CHANGING MATHEMATICS TEACHING EFFICACY OF COLLEGE STUDENTS: THE IMPACT OF INFORMAL LEARNING EXPERIENCES

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Abstract

The current research examined the impact of facilitating a week-long mathematics middle school camp on college students' mathematics teaching efficacy beliefs. The participants of the research study were five undergraduate students hired as counselors for the mathematics camp. A parallel convergent mixed method design was used to analyze both survey and written-response data from each undergraduate student. College students responded to the Mathematics Teaching Efficacy Beliefs Inventory (MTEBI), to which they self-reported their teaching efficacy beliefs for mathematics before and after facilitating mathematics activities throughout the week. In addition, qualitative data was gathered through college students' daily journals in which they recorded their beliefs about facilitating the camp and student learning that occurred throughout the day. Paired sample t-tests were conducted, and results suggest positive changes occurred in college students' beliefs about teaching mathematics. Analysis of the qualitative data using open and axial coding, along with member checking, revealed the positive impact of informal experiences.

Keywords: mathematics, teacher efficacy, preservice teachers, informal experiences

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Teachers possess self-efficacy in their ability to teach effectively, defined as teaching efficacy (Woolfolk Hoy, 2000). Teaching efficacy is subject-specific; therefore, teachers may feel more confident in delivering content in one discipline over another (Woolfolk Hoy). Further investigations offer that differences in teaching efficacy may result from one's self-efficacy in a subject (Woolfolk Hoy; Woolfolk Hoy & Spero, 2005; Buss, 2010). This is of great importance when preparing and training preservice teachers (PSTs) as future teachers. As preservice teachers gain the content knowledge to teach effectively, many remain unsure of their ability to deliver the content required of their discipline effectively (Woolfolk Hoy; Ball, 1990). Specifically, many preservice teachers struggle with beliefs about their ability to teach mathematics (Enochs, Smith, & Huinker, 2000; Akin & Kurbanoglu, 2011), and research suggests that teachers with low teaching efficacy may be less likely to work with struggling students (Ashton, Dota, & Webb, 1983).

To support preservice teachers in their learning experiences and to impact their teaching self-efficacy in a positive way, investigating a variety of learning experiences may be needed. Some researchers recommend the use of informal experiences to influence preservice teachers positively in both professional development and in attitudes towards teaching

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mathematics (Katz et al., 2011; Tuchman & Issacs, 2011). Facilitating summer mathematics camps may be one such way to impact preservice teachers' mathematics teaching efficacy because of the nature of this informal experience.

Theoretical Framework

Bandura's Social Cognitive Theory (Bandura, 1986) defines self-efficacy as one's perception of his or her ability to be successful on a task. According to Bandura, efficacy beliefs are different than outcome expectancies. Personal self-efficacy is defined as the perceived judgment of one's own capacity to complete a task, and that can differ from the anticipated outcome from engaging in the task. Bandura (1997) suggests that self-efficacy is developed from one's experiences while working on a task. Especially in school, students evaluate their success or failure after completing a task and create their self-efficacy based on that. Defined as mastery experiences, students' successful encounters with tasks lead them to develop confidence to engage in future tasks (Bandura, 1997). Additionally, self-efficacy is task specific; in other words, one may possess high self-efficacy for one discipline or for understanding particular concepts in one discipline while possessing low self-efficacy for other disciplines and tasks within them (Bandura, 1986). This becomes even more critical when considering the discipline of mathematics. High mathematics self-efficacy, which describes a student's belief about his or her ability to be successful on a mathematics task, may result in greater mathematics success (Klassen, 2004). Correlational studies suggest that greater mathematics self-efficacy may result from greater success in mathematics lessons (Pajares & Kranzler, 1995; Zimmerman, Bandura & Martinez-Ponz, 1992). Teachers who assist students in gaining a more thorough understanding of mathematics problems and concepts are likely to influence students' mathematics self-efficacy and eventual success in mathematics.

Teaching Efficacy

Similar to self-efficacy, teaching efficacy is defined as the belief in one's ability to be an effective teacher (Gibson & Dembo, 1984). Though a teacher may possess high self-efficacy for a particular discipline, he or she may or may not possess high self-efficacy for teaching it. Differences in teaching efficacy may lead to various student outcomes, resulting from teaching strategies either effectively or ineffectively employed and also from the teacher's persistence when faced with teaching difficulties. Teachers with high self-efficacy for instructional delivery are more likely to teach well and impact learner success. Teacher mathematics self-efficacy is defined as a teacher's beliefs regarding his or her ability to deliver effective mathematics instruction, which results in improved student outcomes (Woolfolk Hoy, 2000). By providing preservice teachers with various opportunities to teach content, these preservice educators may be better prepared to become successful content teachers.

Mathematics Anxiety and Self-Efficacy

Ball (1990) states that beliefs such as preservice teachers' traditional views on teaching and anxiety of performing mathematics can pose barriers to developing a reformed vision of teaching mathematics. Assisting preservice teachers in developing greater teaching efficacy is salient to the development of their mathematics self-efficacy. Because mathematics is comprised of a variety of strands with different techniques and many students lack confidence in mathematics, self-efficacy for teaching mathematics has been frequently researched because of its impact on teachers' mathematics anxiety. Akin and Kurbanoglu (2011) conducted a study to examine the relationship between mathematics anxiety, mathematics attitudes, and self-efficacy for university students. They used correlation analysis using a structural equation model and confirmed previous research which suggests mathematics-anxiety as a consequence of low self-efficacy.

Mathematics anxiety is not just a dislike for mathematics but rather discomfort, a feeling of tension, helplessness, and mental disorganization when one has to perform mathematically (Richardson & Suinn, 1972; Wood, 1988; Vinson, 2001). Moreover, research also offers that teachers with high mathematics anxiety and low self-efficacy of teaching mathematics avoid teaching mathematics, which may hinder independent thinking about mathematics among students (Karp, 1991; Trice & Ogden, 1986). Researchers such as Wood (1998), Bush (1989), and Trujillo and Hadfield (1999) suggest that teachers with mathematics anxiety and low self-efficacy tend to unintentionally transfer and create mathematics anxiety

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among their own students. Hence, a need exists to provide prospective teachers with experiences that can positively impact their self-efficacy of mathematics. Prospective teachers who lack confidence and have low self-efficacy of content and teaching of mathematics tend to be teachers who have negative attitudes towards mathematics and teach in ways that develop low self-efficacy in their own students (Bekdemir, 2010). For educator preparation programs, understanding how teaching efficacy in mathematics impacts teaching methods and student achievement may help them prepare preservice teachers with the confidence and skills needed to become successful teachers.

Experiences for Preservice Teachers

According to Bandura (1986), self-efficacy is malleable and is impacted by the mastery experiences in which students are engaged. This becomes critical in teacher preparation programs. Preservice teachers should be provided with various opportunities to teach in their content areas, so that they may be better prepared to become successful content teachers. Though every teacher preparation program provides preservice teachers with opportunities to teach in traditional classroom settings, preservice teachers may also benefit from other experiences as well. According to Mohr-Schroeder et al. (2014), Tuchman and Issacs (2011), and Tichenor and Plavchan (2010), summer camps provide an informal learning environment which is instrumental in strengthening and reinforcing students' mathematics skills, thus preparing and inspiring students of all backgrounds to take higher level mathematics and science courses and increasing retention and enrollment for education programs. Gresham (2009) states that mathematics teaching efficacy may result from one's own negative beliefs and anxiety about mathematics, leading to decreased beliefs about one's ability to teach mathematics effectively. Informal experiences such as summer camps can provide an environment with no pressure of grades to help college students experience teaching of mathematics concepts in a more relaxed setting (Tichenor & Plavchan). Woocher (2004) and Tuchman and Isaacs (2011) recommend the use of high-quality informal experiences.

Motivated by this argument, the purpose of the current research was to understand whether or not college students' mathematics teaching efficacy beliefs would be impacted by facilitating a one-week intervention program for middle school students. Research questions were as follows:

1. To what extent do college students' mathematics teaching efficacy beliefs change following instructing a week-long mathematics summer camp?
2. How do college students' beliefs and attitudes about teaching mathematics change while instructing a week-long mathematics summer camp?

Methods

Five college students were hired as camp counselors for a week-long middle school mathematics summer camp, comprised of 20 students entering 6th, 7th and 8th grades. Three of the college students were education majors (special education, 4-8 generalist, and EC-6), while the other college students had majors outside the college of education (engineering and pre-law). All five college students reported previous experience working with children in the middle grades, though all the experiences were varied. The college students also revealed varied levels of expertise in their mathematical understanding.

Prior to the camp, college students participated in an all-day training, led by a certified mathematics educator, to assist them in understanding the mathematics concepts and the related activities. The college students worked through each mathematics activity themselves to ensure their understanding, comfortability, insight into the concept, and proper facilitation of each activity for the middle school students. The camp activities were designed to help middle school students learn how to apply difficult mathematics concepts to the real world; therefore, activities were hands-on and related to both current middle school mathematics standards and student interest. Camp counselors were responsible for leading the activities for small groups of three to four students and to facilitate student discussions to scaffold mathematical understanding of the concepts.

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Data Sources

To answer the research questions, researchers determined that both qualitative and quantitative research methods should be applied; therefore, a parallel convergent mixed-methods study was conducted. According to Morse (1991), convergent design helps “to obtain different but complementary data on the same topic” (p. 122). Furthermore, Creswell and Plano-Clark (2011) recommend a convergent parallel mixed method design when both qualitative and quantitative data are compared and contrasted for overall results of the study. The current study involves comparing quantitative and qualitative data in the form of survey and daily reflections to inform the results of the study.

Quantitative. College students’ mathematics teaching efficacy was assessed using the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI; Enochs et al., 2000). The MTEBI is comprised of two independent subscales, personal mathematics teaching efficacy (PMTE) and mathematics teaching outcome expectancy (MTOE). The PMTE assesses information related to teachers’ beliefs about student performance based on teacher actions (“I will continually find better ways to teach mathematics”), while the MTOE focuses on a teacher’s beliefs about his or her ability to teach (“If students are underachieving, it is most likely due to ineffective mathematics teaching”).

Qualitative. In addition to completing the surveys prior to and following the camp, college students also recorded their beliefs and attitudes about teaching mathematics in their daily journals. Students noted their experiences in teaching various mathematics concepts through the hands-on approach with activities connected to real-world. Counselors responded to questions, such as the following: What did you gain from facilitating students’ learning today? What stood out for you today? Describe an “aha” moment for you today.

Daily journals were completed in a Word document immediately following the camp every day. College students also completed a final reflection at the end of the camp to indicate what they gained from teaching the camp and what impact it had on them, for overall reflection about themselves and their teaching.

Results

Quantitative

In order to determine whether college students’ mathematics teaching efficacy was impacted as a result of the camp, averages for each subsection for self-efficacy were first determined for both the pre-test and the post-test. Then, a paired samples t-test was conducted for the college students’ responses to both sections of the MTEBI. Only one of the self-efficacy subscales attained significance, the MTOE, and the scale revealed an increase in mean differences between the pre-test (M=29.4, SD=3.58) and post-test (M=31.80, SD=4.44); $t(5)=.3.54$, $p = .02$. In other words, college students’ average responses to the MTOE increased significantly following their participation as a counselor in the camp. Students indicated little change from pre-test to post-test in the PMTE (as seen in Table 1).

Table 1
Results from Paired Samples t-Test Indicating Mathematics Teaching Efficacy

Self-Efficacy Construct	*t*
Personal mathematics teaching efficacy	3.54*
Mathematics teaching outcome expectancy	-.18

Note. * $p < .05$

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Qualitative

The daily reflections were analyzed qualitatively and independently by the two researchers. First, each of the researchers independently open-coded the reflections to form initial categories and segmented the information into tentative themes. Each of the researchers then independently used axial coding by taking the open codes to form categories or themes that relate to each other. Creswell (2007) defines axial coding as a way for researcher to take an open or divergent code and then go back to the data and create categories around the open codes. After independent coding, the researchers held discussions to compare and contrast the categories and themes for qualitative data results. Reliability of the codes was established through inter-coder agreement and member checking by the two researchers.

Member checking and cross-validating each researcher's codes on changing beliefs and attitudes among counselors throughout the week-long experience led to the emergence of three overarching categories/themes: increased understanding of student differences, importance of extrinsic motivation and the teacher to encourage students, and the importance of connecting mathematics to student interest and real world to keep students on task. Qualitative results can be seen in in Table 2.

Table 2
Themes from College Students' Daily Reflections

Theme	Evidence
Understanding Student Differences	• "Each student requires different levels of attention." • "It taught me that there are kids that could be on the same grade but on completely different level, even if they aren't in the same grades, some kids may just surprise you" • "I observed the children I noticed a difference in a lot of their attitudes"
Teacher to Encourage Students	• "ALL students can get excited and learn about mathematics as long as the instructor is excited and shows the students that they care about their learning experiences." • "I realized that many students need an extra push or encouragement to truly show their knowledge. My students knew what to do and had great ideas but needed me to encourage a discussion." • "When they get into formula and math that they haven't learned they get into the "I don't understand" and "it's too hard" mode, but just a little push in the right direction will really help them to grasp onto the unfamiliar."
Connecting Math to Students' Interests and Real-World Applications	• "The students can see how mathematics is used in the real world and be able to apply it to their own personal lives. Students learn better when the activities are relatable." • "No matter how difficult the concept if there is activity or real-world application which allow someone to apply that concept to that application, they will understand that concept better." • "I learned that adding a robot means kids, who normally roll their eyes when asked to complete an equation, will eagerly and willingly do any math you ask them."

Student differences. Student differences as an important component of teaching mathematics was realized by the college students. The experiences working with students and facilitating the camp every day resulted in college students' increased awareness of the differences in learning abilities and styles among middle-school students. The college students mentioned the different levels of understanding and learning of the students in several of their reflections. For example, the

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greatest impact of the camp for two counselors was to realize that “kids in same grade could be at completely different levels” and that “each student is different” and requires different attention and guidance. In addition, others mentioned the understanding of students as different learners, such as kinesthetic or visual, and the need to incorporate all learning styles to teach for understanding.

Importance of extrinsic motivation. The researchers also found another emergent theme from the reflections, emphasizing the importance of motivation as encouraged by the teacher or extrinsic factors. Several college students commented on the teacher and motivation as the keys in learning, such as “the teacher needs to make mathematics fun”, “as teachers we need to be excited to have students excited” and “ALL students can get excited and learn about mathematics as long as the instructor is excited and shows the students that they care about their learning experiences.” In addition, the college students also realized the need for a teacher to support, to guide, and to encourage learning. One of the college student said “I realized that many students need an extra push or encouragement to truly show their knowledge. My students knew what to do and had great ideas but needed me to encourage a discussion” which was echoed by others in different ways (see Table 2). Further on, college students developed an awareness of the importance of developing “rapport” between teacher and students for effective learning. They talked about matching personality, being encouraging, and maintaining a “patient attitude”.

Connecting mathematics to real-life. The most prominent theme that emerged from daily reflections was an understanding of the need to connect learning to students’ interests and real-life. All camp counselors talked about the need to make mathematics concepts relatable to the students and their lives for meaningful learning to happen. For example, two of the counselors wrote that “no matter how difficult the concept, if there is an activity or real-world application which allows someone to apply that concept to that application, they will understand that concept better”, and “students learn better when the activities are relatable.” In addition, all the camp counselors mentioned the importance of connecting learning to students’ interests. For example, according to camp counselors, the robotics lessons were most successful because the students were interested in working with robots.

Discussion

The purpose of the research study was to understand the extent that college students’ mathematics teaching efficacy might change while facilitating a week-long mathematics summer camp. College students indicated that their teaching efficacy changed as a result of facilitating the week-long mathematics camp. Specifically, their mathematics teaching outcome expectancy (MTOE) increased, which indicates that counselors experienced an increase in their beliefs about their ability to teach mathematics concepts to students. After participating in a week long hands-on learning experience with students, college students self-reported that they felt more confident in helping middle school students to improve their performance in mathematics, which is supported in previous research about facilitating hands-on experiences (Stein & Wang, 1998; Tuchman & Isaacs, 2011). In addition, college students’ reflections showed their increased understanding of specific strategies, such as motivation, interest, and differentiation that can help to improve student motivation and participation in mathematics. Though counselors did not indicate a change in personal mathematics teaching efficacy (PMTE) on the MTEBI, one college student did reflect that the camp helped her “adapt and be resilient without interfering with the students’ ability to learn” and “increased mathematical knowledge and pedagogy” at the end of the camp. The most prominent theme that emerged was college students’ understanding of the importance of connecting mathematics to students’ everyday lives. This theme may be more important, as research shows that preservice teachers that have not experienced mathematics learning or teaching through connection to real-world in an engaging manner tend to have low self-efficacy of teaching mathematics and more apt to transfer their own mathematics anxiety to students. Therefore, experiencing facilitating mathematics instruction in a hands-on real-life connection helped college students develop their own self-efficacy of teaching mathematics and significantly impacted their mathematics anxiety.

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Educational Impact

Camps like the one in this study have significant implications for college students and preservice teachers in mathematics. Participating in camps helps empower college students to make decisions that provide them with real-life experiences impacting their beliefs about teaching and learning. This is significant, because preservice teacher's attitudes are still malleable. Research indicates that established teachers' expectations regarding their own ability to teach and impact students' learning is less likely to change significantly, but impacting college students' self-efficacy can provide them with more flexible attitudes that may transfer to their future careers (Woolfolk, Hoy & Spero, 2005; Buss, 2010; Tuchman & Isaacs, 2011). Leading camps in specific disciplines, such as mathematics and science, can provide the means to experience content and teaching in a hands-on setting, and this may generate confidence. If so, it may translate into positive attitudes towards teaching mathematics and science.

Hands-on experiences in teaching have yet another major implication, which is to enhance the knowledge and self-efficacy of preservice teachers. Traditionally, college students have not had positive experiences learning mathematics in school. It is possible that facilitating a summer mathematics camp not only helps them develop confidence in their own ability but also positively impacts their view about their ability to teach a core subject. This research has implications for not only future teaching but also for STEM fields.

Yet another implication comes from the fact that preservice teachers have generally been taught mathematics through traditional means, and hence they have not experienced mathematics learning through real-world experiences. Mathematics summer camp provides one such platform for preservice teachers to experience teaching and learning of mathematics concepts through the real-world. Activities during the camp in this study included mathematics in the fountain, on the stop sign, in bubblegum, in creating giants, filling a glass, etc. These experiences provide an opportunity for preservice teachers to enjoy and develop a love for mathematics while not worrying about completing lesson plans or fulfilling course requirements. Experiencing the excitement of understanding mathematics through middle-school students can provide a powerful impetus to preservice teachers for their own mathematics learning. For example, as one of the college students said, "The moment that stood out to me was when the students were translating their own measurements into proportions close to Shaq's. They were so very amazed to see how big and tall they would be; it was nice to see the look of sheer wonder on their faces." This supports the premise that mathematics camps and providing preservice teachers with the opportunities to facilitate those camps is a positive move for teacher education programs.

Limitations and Future Research

Though the current research did find some significant results and findings for improving self-efficacy in future teachers of mathematics, some limitations should be considered. First, it can be assumed that due to a small sample size, a significant increase in PMTE was not seen, but perhaps a longitudinal measure or experience in a longer program, such as student teaching, would help to increase college students' PMTE. Future research may consider measuring student teacher's mathematics teaching efficacy during a semester-long hands-on experience to determine whether self-efficacy may increase. Another limitation of the current study was due to the fact that only three of the participants were teacher education majors. Though the other two participants had completed mathematics courses at the university level and had had previous experience working with kids, they had limited pedagogical knowledge in the field of education which may have skewed the results for self-efficacy measures. Future research may seek to validate results of this study by only focusing on those with majors in the field of education and concentrations in mathematics. In addition, the camp was only one week and hence influence of the camp facilitation may be presumptuous, but the results do show a change. By participating in additional camps and activities scattered throughout the year may offer another way to extend additional support for them to experience and enjoy teaching and learning mathematics.

One of the facts not highlighted by the camp was mathematics content knowledge and the difficulties faced by college students in facilitating the mathematics content for the middle school students. A future area of research would be

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investigating their pedagogical and content knowledge attitudes and perceptions as a result of facilitating a mathematics camp. Despite the small sample size and diverse sample of participants, results may provide those in the field of mathematics teacher education with another way to assist mathematics preservice teachers to improve their confidence and develop effective strategies for preparing to teach. In addition, college students participating in these experiences are more likely to make connections with other disciplines and thus may become more open to STEM fields.

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