would the use of manipulatives as math skill support, in single gender study experiences, be viewed positively or negatively by the students involved? Can working with manipulatives make math concepts that students perceived as abstract more clear and usable?

Methodology

Method and Rationale

This was a qualitative case study with limited quantitative data. The method was appropriate due to the limited time given for the intervention and gathering of data, as well as the small size of the two participant groups. Data collected from this study was too small to infer results to other populations, as quantitative analysis would not be reliable at this scale. Much of the data gathered relating to gender experiences was in the form of a survey, thus lending itself to qualitative analysis. Students were assigned letter and number designations for privacy, G for girl and B for boy followed by a number 1-6. They retained these designations throughout the study. The results of this study were intended as action research to track change only in this specific population for the purposes of noting their potential improvement.

Sample

This study was drawn from a convenience sample of twelve students in two groups that were identified by their teacher as struggling in math skills. There was no random sampling or control group, and the number of participants was too small to infer findings to any other populations. However, it was the grouping assigned to me and helpful on a classroom scale to test methods of helping a particular population of students. The two groups of sixth grade students in this case study were one of six boys and one of six girls. Both of the groups were from regular math classes that met separately due to the sixth grade math classes all being single-gender specific, and at different times. This gave opportunity to examine perceptions from a gender viewpoint as well as a math support point of view.

Instrumentation

Students in the two groups were given a twelve question pre-test at the start of the study to establish their current understanding level in dealing with fractions and decimals. Each of the two groups received four sessions of focused concept reinforcement of fractions and decimals using manipulatives: dominoes, unifix cubes, real world pictures where these concepts were used, fraction pieces, geoboards, and calculators. At the end of the fourth session they took a posttest of the same number of problems, and of similar questions, as the pre-test. Both tests were created based on similar problems the students had struggled with in class and can be found in the appendices as A1 and A2. Students were then given a survey of six questions to complete and return to the researcher for evaluation of their experiences and feelings about them. As four sessions of 20 to 25 minutes were all that was allowed for this study, it seemed that two tests, narrowly focused topic support, and a survey were all that could be reasonably done. Neither students nor parents were permitted by the school to be interviewed for this study. The number of students allowed to participate in the study was predetermined as well.

Analysis/Validity

The tests were graded, pre and posttest means were figured, and the scores evaluated. The data for all participants were graphed by comparison of test scores by individual, by the group as a whole and by gender groups for both the pretest and the posttest. Although t-tests to check for significance were run on the test data, the high risk of a Type 1 error due to the very small group sample made the results unreliable so they were not used. The data were evaluated again by comparing scores and means on the

pretest to the same on the posttest, then using that information to establish points and percentages of difference.

The pretest and posttests used, along with full survey responses, are included in the appendices while the questions and condensed responses to the survey are included in the data section of this paper. The questions on the tests were based off concepts the students had found challenging in the sixth grade Saxon Math 7/6 (2004) curriculum. The tests were collected and graded by the researcher following their administration. Students completed a survey after the final test. Eleven of them were returned to the researcher within a few days for analysis. One participant, B4, was absent for both the pre and posttests and did not do the survey. That is why there were only eleven students counted in the results. He did participate in two of the sessions, however.

All tests and surveys were labeled with assigned letter and number designations rather than names to protect the students' identities and to minimize researcher bias when scoring tests. For the survey, the responses were grouped by question and sub-grouped by gender to compare for evaluation. The pre and post-tests were only twelve questions long each, but for all of the students to complete each of the tests would take most of the time for two of the four sessions. Instead, they were given twelve minutes for each test and asked to answer as many as they could, in whatever order they chose within the time. The rest of the time in the four sessions was spent focused on fraction and decimal understanding using manipulatives as physical and visual representations.

Threats to validity for this study were: lack of a control group, very small study group number (eleven students total), no pre-study data on students, outside sources that may have contributed or been the cause of improvement (such as parents, tutors, and

daily math classes), and a convenience sample. Also, the improvement on the posttest may have been due to its similarity to the pretest. Researcher bias: belief that manipulatives make math more understandable to everyone. To combat this bias, paper and pencils for writing out equations was provided at all sessions for students who preferred to work equations with them. Another bias of the researcher was an expectation for single-gender groups to be a more positive and helpful learning environment, and that students would prefer it. Mitigation of this bias was planned for by specifically not talking about that element with the students, except for on one question in the survey, so as to not unduly influence their feelings.

Data analysis includes comparisons of pretest and posttest scores for change by individuals, whole groups, and by gender. Data was evaluated to determine whether changes were significant from pretest to posttest, and by student perceptions of their experience as expressed on their surveys.

Data

The following graph figure shows the distribution of individual test scores for students involved in the study – first from the pretest and secondly from the posttest – to establish changes possibly attributable to intervention strategies conducted between the tests.

Figure 1

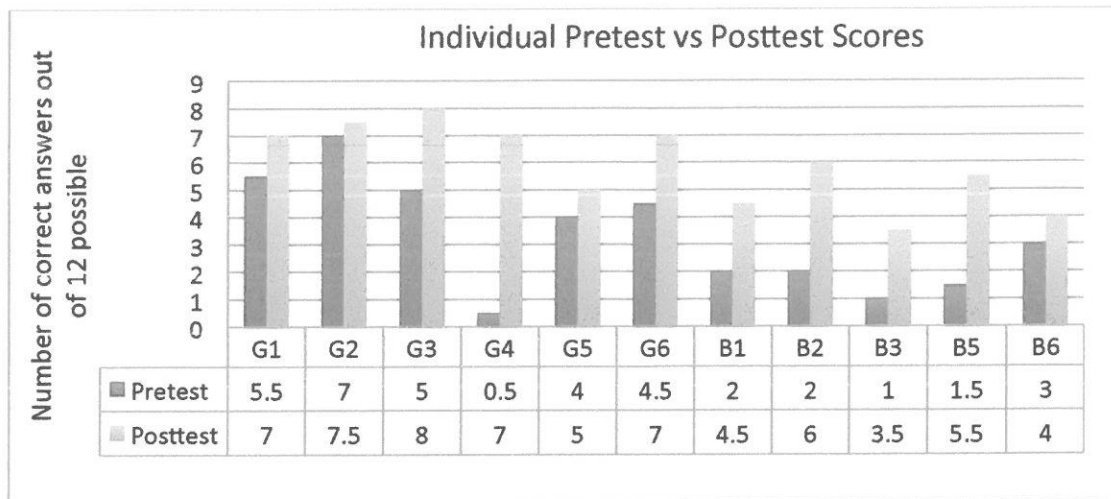


Table 1 shows the total number of students who took the tests, the total group mean scores of the pretest and posttest, and indicates the mean difference of these scores. Table 2 breaks the data down further to compare test mean scores by gender groups. Figure 2 is a more visual comparison of how the mean test scores change from pretest to posttest by gender group.

Table 1

Comparison Of Total Means By Test

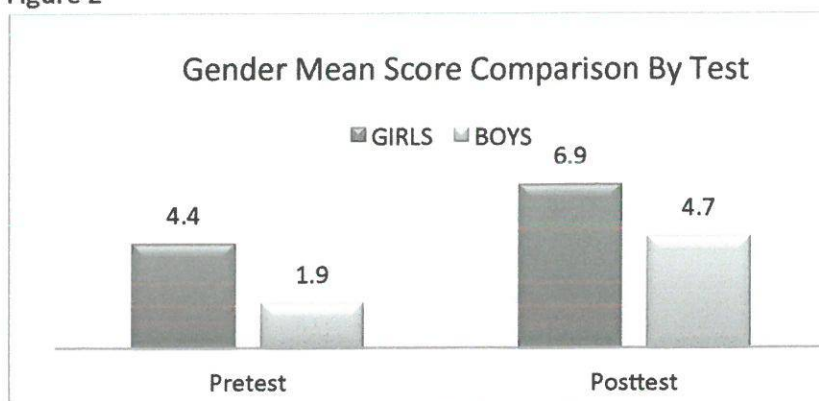
Grouping	n	M
PreTest Scores	11	3.2727
PostTest Scores	11	5.9091
Total Mean Difference		2.63636

Table 2

Group Statistics By Gender

	Gender	N	Mean Score
PreTest Scores	Girl	6	4.4167
	Boy	5	1.9000
PostTest Scores	Girl	6	6.9167
	Boy	5	4.7000

Figure 2



Comparing mean scores for groups by gender in pre and posttests.

Table 3

Combined Survey Results By Gender Group (Full Survey Answers in Appendix)

Girls Responses	Boys Responses
Q1. What did you find the most helpful for math understanding in our times working with hands-on math?	
Working with objects, like dominoes, and interacting the whole time with fractions and decimals.	Using geoboards, fraction shapes and dominoes to make and understand fractions.
Q2. What did you like best of the math tools (manipulatives) we used?	
Four liked the unifix cubes best, two liked the dominoes, two the fraction pieces, one the geoboards and one liked drawing fraction pictures best.	Getting to use our hands and not just books. Using fraction pieces, and unifix cubes to understand fractions and decimals. Easy to understand.
Q3. What do you feel you understand better or learned from our four sessions working together?	
Fractions and decimals – multiplying, dividing, identifying them.	Decimals, fractions, and how to understand the concepts better with things like colored blocks.
Q4. What would you still like help with understanding in math?	
Working with more manipulatives, more help with decimal division and changing fractions to percent.	Understanding and using pi (π) and dividing decimals.
Q5. How do you feel about meeting with just boys or just girls to work on math? Did it help you? How?	
Felt comfortable with the single-gender group, felt it helped us stay focused and cut down on distractions.	Like the idea when the guys are nice and help each other, but didn't like when some boys distracted others. Being focused was more important than gender.

Q6. *Would using hands-on math tools help you in understanding other math?
How?*

All but one said yes, because they are visual and would help with understanding. G1 said she preferred writing instead.

It could help with seeing what we are learning. It depends on what kind of math it is.

Analysis

Figure 1 displays scores for each student on the pretest and posttest for side-by-side comparison. The full record of questions attempted vs number correct is listed in A3 of the appendices. The data shows that every student had improved scores from their pretest to their posttest, though to varying degrees. The highest score was on the posttest by G3, and the lowest was on the pretest by G4. G3 answered the same number of questions on both tests (8), but got three more of them correct on the pretest than the posttest. G4 answered five questions on the pretest, but answered them incorrectly except for half of one question. On the posttest she answered 7 and got them all correct. G2 was the most consistent in her test scores, but she answered eleven questions on the pretest and missed four then answered nine questions on the posttest and only missed one and a half so her accuracy still improved. All of the students improved their number of correct answers on the pretest to those on the posttest. The range of improvement was 0.5 - 6.5 points with a mean of 2.6 points improvement overall on the 12 question test.

Table 1 shows the combined mean scores of all the students on the pretest and posttest, as well as the mean difference in scores between the two tests. There is a 2.6 points out of 12 possible score increase (+22%) in the group mean score from pretest to posttest. This gain shows that something caused improvement of conceptual

understanding in these eleven students so they were better able to answer more of the questions they had difficulty with at the start of the study.

Table 2 splits the total pretest and posttest mean scores by gender to compare them, and Figure 2 supports the information in Table 2 with a visual representation of the data. The girls' group scored better on average than the boys' group on the pretest and posttest by 2.5 points on the pretest (21%) and by 2.2 points (18%) on the posttest. The boys' group had a mean increase of 2.8 points (23%) from pretest to posttest and the girls' group had 2.5 points (21%) mean increase from pretest to posttest. Therefore the boys' group showed greater improvement in their mean score by 2% over the girls' group. They many have gained more understanding of fractions and decimals from working with manipulatives in the study, or they may have been more focused on the second test day. The variables were not controlled tight enough to be sure of the cause.

The improvements achieved by the students in this study could have resulted from the help they received from their interaction with manipulatives, or they might also be due to other factors. Without a control group to compare the results to it is not possible to say the working with manipulatives was the cause. Still, the goal was to improve the understanding of specific concepts in this group of students and that goal seems to have been reached.

The survey responses showed both groups felt using the manipulatives had been helpful to them in making fraction and decimal concepts more clear for them, that they enjoyed using them and would find them useful to use again. There was not a clear preference for a specific type of manipulative by either group. As for working in gender specific groups, the girls responded more positively about their preference in working

with just girls for the sake of social comfort and focus. The boys were more concerned about the focus ability of their group than the gender makeup. Both groups benefitted from interacting in a small group setting where they could help one another without being graded on the efforts of the others. See appendix A5 for complete survey answers.

Implications/Recommendations

This study's results are not reliably transferable to any other population, as it was mostly classroom specific and action research based. However, the study was useful for the group of students in a particular classroom that benefitted by improvement in their understanding of fractions and decimals. It seems that using math manipulatives, with these sixth graders, in small groups, to support improved understanding of a targeted subject, was helpful based on their improved test scores and positive responses on the survey. Working with students in single gender groupings may also increase the comfort level, and therefore focus, of the students at this age, particularly with girls. However, the supportive nature of the group is likely more important than the gender makeup.

The small scope of my study leaves me with questions about whether it would be useful to repeat the study on a larger scale. Did these groups improve due to the intervention or were there other causal factors involved? Would students who were not struggling with the concepts taught still benefit from targeted work with manipulatives? My recommendation for further studies would include checking for reliability of outcomes using a larger selection of small groups to see if the improvement would be seen in all, only some, or none of them. Control groups would also be helpful in comparison to see if students of similar needs and understanding levels would improve at

the same rate with only regular class instruction. Interviewing the primary mathematics instructor pre and post intervention to track student grades for evidence of change should be done in future studies. Another possible avenue of investigation is studying if working with manipulatives is more helpful as remedial help on an as needed basis, or if it would benefit a group more as regular and long-term instructional support. Student single-gender and mixed gender groupings could be tested in more depth to see if the gender factor follows a pattern or depends on the group participants more than the gender.

Conclusion

I set out to learn more about what conditions and tools are helpful for supporting students learning. Do students benefit from working with math manipulatives to support better contextual connections? Will they help students struggling with math concepts gain a better understanding of the underlying principles and improve their mathematics ability? Do students feel more focused in single gender groups? Do they view it as helpful?

What I observed was students whose understanding of fractions and decimals improved, as evidenced by increased scores from pretest to posttest. This improvement may have been because “students actively construct their own mathematical understanding, which is often accomplished through the use of manipulatives,” (Boggan et al., 2010, p.2) or it may have been due to time and other learning factors. Either way, the students’ improvement in their math understanding to their benefit after being guided through targeted investigation with math manipulatives. The girls in the study expressed they were more comfortable in their group because of being with all girls. The boys said they felt being in a single gender group was good, but that any group

of focused students would be as helpful. The only thing proved by this study is that students had measurably improved scores on post testing following four sessions of work with math manipulatives, and that girls measurably did better than the boys in these two groups. I observed that the students had fun using the manipulatives and that they got better at thinking about math differently over the four sessions because of the thought required. More study in the future would be necessary to establish more reliable cause and effect connections for older students using manipulatives for targeted concept support. As for whether single-gender groups help students focus better or improves their learning experience, the literature and study show that some students have benefited from working in single-gender groups. This researcher thinks it depends on the students and teachers involved.

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Appendices

A 1 Pre Test

Math Skills Assessment - please show your work for each problem.

Student: _____ Block: _____

1. What is the difference when the product of 0.6 and 0.2 is subtracted from the sum of 0.6 and 0.2? _____
2. If you are buying a game that costs \$16 and the sales tax is 8%, how much will have to pay for the game in total? _____
3. If a pizza is 12 inches across (diameter), what is the circumference of the pizza?
(Use 3.14 for π) _____
4. $0.5 \times 0.2 \times 0.7 =$ _____
5. $0.51 \div 0.3 =$ _____
6. $0.615 \div 0.6 =$ _____
7. $3 - X = 2.17$ $X =$ _____
8. $5\frac{1}{6} - 2\frac{2}{3} =$ _____
9. $6\frac{3}{8} - 3\frac{4}{8} =$ _____
10. Find the averages of each column:

a.	b.	c.
12	15	18
37	26	79
23	32	52
16	68	64
<u>5</u>	<u>41</u>	<u>37</u>

a. _____

b. _____

c. _____
11. Mary counted 16 cupcakes left from the batch her mother made for the picnic. If two-fifths ($\frac{2}{5}$) of the cupcakes are left, how many cupcakes did her mother make?
12. If you split seven apples evenly with four people how much would each person get? Show your answer with a diagram and a mixed number.

Post Test

Math Skills Assessment 2- please show your work for each problem.

Student: _____ Block: _____

1. What is the difference when the product of 0.8 and 0.3 is subtracted from the sum of 0.8 and 0.3? _____
2. If you are buying a hamburger and fries that cost \$6 and the sales tax is 8%, how much will have to pay the cashier? _____
3. If a tire is 18 inches across (diameter), what is the circumference of the tire?
(Use 3.14 for π) _____
4. $0.5 \times 0.2 \times 0.7 =$ _____
5. $0.51 \div 0.3 =$ _____
6. $0.615 \div 0.6 =$ _____
7. $(2.45 + 5.327) \div 3 =$ _____
8. $5\frac{1}{10} - 2\frac{2}{5} =$ _____
9. $6\frac{3}{4} - 3\frac{7}{8} =$ _____
10. Find the averages of each column:

<p>a.</p> <div style="display: flex; flex-direction: column; align-items: flex-start;"> <div>12.2</div> <div>37.0</div> <div>23.0</div> <div>16.3</div> <div><u>5.54</u></div> </div>	<p>b.</p> <div style="display: flex; flex-direction: column; align-items: flex-start;"> <div>15.12</div> <div>26.04</div> <div>32.00</div> <div>68.50</div> <div><u>41.11</u></div> </div>
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a. _____

b. _____
11. Mary counted 15 cookies left from the batch her mother made for the bake sale. If one third ($\frac{1}{3}$) of the cookies are left, how many cookies have been sold?
12. If you split 3 pizzas, with 10 slices each, evenly with 6 people how many slices would each person get? Draw a picture to go with your answer.

Pre and Post Test Data:

	Pre-Test- 12 min attempted/correct/total	Post-Test- 12 min attempted/correct/total
G1	7/5.5/12	9/7/12
G2	11/7/12	9/7.5/12
G3	8/5/12	8/8/12
G4	5/5/12	7/7/12
G5	4/4/12	7/5/12
G6	10/4.5/12	7/7/12
B1	8/2/12	6/4.5/12
B2	6/2/12	8/6/12
B3	5/1/12	4/3.5/12
B4	NA	NA
B5	6/1.5/12	9/5.5/12
B6	7/3/12	7/4/12

A 4

*Case Study Session Notes:***Day 1 – 25 min**1st block Boys/ 3rd block Girls: - Math Regular

Introduce myself and expectations

Administer pretest (12 min)

Practice fractions and reciprocals with dominoes

Foam fractions – make 3 whole shapes using fraction pieces, find dominoes that match the combinations or draw and label the fractions.

Hand out fraction equivalent sheet for reference

Challenges:

Proper use of remainders in averages, etc.

Multiplying decimals

Dividing fractions and decimals

Direction of subtraction for fractions in mixed numbers

Observations:

B1: lacks focus – chatty and distracting others

B3: tends to stare blankly, then snap into focus

G2 quick, but not solid on some concepts, especially decimals

G5 thinks slowly and deliberately, but is most often correct when she arrives at an answer

Day 2 – 20 min. per group

Usborn – Fractions and Decimals

(pg 6&7) identify sliced pie fractions,

(pg 8&9) identify striped umbrella and flag fractions

make flag paint fractions w/unifix cubes

Practice mixed number subtraction w/unifix cubes ($1\frac{1}{2} - \frac{4}{6} =$)

B3 Understands the borrowing concept
 B6 Followed the others, but did not understand
 B1,2,4,&5 Sometimes understood, but subtracted fractions backward
 G1 – 6 All could identify fraction parts, but had trouble understanding how to break whole #s down or represent them with cubes
 Bs and Gs Subtracted fraction parts of mixed equations backward and forgot to borrow

Day 3 – 20 min. per group

Practiced with labeled fraction pieces
 Geoboard fractions and equivalents
 Write fractions/decimals expressed in pictures (pies and bars divided into 10 w/ shading) do together and talk through.
 Pizza division practice with paper plate pizzas (12 slices between 6 people, 2 pizzas of 10 slices ea/4 people)

B1, B4 and B6 had trouble with fraction identification but understood geo pattern fractions
 G1 Had trouble with trying to translate fraction to decimal – then understanding clicked.
 G2 Did not reduce, but got fractions & decimals correct otherwise
 G6 Tended to use fraction denominator as the decimal part on paper
 G5 Tended to use fraction numerator as the decimal on paper
 G3 Skipped #6 and used numerator as the decimal for #4 on paper.
 Figured out a fraction comparison series on geo board
 G4 Suddenly understood fraction equivalent when using geo board

Day 4 – 25 min per group

Fraction and decimal division with dominoes using calculators to check work
 Foam fraction pieces practice
 Post-test – 12 min.
 Handed out exit survey's to be filled out and returned to me.

The Boys were squirrely due to an unexpected recess and exciting drama/music lesson before their session.
 B6 seemed more engaged today
 The Girls were more settled after lunch, but more tired than usual due to an exciting day.
 G2 hardly talks (largely due to her language difficulties).
 G6 got enthusiastic about learning
 G1 was catching on to how fractions and decimals work.

A 5

G = Girls, B = Boys Survey Responses:

1. What did you find the most helpful for math understanding in our times working with hands-on math?

G1: I found (the) visual and mental helped, but mostly visual.
 G2: Fractions
 G3: Yes, the way you worked us on the objects was great.
 G4: The last session where we worked with dominoes.

G5: I found that learning more about fractions, and how to use them, was the most helpful for my math understanding in hands-on math.

G6: What I found most helpful was the whole time just interacting with fractions and decimals.

B1: The rubber bands (on the geo-peg boards).

B2: The understanding of decimals and fractions.

B3: The making fractions with the shapes.

B4: no survey returned

B5: I understood the fractions the most. It was the easiest to do.

B6: I thought learning how to divide fractions and knowing how to do it (helped the most).

2. What did you like best of the math tools (manipulatives) we used?

G1: I liked the dominos!

G2: Making fractions by tools – the circle and rectangle.

G2: I liked the square block fractions best.

G4: Dominoes and building (unifix) blocks.

G5: The manipulatives I liked best that we used were the peg-boards (geo-boards) and the connecting (unifix) blocks.

G6: I liked the cubit cubes (unifix cubes) and how we had to explain with the picture and words (what the fractions and mixed numbers looked like).

B1: Decimals and fractions

B2: That they were easy to understand

B3: The fraction pieces

B4: no survey

B5: I liked when we made fractions with (unifix) blocks.

B6: I liked that it was hands on and different from when we used just our math books.

3. What do you feel you understand better or learned from our four sessions working together?

G1: Multiplying decimals and moving the decimal

G2: I learned more about fractions and I understand them better

G3: I learned more about fractions.

G4: I can clearly understand now how to divide fractions and work with them.

G5: I feel that I understand fractions and certain decimals that are commonly used because we used the fractions and decimals practice book (Usborne Math Skills – Fractions and Decimals).

G6: I feel more comfortable with fractions and decimals.

B1: Decimals and fractions

B2: I felt calm, normal, and a little better on how to understand fractions.

B3: The multiplying and dividing decimals.

B4: no survey

B5: I understand the fractions and the decimals.

B6: I think I understand just the concept of math and how there are different ways to do it. You can do things just by having (unifix) blocks.

4. What would you still like help with understanding in math?

G1: I get everything

G2: I would like more math tools.

G3: I do not need any more help understanding anymore about this. I feel like I got it all down.

G4: Maybe (I would like help), I will see (what more I need help with).

G5: The subjects I would still like help with understanding in math are how to recognize fractions in whole shapes, and turn those fractions into percentages. I think I also don't have division with decimals down yet.

G6: I have a math tutor who does help me, but I would still like an opportunity to get more help using math tools.

B1: pie (π) 3.14

B2: Nothing

B3: Pie (π)

B4: no survey

B5: I don't need any more help

B6: I think I need more help in dividing decimals.

5. How do you feel about meeting with just boys or just girls to work on math? Did it help you? How?

G1: I felt comfortable with the same gender meeting.

G2: It helped me

G3: Yes, it did help me and I felt very good about it because there were no distractions.

G4: It did. With just girls, I think all of us are less distracted and are able to participate more.

G5: I feel good about meeting with just girls. I believe it did help me because it kept me a bit more focused seeing other girls working hard on the subjects I was working on too. It made me want to do my work.

G6: Yes, because it is a comfortable environment.

B1: I felt that it helped me learn the subjects better.

B2: Yes, because we compared answers and other stuff. No, because some of them were goofing off.

B3: I don't really know. It was kind of distracting but not at the same time. Well it was nice to be with my friends.

B4: No survey

B5: It felt good

B6: I think it was more of a distraction. It kind of helped me. Well, I think just having a nice group of guys helped too.

6. Would using hands-on math tools help you in understanding other math? How?

G1: Not really, I like writing the problem out on paper instead.

G2: They would help me understand more.

G3: Yes, because then I know what it would look like.

G4: It will help because I can use the same tools in different problems that may pop up.

G5: Yes, I think using hands-on math tools may help me in understanding other math, like a circumference of a circle. For example, the hands-on math tool that is made of foam and represents many fractions or pieces of a whole circle could be used as a visual aid or something to measure and find the circumference of.

G6: Yes. Just to feel and interact with math.

B1: Yes, because you would actually be learning it.

B2: I don't understand the question very well, like writing it out then yes, otherwise no.

B3: Probably because you can see what you're doing with the tools.

B4: no survey

B5: No

B6: Kind of, depending on what kind of math it is. Because a lot of stuff I already know.