Impact of Informal Experiences: Changes in Mathematics Motivation for Middle Schoolers

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Abstract

The current research sought to examine the impact of a week-long mathematics camp on motivation and self-efficacy beliefs of participating middle school students. Middle school students participated in a one-week mathematics camp on a college campus, where they worked on authentic mathematics activities that were applied to real world concepts. The activities were developed by a mathematics educator and were facilitated by trained college students. Middle school students responded to the Sources of Self-Efficacy measure before and after the mathematics camp to determine whether changes occurred in various motivational variables resulting from their participation in the camp. Parallel t-tests indicated significant positive changes in students' vicarious experiences and mastery goals to suggest that participation in the camp may have caused students to feel more confident in their ability to work through math problems and to adopt learning goals for mastering mathematics content. Providing middle school students with informal learning experiences in mathematics may help them in creating long-term goals for their learning.

Keywords: mathematics, secondary education, motivation

1. Introduction

1.1 Introduction of the Problem

Research has explored several aspects of teaching and curriculum, including teacher's knowledge, student learning, classroom management, extra-curricular activities, and curriculum; however, most research in these aspects has occurred within a school setting. Though research on the impact of experiences outside of school is limited and not explored fully, existing research does suggest that students' participation in informal experiences, such as summer camps, increases achievement, self-efficacy and improves social comfort in children because of the informal learning environment, new activities, small teaching ratio, and independence (Bhattacharya, Mead, & Nathaniel, 2011; Colyn, DeGraaf, & Certan, 2008; Fields, 2009; Gilmour & McDermontt, 2008; Tichenor & Plavchan, 2010). Specifically, informal learning experiences have positively impacted African American high school students' career choices in science-related fields (Bhattacharya et al., 2011) and the development of girls' confidence to pursue and enroll in STEM fields in college (Dave et al., 2010). Edwards, Kahn, and Brenton (2001) further state that summer camp interventions contribute to higher student achievement, and they call for similar programs to help students gain confidence in their own ability. This may be especially important in fields such as mathematics, in which many students experience difficulties in understanding mathematical concepts and "math anxiety" continues to be a be a growing barrier for students' success in mathematics (Ashcraft, 2002).

Mathematics anxiety is not just a dislike for mathematics but rather a discomfort, feeling of tension, helplessness, and mental disorganization that occurs when one has to perform mathematically (Richardson & Suinn, 1972; Vinson, 2001; Wood, 1988). The negative feeling towards mathematics is projected in other areas and impacts students' self-confidence, attitudes, and their ability to do well in school. Therefore, helping students to develop a positive attitude in mathematics may lead to greater self-efficacy, which is important to students' eventual success in education. In this paper, researchers share the curriculum of a week-long mathematics camp for middle school students, the implications of the camp, and the impact of camp participation on self-efficacy and motivation for the students.

1.2 Self-efficacy

Self-efficacy has been described as one's belief about his or her own ability to be successful at a task (Bandura, 1986). Self-efficacy is task specific; in other words, one may possess high self-efficacy on some math concepts and low self-efficacy on others. Those students with greater mathematics self-efficacy possess the belief that they have a greater chance at being successful in a specific mathematics task, while those with lower mathematics self-efficacy feel less confident in their ability to be successful in a mathematics task (Klassen, 2004). Researchers have found that greater mathematics self-efficacy is positively related to greater success in math lessons (Pajares & Kranzler, 1995). To the contrary, Ramirez, Gunderson, Levine, and Beilock (2013) explain that math anxiety can negatively impact children's math achievement as early as first and second grade, thus making it critical to develop interventions that aim at improving and increasing math achievement. Students, who possess greater beliefs about their ability to be successful in mathematics are more likely to perform well in other subjects too, while those students with lower self-efficacy beliefs in mathematics are less likely to perform well in mathematics, in other subjects, and in school. Teachers who assist students in gaining a more thorough understanding of mathematical problems and concepts are likely to influence students' math self-efficacy and eventual success in mathematics.

1.3 Achievement Goals

Research in achievement goals explains that students adopt goals for learning as one of two types: mastery goals or performance goals (Ames, 1992). Students who adopt mastery goals seek learning opportunities with a focus on understanding the content and increasing competence, while learners who possess performance goals maintain a focus on achievement for the purpose of demonstrating their competence. Research in achievement goals suggests that mastery goals may be more adaptive in helping students to gain a thorough understanding of the subject, while performance-oriented goals may cause students to learn the material only for the sake of out-performing their peers (Pintrich & De Groot, 1999). Much of the research relating achievement goals to student grades suggests that performance-oriented goals may be the most adaptive because these are the goals that help students to focus on improving grades. As students are presented with opportunities to engage with the content, they are more likely to adopt goals of master.

Also, research studies in achievement goals suggest that mastery goals of students in middle school may more significantly relate to students' academic performance (Paulick, Watermann, & Nuekles, 2013). Therefore, students who have opportunities to participate in non-competitive environments, may be more likely to establish their mastery goals for learning. Especially in mathematics, students may be more focused on performance goals as they work to complete assignments.

1.4 Authentic Learning Experiences

By providing middle school students with a curriculum to include foundational skills for developing their mathematical conceptual understanding, such as measurement, proportionality, data analysis, graphing, and linear equations, students benefit from the reinforcement of these concepts. Additionally, skills taught through hands-on, real-world, and engaging activities that require students to reason, communicate with one another to build shared understanding, and use and connect different representations, allow students to deepen their understanding and flexibility of various math concepts (Principles to Action, 2014; NCTM, 2000). According to Mohr-Schroeder et al. (2014) and Tichenor and Plavchan (2010), summer camps provide an informal learning environment that could not only be instrumental in strengthening and reinforcing students' math skills but can prepare and inspire students of all backgrounds to take higher-level math and science courses. Research in science summer camps has shown that informal environments provide the experience in learning that is rarely accessible in the traditional classroom and motivates students to experiment, explore, and critically think about various science concepts (Saul, Reardon, Pearce, Dieckman, & Neutze, 2002). Summer camps help provide focus and learning for ideas that are often ignored or undervalued by traditional curricula; therefore, researchers call for the need of summer camps to provide the opportunity for students to attain social comfort and increase self-efficacy through exploring activities, social encounters, and critically thinking (Bhattacharya et al., 2011; Colyn, et al., 2008; Fields, 2009). Summer camps may be the medium through which the students learn to "appreciate, enjoy, and learn math" (Tichenor & Plavchan, 2010, p. 74) and give them an opportunity to grow socially and intellectually (Wentzel, 1998).

1.5 Research Goals and Question

Since the struggle of many middle school students in mathematics could lead to low performance in high-school and even college, researchers created a week-long camp to provide students with an opportunity to gain a better understanding of foundational mathematics concepts through hands-on learning by exploring proportionality, measurement, graphing, data analysis, and geometry. The purpose of the camp was not only to provide hands-on learning experiences, but also to understand whether a hands-on learning experience would change middle school students' motivational beliefs about mathematics and decrease their anxiety related to mathematics. The research question that guided the study was: To what extent does mathematics self-efficacy and mathematics motivation change for middle school students resulting from attending a week-long math summer camp?

2. Method

2.1 Participants and Setting

Students were recruited for the week-long summer camp from local middle schools through flyers and their school counselors. Interested students completed an application and an essay about why they wanted to attend the camp. Students were chosen by the researchers, based on interest in the camp and agreement to participate in the research component of the camp. All students and parents completed consent forms to participate in the research study and camp. The sample was comprised of nineteen middle school students, self-reported as male (n=6) and female (n=13) and who indicated they had completed 5th (n=1), 6th (n=4), 7th (n=13), and 8th (n=1) grades.

The camp was conducted on a college campus by the two main researchers and was fully funded by a local endowment. College students were hired as camp counselors, and each had varied experiences with mathematics and teaching. The counselors attended a training session prior to the camp to learn about the curriculum and activities. The camp lasted four hours each day for five days. The activities took place both in a classroom on campus and around the campus itself. During the camp, the counselors facilitated groups of three to four students as students worked on different activities.

2.2 Curriculum

The curriculum for the mathematics activities was developed by examining the Texas Essential Knowledge and Skills Standards (TEKS, 2012), the National Council of Teachers of Mathematics (NCTM, 2000) and the mathematical practices as highlighted by Common Core State Standards (CCSS, 2010) for middle school students. The camp involved a variety of mathematical process standards developed by a mathematics teacher educator and included activities in communication, problem-solving, connections, representations, reasoning within the content of measurement and data, expressions, equations, relationships, and numbers and operations. The focus of the camp was developing students’ understanding in the various strands with a specific focus on geometry and algebra. These content areas were chosen by a mathematics education expert after looking at state standards and benchmarks at the local school districts.

During each day of the camp, the students were exposed to real-world problems that involved critical thinking and collaboration with peers. For example, one day the students took a tour of the campus while solving problems based on questions such as: How much water can be occupied by the fountain?, How many bricks are below the statue?, How many advertisements can be put on the bulletin board?, How much paint is needed to coat the University Seal?, and many more. These problems were designed by the mathematics education expert and a graduate student aligned to the Gear-Up Math curriculum (from the GEAR UP Waco Project funded by the U.S. DOE, 2017). Another example of problems used in developing not only understanding but also teamwork and fluency occurred when students participated in a relay race by solving two or three algebraic equations and plotting themselves as points on a coordinate plane, which allowed them to visually understand the equation of line (Gupta & Cobb, 2018). Students also developed their understanding of coordinate planes by using Nerf guns connected to geometrical shapes. Some of these lessons have been published in a chapter on integrating movement into mathematics education (Gupta & Cobb, 2018). The goal of the camp’s curriculum was to develop students' social skills and give them an opportunity to develop a deeper understanding of mathematics to allow students to find the relevance of mathematics in the real-world.

2.3 Instrument

Every student completed a self-report survey comprised of two parts: demographics and Likert statements. Students completed the demographic and Likert portion the first morning of the camp and completed the Likert portion again on the last day of the camp. The demographic section asked students to report their age, gender, current grade level in school, current score in mathematics class, and their ethnicity. The second section containing Likert-scaled items (1=extremely false to 6=extremely true) was approximately 75 questions long and took students about 30 minutes to complete. Most of the items on the survey were taken from the Sources of Self-Efficacy Measure (SSEM) assessing various sources of students' self-efficacy: Mastery Experience (pretest α=.85, posttest α=.79; ex. "I make excellent grades on math tests."), Vicarious Experience (pretest α=.74, posttest α=.91; ex. "I often try to picture myself working through the most difficult math problems."), Mastery Goals (pretest α=.74, posttest α=.52; ex. "I like math assignments that really make me think."), Performance Goals (pretest α=.86, posttest α=.72; ex. "I'd like to show my math teacher that I'm smarter than the other students in my class."), Physiological State (pretest α=.81, posttest α=.75; ex. "I get really nervous while taking math tests."), Engagement in Mathematics (pretest α=.63, posttest α=.87; ex. "When I do poorly on a math assignment, I just try harder next time."), and Mathematics Self-Construct ("I have always done well on math assignments.") (Usher, 2007). Academic self-efficacy in mathematics was also assessed using five items from the Motivated Strategies for Learning Questionnaire (pretest α=.81, posttest α=.98; MSLQ; Pintrich & De Groot, 1990).

2.4 Data Analysis

SPSS version 22 was used to analyze the quantitative data. Inter-item reliability analyses were first conducted for each subscale of the SSEM and for the MSLQ. Because all alpha levels were greater than.7, all scales were deemed reliable enough to conduct further analyses. (Reported alpha levels can be found in the results section.) The means and standard deviations for each component of the SSEM were first calculated, in addition to the means and standard deviations for the MSLQ. To answer the research question, the researchers conducted a paired samples t-test to measure mean differences in the remaining middle school students' pre- and post-test data for each self-efficacy component.

3. Results

Several of the components revealed a significant change in mean differences from the beginning to the end of the intervention. The results are listed below, separated by each domain of the scales.

3.1 Vicarious Experience

Most notably, the vicarious experience measure revealed an increase in mean differences from the pre-test (M=3.10, SD=1.37) to the post-test (M=3.70, SD=1.37); $t(14)=2.41$, $p<.05$, which suggests that students felt that after the camp they were more likely to improve self-efficacy based on experiences with others. In other words, students' participation in the camp provided them with an opportunity to work with similar students, and these vicarious experiences offered them a chance to improve their own efficacy skills.

3.2 Physiological State

In addition, the variable physiological state revealed a decrease in mean differences between the pre-test (M=2.97, SD=1.03) and post-test (M=2.54, SD=1.15); $t(18) =2.33$, $p<.05$ indicating students were less anxious and tense when working on math following the week-long math camp. Because math anxiety can inform students' self-efficacy, providing students with opportunities that decrease anxiety may be related to increasing students' self-efficacy.

3.3 Achievement Goals

The achievement goal variables revealed a significant change as well. Mastery goals revealed an increase from pre-test (M=2.45, SD=1.37) and post-test (M=3.45, SD=1.88); $t(18)=2.57$, $p<.05$ to suggest that following the camp, students were more likely to adopt goals to master the content than they were before the camp. No other self-efficacy components revealed a significant difference in means. In other words, students participating in the camp increased their beliefs in the importance of setting goals to master the content (See Table 1 for all results.)

Table 1. Results from Paired Samples t-test Indicating Students' Change in Sources of Self Efficacy

Self-efficacy Construct	*t*
Academic self-efficacy	.13
Mastery experience	.76
Vicarious experience	2.41*
Physiological state	-2.33*
Engagement in mathematics	.49
Mathematics self-construct	-1.55
Mastery achievement goals	2.57*
Perform. achievement goals	1.22

Note. * p< .05

4. Discussion

The purpose of the current research was to examine the impact of participating in a week-long summer mathematics camp on middle school students' self-efficacy beliefs. Overall, the results support the limited research on informal experiences (Colyn, et al., 2008; Dave et al., 2010; Fields, 2009; Gilmour & McDermontt, 2008; Tichenor & Plavchan, 2010) and previous research that explains how success in mathematics may affect one's self-efficacy beliefs as well as achievement goals (Pajares & Kranzler, 1995; Walker & Greene, 2009).

Middle school students with low mathematics self-efficacy at the beginning of the camp reported a positive change in efficacy beliefs for mastery goals and performance approach goals, suggesting that participating in the hands-on learning experience and collaborating with other students positively affected their goals to master mathematics and goals for working in math to improve their grades. Previous research also suggests that students with greater self-efficacy in a subject are likely to have more positive achievable goals (Walker & Greene, 2009). In addition, middle school students reported a decrease in their physiological state resulting from the week-long mathematics camp. Researchers Wigfield and Meece (1991) state that math anxiety not only leads to negative reactions to math, such as discomfort, fear, and nervousness but also manifests itself into worries of doing well in mathematics. As indicated by the survey, students reported greater math anxiety at the beginning of the camp, which decreased following their participation in the camp, thus showing that participation in the camp did provide some support in helping students become more comfortable doing the math. Though some of the self-efficacy constructs revealed an increase, several constructs revealed a decrease during the intervention. Perhaps students with low mathematics self-efficacy may not improve their beliefs about mathematics constructs, such as mastery experiences nor mathematics self-construct with only a week to practice hands-on learning experiences, or perhaps working intensely with mathematics for a week may have caused some students with lower mathematics self-efficacy to actually decrease their ability beliefs. One limitation of the current study was the small sample size, since the camp was limited to one university and a total of 20 middle school students. Because the camp was open to all students, only a few numbers of students participated who indicated lower self-efficacy in mathematics. In spite of the limitations, participation in the camp had a positive impact on middle school students and offers that there is a need to support and increase the frequency of interventions like this to foster self-efficacy in mathematics.

Camps, such as those described in this manuscript, have significant implications in providing colleges of education with another way to service the neighboring school districts and the students. For middle school students, hands-on learning opportunities in mathematics provide them with an opportunity to better understand mathematics in the real world (Wentzel, 1998). In addition, summer camps may offer students with lower mathematics motivation a means to practice the skills they have learned throughout the school year and may lower their anxiety related to mathematics (Mohr-Schroeder et al., 2014; Tichenor & Plavchan, 2010). It is true that not every student can participate in a summer camp or wants to, hence there is a need for collaboration and funding to provide that opportunity for more students to attend. Moreover, the curriculum of the camp needs to be hands-on and engaging to motivate and develop students' confidence towards mathematics. Middle school is a transition from elementary to high-school where students are learning fundamental concepts that have more rigor and are building blocks for high-school. Any additional experience outside of the school that helps develop mathematical understanding, such as discussed in this manuscript, can be beneficial. Students in the current research study enjoyed the activities while gaining both mathematical confidence and knowledge of mathematical concepts.

Data analysis highlighted that students that participating in the mathematics camp felt more confident in working math problems when exposed to others with similar abilities and when anxiety was lower. These results suggest previous research that suggests the inverse relationship between math anxiety and performance (Ashcraft, 2002). Students' worked problems related to slope and other difficult mathematics concepts, and their confidence with math concepts was improved. Because a large part of success with mathematics results from automaticity with math facts, these results offer hope for students to have a successful future in mathematics.

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