DECREASING MATHEMATICS ANXIETY AND IMPROVING MATHEMATICS ENGAGEMENT IN ELEMENTARY CHILDREN DURING OUT-OF-SCHOOL-TIME WITH THE NAVIGATING NUMBERS INTERVENTION

by
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Abstract

Elementary school children from low-socioeconomic backgrounds have historically demonstrated low proficiency in mathematics. The following research study examines the causes of low mathematics proficiency among students from low-socioeconomic backgrounds, describes a needs assessment study that was conducted to understand the mathematics needs of students at two Baltimore City youth centers, and then describes an intervention that was designed to reduce mathematics anxiety and increase mathematics engagement. Children from one Baltimore City youth center in grades 3, 4, and 5 participated in an intervention that used mindfulness exercises and computer-aided instruction to decrease mathematics anxiety and increase mathematics engagement respectively. After the intervention, quantitative and qualitative data were analyzed to evaluate the results. The blended results from both data sets suggested neither any decreases in mathematics anxiety nor any increases in mathematics engagement.

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Conducting this research project was both challenging and insightful. I began this work as an idealistic graduate student thinking that technology could save the day. However, I walk away with more of an appreciation for how important people are to solving the challenges that we all face as human beings, be it learning mathematics or simply how to live healthy and productive lives. I have also been humbled by the support and encouragement I have received from my advisor, advisory committee, the youth center staff, my wife, my children, and my colleagues during this process. The results did not turn out as I had hoped; however, I believe this research study is another important step toward figuring out how human beings can leverage machines to help improve the quality of life for everyone—especially those who need it most.
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Executive Summary

This dissertation was conducted to understand the barriers to mathematics proficiency for Baltimore City students from low-SES backgrounds. The dissertation focuses on children in grades 3 through 5 who attended afterschool programs offered by their local youth center.

Determining how to increase mathematics proficiency is a broad area of study that requires the use of a theoretical framework to better understand the causal factors specific to this population of children. After reviewing learning theories related to mathematics proficiency, social cognitive theory (SCT) was the most relevant to helping me understand mathematics proficiency in the context of out-of-school time programs provided by organizations similar to neighborhood youth centers. The three central tenets of SCT are the reciprocal relationships between the person, the environment, and their behavior (Bandura, 1986). The literature review was conducted based on these three tenets.

The 15 causal factors of low mathematics proficiency that I identified were the school setting, family background, school policies, teacher quality, stereotype threat, out-of-school time, academic enrichment, teacher-student relationship quality, teacher beliefs, academic identity, academic self-efficacy, academic engagement, mathematics curriculum, mathematics instruction, and mathematics anxiety. After examining the causal factors related to the three tenets of SCT, I determined the factors with the most effect on mathematics proficiency that could be assessed and treated while at the youth center were mathematics anxiety, mathematics engagement, and academic self-efficacy.

After gaining a better understanding of the causal factors related to low mathematics proficiency in students from low-SES backgrounds, I designed and conducted a needs
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assessment to determine the mathematics anxiety, mathematics engagement, and academic self-efficacy levels of children at two Baltimore City youth centers. The needs assessment was a quantitative research study that evaluated mathematics anxiety, mathematics engagement, and academic self-efficacy using the Modified Abbreviated Mathematics Anxiety Scale, Elementary Student Engagement Instrument, and Modified Self-Efficacy Youth Questionnaire respectively. The study was conducted during the summer and included 20 children in grades 3 through 5 from two Baltimore City Title I schools. Findings from the mathematics anxiety assessment suggested that 85% of the children who participated exhibited some form of mathematics anxiety. Results from the questionnaire used to measure mathematics engagement showed that 95% of the participants were not engaged with mathematics academically. The final causal factor evaluated was mathematics self-efficacy. Findings from this assessment showed that 85% of study participants had moderate to high academic self-efficacy. After I reviewed the results from the needs assessment, I concluded that elementary students who attended the youth center might benefit from an intervention that focused on decreasing mathematics anxiety and increasing mathematics engagement. Since a vast majority of the participants showed moderate to high levels of academic self-efficacy, I did not include methods to address academic self-efficacy in the intervention.

The next step in the project was to review literature related to interventions for elementary students focused on decreasing mathematics anxiety and increasing mathematics engagement, preferably during out-of-school time. The interventions designed to increase mathematics anxiety included expressive writing, cognitive modeling, and computer adaptive programs. Expressive writing and computer adaptive programs both
showed varying degrees of effectiveness at reducing mathematics anxiety (Maloney, Schaeffer, & Beilock, 2013; Park, Ramirez, & Beilock, 2014). However, both were primarily used in the classroom setting. Cognitive modeling techniques, however, such as mindfulness exercises, had been used in both classroom and out-of-school time settings (Diamond & Lee, 2011; Khng, 2017). The greatest opportunity to use an intervention with demonstrated effectiveness and to contribute to the body of research related to using cognitive modeling to treat mathematics anxiety was to design an intervention that utilized mindfulness techniques. After examining the literature related to increasing mathematics engagement, the following types of interventions were explored: improving academic identity, computer-aided instruction, parental involvement, peer-assisted learning groups, and goal setting. The intervention for mathematics engagement was also selected based on which had the greatest potential impact and could be implemented in the youth center setting. Computer-aided instruction interventions conducted by Cole and Griffin (1987); Foster, Anthony, Clements, Sarama, and Williams (2016); Laffey, Espinosa, Moore and Lodree (2003); and Page (2002) showed evidence of increasing mathematics engagement for students from low-SES backgrounds. Since the literature has shown evidence of effectiveness, the youth centers have computer labs, and the number of high quality and engaging computer-based mathematics programs continues to increase, I decided to design an intervention that included computer-aided instruction. To implement the intervention, I also had to use platforms that were free of charge and could be easily accessed from a central website. After evaluating several platforms that met my selection criteria, I chose to address mathematics anxiety with the Mindful Choices curriculum from How iDecide. The platform chosen to increase mathematics engagement was a combination of Khan Academy
and Tivitz. Khan Academy was used to provide mathematics instruction in an engaging way, and Tivitz was used to practice mathematics using mathematics games. The Mindful Choices, Khan Academy, and Tivitz exercises were integrated into a website that I developed to make accessing the platforms easier during the intervention. The theory of change of the intervention was that the intermediate outcomes of the mindfulness, Khan Academy, and Tivitz exercises would be decreased mathematics anxiety and increased mathematics engagement. The impact of those outcomes would result in increased mathematics proficiency (Skinner & Pitzer, 2012). This theory of change was operationalized by dividing each exercise into three modules. Module 1 was designed to decrease mathematics anxiety through the use of mindfulness techniques, such as breathing exercises. Modules 2 and 3 were designed to increase mathematics engagement using computer-aided instruction programs, such as Khan Academy and Tivitz.

There were three research questions that I identified at the outset of the intervention. Research question one was, “Was the intervention completed with fidelity?” Research question two was, “Was completion of the intervention associated with a decrease in mathematics anxiety?” And research question three was, “Was completion of the intervention associated with an increase in mathematics engagement?” I developed a logic model to capture the inputs and activities that I needed to perform to obtain the desired outcomes and impacts from the research study. The research method used to evaluate the intervention was a mixed-methods approach with a parallel convergent design. This design gave me the best chance of increasing the confidence in my results, especially with a small sample size. The research study was conducted after COVID-19 restrictions were reduced at the youth center. The intervention was conducted with 11 youth center participants who
attended the local Title I elementary school. Participants were either third, fourth, or fifth grade students. I conducted a mathematics placement assessment and issued mathematics anxiety and engagement preintervention questionnaires the week before the intervention began. I delivered the intervention for 30 minutes from Monday through Thursday for six consecutive weeks during July and August of 2021. The week after the intervention concluded, I administered the mathematics anxiety and engagement postquestionnaires and conducted a focus group interview with the participants. Results were analyzed after the intervention.

An analysis of the results indicated that the intervention was implemented with high fidelity for two participants, moderate fidelity for two participants, and low fidelity for seven participants. This is important to note because the fidelity of implementation could have a direct impact on the mathematics anxiety and mathematics engagement results. The blended data for both mathematics anxiety and mathematics engagement did not suggest a decrease in mathematics anxiety or an increase in mathematics engagement. However, independent quantitative and qualitative results for mathematics anxiety and mathematics engagement show some evidence of change in a small percentage of participants. Recommendations for future studies include using or developing exercises that are developed specifically to decrease generalized mathematics anxiety, provide mathematics instructional videos that are more interactive, increase the duration of the intervention, and to limit the interaction between mathematics anxiety and mathematics engagement modules.

It is important to note that the intervention was delayed by over one year due to the COVID-19 pandemic. The pandemic caused a decrease in the number of youth center
attendees, which decreased the candidate pool for the research study. Participants in the study were required to wear masks and be separated by a distance of at least six feet. This requirement also limited the total possible study participants to 15 children. Another possible effect of the pandemic on this study was Zoom fatigue. This is when children spend too much time in front of the screen of a computer or mobile device which results in decreased learning (Peper et al., 2021). Prior to the research study, children who participated in the study spent much of the 2020-2021 school year attending classes remotely using a computer from their homes. Zoom fatigue could have also contributed to a lower desire to participate in screen-based interventions. When this research study was initially designed, computer-aided learning strategies were not widely used with this student population. This, in addition to the small sample size, should be taken into consideration before attempting similar studies.
Chapter 1 – Understanding the Problem of Practice

Many students from low-socioeconomic backgrounds will not have the opportunity to pursue careers in science, technology, engineering, and mathematics (STEM) fields if they do not develop a firm foundation in mathematics. According to National Assessment of Educational Progress (NAEP) test results, many students from low-socioeconomic status (SES) backgrounds score below proficient on state assessments as early as the fourth grade (Vanneman, Hamilton, Anderson, & Rahman, 2009). Completing Algebra I by eighth-grade is highly related to acceptance into STEM majors and success in college (Spielhagen, 2006). Therefore, elementary students need to be proficient in mathematics. Since student preparation in mathematics is cumulative, if students do not establish an adequate foundation during elementary school, it is unlikely they will successfully complete Algebra I by eighth grade (Spielhagen, 2006; Stein, Kaufman, Sherman, & Hillen, 2011). Students who take and succeed in advanced mathematics also earn more during their lifetime compared to students with low levels of mathematics proficiency (Spielhagen, 2006). Students with undergraduate degrees in engineering and computer science have a starting salary that averages 20% more than college graduates with degrees in humanities and social science (BLS Data, 2015; Rose & Betts, 2004). High paying careers in STEM often require the problem-solving and computational skills developed while taking advanced mathematics. Since low proficiency in mathematics can prevent students from being considered for STEM majors in college, it is critically important for students to adequately prepare for college coursework and ensure they are proficient in foundational, intermediate, and advanced mathematics. Other subjects have the potential to pave the way out of
poverty, but few subjects provide the return on investment that STEM careers do (Rose & Betts, 2004).

**Problem of Practice**

This research study examines the causes of low proficiency in mathematics of elementary students in Baltimore City, proposes an intervention to address those causes, and presents an evaluation of the intervention. The problem of low proficiency in mathematics became apparent after learning that children at a youth center in Baltimore City had trouble performing basic arithmetic operations, which are foundational to STEM literacy. The children had trouble calculating multi-digit addition and subtraction and performing operations with fractions. This was problematic because they were not able to fully participate in STEM programs without those skills. Not only did these present challenges to participation in the immediate STEM program, but it was also disconcerting because it could result in fewer opportunities to succeed academically and choose a STEM career. After having the children complete a mathematics assessment, I determined that many of them were at least one grade level behind in mathematics. This is what led me to try and understand the causes of low mathematic proficiency amongst elementary children from low-SES backgrounds in Baltimore City.

Many of the children at the youth center who attend the local elementary school score below proficient in mathematics (NAEP Baltimore City Report Card, 2015). According to the NAEP Baltimore City Report Card (2015), Baltimore City Public Schools (BCPS) consistently rank among the lowest performing in mathematics proficiency across the nation. NAEP includes mathematics assessments administered to fourth grade students once every two years and rates performance in mathematics as *below basic,*
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basic, proficient, or advanced (Bandeira de Mello, Bohrnstedt, Blankenship, & Sherman, 2015; NAEP Baltimore City Report Card, 2015). When 2015 fourth grade mathematics NAEP results are compared to 2013 results, the proportion of BCPS students who performed at or above proficiency decreased from 19% in 2013 to 12% in 2015. BCPS also saw the number of students performing below the basic level of proficiency in 2015 increase by 11%. Finally, out of 23 urban public school districts that took the NAEP assessment, fourth grade students in Baltimore City scored lower than 18 other urban school districts.

Approximately 80% of the BCPS population is African American, with 9% each of both White and Hispanic students (NAEP Baltimore City Report Card, 2015). The average NAEP test scores in mathematics for White students were 20 percentage points higher than African Americans and nine points higher than Hispanics. NAEP results also indicated that 73% of White students had a basic level of proficiency in mathematics, compared to 47% of African American students and 67% for Hispanic students. Comparing genders showed that the average score was the same for males and females. The percentages of males and females who performed at or above basic were similar, varying by only two percentage points. Results for students eligible for the National School Lunch Program (indicating students from low-SES backgrounds) revealed that 47% of the students scored below basic and 10% of students scored proficient or advanced. The results from specific Baltimore City schools show a clearer picture of the challenges across the city.

During the 2015-16 school year, Maryland students took the Partnership for Assessment of Readiness for College and Careers (PARCC) test to determine their
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proficiency in mathematics and reading. A total of 189 students in grades 3 through 5 from the school that feeds the neighborhood youth center of interest took the PARCC assessment in mathematics. On a five-point scale (1 meaning did not meet expectations and 5 meaning exceeded expectations), less than 5% of students in grades 3 through 5 exceeded expectations, 13.8% met expectations (level 4), 20.9% approached expectations (level 3), 31.6% partially met expectations (level 2), and 32.6% did not meet expectations (level 1) (MSDE Progress Report, 2016). Although determining students’ individual level of performance on the PARCC assessment was not possible, results from the local youth center’s feeder school indicated the presence of low mathematics proficiency among students at the school.

A student’s opportunity to learn is not limited to the classroom, and growth in achievement gaps has also been attributed to a lack of academic enrichment and practice during out-of-school time (OST) (Halpern, 1992; Kane, 2004; Lauer, Akiba, Wilkerson, Athorp, Snow, & Martin-Glenn, 2006). Children spend approximately six hours per day during the school year receiving classroom instruction. The remaining 10 waking hours is spent out of school. During a focus group conducted at the youth center, many of the children’s parents reported that they have trouble providing homework help or enrichment during OST due to a lack of time or familiarity with current mathematics strategies. Approximately 10% of children who attend the neighborhood school go directly to the neighborhood youth center for aftercare. Most of those students remain at the youth center for at least an hour per weekday during the school year. Neighborhood families have also come to rely on the programming provided by the youth center to help their children with homework and provide academic enrichment. However, due to overcrowding and limited
staffing, the youth center is not able to provide the same level of academic enrichment as for-profit academic enrichment programs. If local youth centers could provide the same quality of academic enrichment during OST that children from higher SES backgrounds receive, mathematics proficiency might be increased during the school year and summer (Halpern, 1992; Kane, 2004; Lauer et al., 2006).

Since youth centers are common fixtures in low-income urban neighborhoods and their goal is to provide a safe environment to improve the outcomes of at-risk youth, youth centers could be appropriate environments to improve mathematics proficiency and increase children’s chances of succeeding academically. The youth center of interest has a longstanding partnership with a local organization that focuses on increasing the number of STEM professionals from under-resourced communities. This research study attempts to determine whether enrichment in mathematics offered through the youth center could improve the children’s academic performance in mathematics.

In this chapter, I review the literature on the causal factors of low mathematics proficiency among students in primary and secondary schools. The following literature review was conducted to gain an understanding of the causal factors of low mathematics proficiency among students from low-SES backgrounds.

**Theoretical Framework**

My problem of practice is the low mathematics proficiency of third through fifth grade students from low-SES backgrounds at Baltimore City youth centers. I used social cognitive theory (SCT) to conceptualize my problem of practice. The SCT model provides a conceptual framework that explains how students learn through the reciprocal interactions between the person, their behavior, and the environment (Figure 1.1) (Bandura,
I chose this framework because it helped explain the interactions that children experience that could influence proficiency in mathematics. For example, a child’s learning environment may interact with their behavior during mathematics instruction and influence their learning outcomes. A child’s behavior during mathematics instruction could affect their learned experience, which in turn affects their comprehension of mathematics concepts. Finally, the same child’s learning experience could also result in positive or negative feelings about the learning environment. Each interaction is bi-directional and addresses the factors that influence learning (Bandura, 1986).

![Diagram of social cognitive theory](image)

*Figure 1.1. Social cognitive theory illustrated by the central tenet of triadic reciprocity of causality (Bandura, 1986). Depicts the interactive determinants that influence mathematics proficiency.*

The articles in this literature review were identified using the model of triadic reciprocity to help conceptualize low mathematics proficiency in the Baltimore City youth center of interest. Each causal factor in this literature review is related to a reciprocal interaction between the person, their behavior, and the environment (Figure 1.1). Examples of how causal factors were identified include reviewing articles that examined the reciprocal interaction between environment and person that determined how teachers and
the school environment directly affect a student’s mathematics proficiency. Reviewing articles related to the reciprocal interaction between the environment and behavior to identify factors that influence how parent and teachers’ perceptions about learning affect a student’s behavior towards mathematics. Finally, articles that examined the causal factors related to the reciprocal interaction between behavior and the person and how student behaviors, such as anxiety, can impact what a student thinks about their mathematics proficiency. Since the triadic reciprocity model addresses the major processes that determine how learning occurs, SCT provided a conceptual framework that helped me conduct a comprehensive review of literature related to the causal factors of low mathematics proficiency.

**Review of Literature on the Causes of Low Mathematics Proficiency**

This section reviews research literature to explain low mathematics proficiency in elementary students from low-SES backgrounds to inform the development of a needs assessment study. Literature from peer-reviewed articles, federal and state research, and books by researchers with publications in peer-reviewed journals were selected. During the review, I used SCT as a framework to identify the causal factors of low mathematics proficiency of third through fifth grade students from low-SES backgrounds at Baltimore City youth centers. The causes of low mathematics proficiency are vast and required a systematic way of identifying them. Therefore, I used the three primary determinants of SCT as a framework to search for related categories of literature. The categories were reflective of the interactions between person and behavior, person and the environment, and the environment and behavior. Since there can be more than one reciprocal interaction for each causal factor, the triadic reciprocity model was used to ensure that there were
multiple constructs representing each interaction. This approach resulted in the identification of 15 causal factors that contribute to low mathematics proficiency. Those factors are school setting, family background, social policies, stereotype-threat, teacher quality, OST academic enrichment, teacher-student relationship quality (TSRQ), teacher beliefs, parental beliefs, academic identity, academic self-efficacy, academic engagement, mathematics curriculum, mathematics instruction, and mathematics anxiety. The person variables that influence behavior could include academic identity, academic self-efficacy, mathematics anxiety, and stereotype-threat. The environmental factors that influence both the person and the person’s behavior may include school setting, family background, teacher quality, OST academic enrichment, TSRQ, mathematics instruction, and mathematics curriculum. And the interactions between the environment and behavior could include social policies, teacher beliefs, parental beliefs, and academic engagement. Many of the factors, such as stereotype-threat and teacher quality, and social policies could be categorized by multiple reciprocal interactions; therefore, it is important to note that my categorization of the factors may be classified differently by others. This approach was used as a systematic way to identify constructs to better understand the causes of low mathematics proficiency for third through fifth grade students from low-SES backgrounds. The following literature review examines these 15 causal factors. The literature review concludes with a summary of the causal factors related to low mathematics proficiency in students from low-SES backgrounds and a recommendation for an empirical needs assessment study.
School Setting

Schools are among the most influential environments that promote learning or prevent students from learning (Bachman, Votruba-Drzal, El Nokali, & Castle Heatly, 2015; Dumay, Boonen, & Van Damme, 2013; Hardiman, 2010; Tanner, 2008). Schools influence learning based on the social interactions between students, teachers, administrators, and parents (Dumay et al., 2013). Learning inside the school building is also influenced by the physical environment, including how well it is designed, decorated, and maintained (Hardiman, 2010; Tanner, 2008). A well-designed classroom environment lets children know how much their teacher cares about them and can help put children at ease during instructional time. Disorganized and inadequate classrooms can make children feel that they and the lesson are not important (Hardiman, 2010).

The social setting, schoolwork, and school facilities often impact students’ feelings about learning. The physical learning environment should include a focus on the importance of the classroom environment’s ability to facilitate learning (Hardiman, 2012). Students are more cognitively stimulated in classrooms that are visually inviting and include calming sounds and scents to put students in an emotional state that is more conducive to learning (Hardiman, 2012). The mechanism of action is that positive physical school environments cause students to release endorphins, which allow the brain to receive more information (Hardiman, 2012; Hardiman, Rinne, Gregory, & Yarmolinskaya, 2012). In instances where the physical environment is unappealing, students have a higher likelihood of being disengaged due to physical cues that indicate a low level of caring by the teacher (Hardiman, 2012). Wu, Hughes, and Kwok (2010) showed that when students are disengaged and disruptive, they are either unable or unwilling to learn. Therefore,
ensuring a suitable school learning environment is important, especially for mathematics, since the physical classroom environment can have a direct effect on learning while in the school (Hardiman, 2012). Not only is the classroom environment important to learning, but the external environment must also be considered when determining the factors that contribute to mathematics proficiency.

The school setting can have profound effects on students’ proficiency in mathematics. The school environment includes the social norms and rules demonstrated by people operating within the physical environment of school ecosystems (Hardiman, 2012). The social norms of a school are established based on the types of student-teacher, teacher-administrator, and administrator-student interactions. Of these interactions, relationship quality between student and teacher is most predictive of mathematics proficiency outcomes, (Allen, Gregory, Mikami, Lun, Hamre, & Pianta, 2013; Pianta, Hamre, & Allen 2012; Wu et al., 2010). Learning is also influenced by forces external to the school environment, such as the child’s family background (Salle, Meyers, Varjas, & Roach, 2015; Sheldon & Epstein, 2005).

**Family Background**

Family background also contributes to mathematics proficiency and includes factors such as family income, family education, and community influence. Family income is related to academic achievement, and low mathematics proficiency is also a function of differences in household income (White, Stepney, Hatchimonji, Moceri, Linsky, Reyes-Portillo, & Elias, 2016; Williams, Haertel, Kirst, Rosin, & Perry, 2011). Between 2001 and 2011, the disparity in academic achievement between students from high- and low-SES backgrounds increased by at least 30% (Reardon, 2011). Students from high-SES families
benefit from their parents’ educational experiences, awareness of academic enrichment opportunities, and the ability to pay for those opportunities (Downey, Von Hippel, & Broh, 2004; Reardon, 2011). Higher-income families with higher levels of education are able to provide academic enrichment, tutors, and high quality summer camps (Downey et al., 2004; Reardon, 2011). However, low-SES households typically are not able to provide the same OST enrichment opportunities (Reardon, 2011). Enrichment support for students from low-SES backgrounds during OST requires considerable financial investment (Rivkin, Hanushek, & Kain, 2005).

In communities with high concentrations of residents from low-SES backgrounds, many earn wages below U.S. poverty standards, have not completed a four-year degree, and face high levels of crime and violence (Royce, 2018; Ruiz, McMahon, & Jason, 2018). Children who live in these communities may face high levels of stress related to food, housing, and personal safety (Royce, 2018; Ruiz et al., 2018; Smith, 2017). These stressors can impede learning by focusing families on fulfilling basic needs such as finding food, shelter, and safety, as well as establishing social belonging, instead of goals more closely associated with self-esteem and self-actualization. According to Maslow’s (1943) hierarchy of needs, students must have their basic needs met before they are able to engage in self-actualizing behaviors, such as learning classroom subjects that are not essential to immediate survival. Since focusing on basic survival needs can translate to being in a constant state of stress, many students from low-SES backgrounds may see little value in focusing on the cognitive development required to reach self-actualized goals. In a study conducted to determine the effects of stress on cognitive functioning, Carrion, Wong, and Kletter (2013) used neuroimaging techniques and showed that students from low-SES...
backgrounds exhibited symptoms very similar to posttraumatic stress disorder. Their findings also supported prior research that showed stress causes the release of cortisol, which reduces the size of the hippocampus and has a negative impact on cognitive development and functioning. Each year over 700,000 US children experience abuse and neglect resulting in pediatric PTSD symptoms (USDHHS, 2010). This is an indication that many US children may be living in environments that cause pediatric PTSD which could contribute to learning difficulties. Greater investment is needed to better understand the extent of pediatric PTSD in these communities and develop strategies to help these students perform on par with their higher-SES contemporaries.

Social Policies

The social policies of metropolitan cities are factors external to the school environment that contribute to low academic performance in mathematics (Gamoran & Long, 2007; Ogbu, 2004; Reardon, 2011). Social policies in this context are decisions made by politicians, policymakers, and government officials at various levels that directly or indirectly have an impact on schools or neighborhood demographics. Examples of these policies include the amount of tax spent on local schools, policies that attract businesses that can provide affordable internet access, and policies that promote mixed-income communities to increase the number of teachers from the local community. Historically, the idea of separate but equal social policies began to be challenged during the 1950s because it had become apparent that the policies resulted in unequal treatment and education. This policy was taken to court in the case of Brown v. Board of Education, which challenged the idea that equal access to education could be realized in segregated schools (Warren, 1953). The process of redlining was another way to discriminate against African Americans and
other ethnic minorities. Redlining was the process of designating specific areas across the United States as high risk locales for mortgage loans (Pietila, 2012). In Baltimore, redlining was used to systematically control where African Americans could buy homes and live by limiting access to mortgage loans and through other unfair housing practices (Pietila, 2012). This resulted in segregated neighborhoods, which led to segregated schools and unequal allocation of school resources (Pietila, 2012). The results of redlining continue to be evident in Baltimore City and contribute to the segregation of schools and the perpetuation of the achievement gap (Reardon, 2016). Decades after desegregation, schools have remained segregated because of school district boundaries, White flight, and a lack of neighborhood diversity (Lipman, 2013). These systematic policies create educational barriers for African Americans and other ethnic minorities, which contribute to low mathematics proficiency (Reardon, 2016).

**Teacher Quality**

Although a single definition of teacher quality is the subject of debate, researchers agree that two of the characteristics of teacher quality that most affect minority students and students from low-SES backgrounds are lack of teaching experience and out-of-field teaching (Hanushek & Rivkin, 2010; Hanushek, Kain, O'Brien, & Rivkin, 2005; Peske & Haycock, 2006). According to some estimates of teacher quality, only 25% of US students have access to high quality teachers (Akiba, LeTendre, & Scribner, 2007), and one-third of US eighth grade students are being taught mathematics by teachers with less than three years of teaching experience, without a mathematics teaching certificate, or without an undergraduate degree in mathematics (Akiba et al., 2007). This lack of teacher experience
across school districts results in teaching inequality and is considered a contributor to achievement gaps, especially in mathematics (Peske & Haycock, 2006).

Another factor related to teacher quality found in school districts with large minority and low-SES student populations is out-of-field teaching (Peske & Haycock, 2006). Out-of-field teaching is when students are taught subjects, such as mathematics and science, by teachers that do not have an undergraduate degree, minor, or teaching certificate in those teaching specialties (Peske & Haycock, 2006). In studies of teacher quality in US urban school districts, middle and high school children are at least two times as likely to be taught by inexperienced and out-of-field teachers (Hanushek & Rivkin, 2010; Hanushek et al., 2005; Peske & Haycock, 2006). This puts minority children from low-SES backgrounds at considerable risk of not becoming proficient in mathematics.

One of these issues alone can have negative impacts on minority students from low-SES backgrounds’ proficiency in mathematics. However, if both are present students are at an even greater disadvantage (Akiba et al., 2007; Hanushek & Rivkin, 2010; Hanushek et al., 2005; Peske & Haycock, 2006). When students are taught by high quality teachers, students are more successful academically and have more earning potential during their lifetime, which is especially beneficial for students from low-SES backgrounds (Milner, 2013; Peske & Haycock, 2006). Although teacher quality has a direct relationship to mathematics proficiency, there is also strong evidence that the mathematics assessment results of African Americans are influenced by stereotype-threat (Okagaki, 2001; Steele, Spencer, & Aronson, 2002; Steele, 1997).
Stereotype-threat

Stereotype-threat occurs when the fear of confirming societal stereotypes about one’s own social group influences the intellectual functioning of a member of the group in question (Steele, 1997). Students in stereotype-threatened situations are subject to the activation of mental processes that have a dampening effect on learning (Steele et al., 2002; Steele, 1997). In a classroom setting where over 80% of students come from low-SES backgrounds and may be taught by teachers from different racial groups and SES backgrounds, students will often find themselves in a learning environment where they may experience stereotype-threatened conditions. The stereotype most closely associated with low-SES African Americans is that they are unable to perform well in academic subjects compared to their White or higher-SES counterparts. Many African American students are aware that school administrators and teachers will compare their standardized test results to White students in their school districts and may expect them to be less proficient. Therefore, under certain circumstances, stereotype-threat may cause these students to perform at lower levels than their White counterparts in their schools or in their school district.

Furthermore, if students’ fear of confirming the beliefs of others about their mathematics ability are affected by stereotype-threat, their performance on mathematics assessments may not accurately represent proficiency. Evidence from studies of stereotype-threat indicates that students may have the ability and skillset required to be fluent and proficient in mathematics, but may be unable to demonstrate it under stereotype-threatened conditions (Good, Aronson, & Inzlicht, 2003; Maloney et al., 2013; Steele et al., 2002). Maloney et al. (2013) provided examples of their study participants demonstrating that they
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knew how to perform mathematical tasks under non-stereotype-threatened conditions; however, they had trouble performing the same tasks under stereotype-threatened conditions. Their findings showed low performance of African American students in mathematics because of a psychological effect instead of an inability to understand or solve the equations. Though stereotype-threat influences mathematics assessment results, mathematics proficiency is also affected by the amount and type of academic exposure children receive during OST.

OST Academic Enrichment

Differences in how children spend their time during OST contribute to low mathematics proficiency and contribute to the widening of the achievement gap (Alexander, Entwisle, & Olson, 2007; Burkam, Ready, Lee, & LoGerfo, 2004). Many children from high-SES backgrounds spend their time in high quality enrichment activities; however, children from low-SES backgrounds typically spend their OST participating in lower quality programs or not enrolled in any enrichment programs. The gap in achievement between high- and low-SES children grows at a slower rate during the school year compared to the summer, and it is during summer break when the gap increases the most (Alexander et al., 2007). The explanation for the increased gap during the summer is that there is a disparity between the gains realized via high and low-quality summer enrichment that cannot be overcome by instruction during the traditional school year (Downey et al., 2004). Examples of high quality OST programming during the school year include tutoring programs such as Kumon, Mathnasium, and Sylvan (Leos-Urbel, 2015). These programs cost an average of $400 per month for each child, which can be prohibitive to parents with lower incomes. The programs also require children to complete
supplemental assignments at home in addition to their homework. These program requirements can be demanding for high-SES families and even more so for low-SES families. Lower quality academic enrichment programs are typically operated by volunteers, have loose selection criteria, are broad in focus, and have low accountability measures. The effects of OST academic enrichment are most apparent when students begin ninth grade (Alexander et al., 2007). Students who have not done well or have not taken the appropriate mathematics prerequisites are unable to take the more advanced mathematics classes that could lead to more career options. In most US school districts, if students have not taken and earned at least a C in Algebra I by the end of eighth grade, they are placed on a curriculum pathway that prevents them from taking mathematics beyond Algebra II before they graduate from high school.

**Teacher-student Relationship Quality**

The relational transactions between students and teachers affect engagement, which has a direct impact on academic proficiency (Hughes, Luo, Kwok, & Loyd, 2008). Examples of the interactions between teacher and student are demonstrated caring, mutual respect, cultural sensitivity, and effort and enthusiasm about instructional content. High TSRQ improves the academic outcomes of students and seems to be more important for students from low-SES backgrounds than for students from high-SES backgrounds (Hughes et al., 2008). High TSRQ is also related to increased effortful engagement, which leads to increased proficiency in mathematics (Hughes et al., 2008). TSRQ also increases school engagement for low-income urban youth (Murray, 2009). Primary and secondary school teachers have reported lower TSRQ for African American students, especially boys, compared to White and Hispanic students (Wu et al., 2010). Any negative tension between
students and teachers can result in a school environment that is not optimal for learning (McCormick, O'Connor, Cappella, & McClowry, 2013), as it can contribute to negative student behaviors and students who are less receptive to learning from the teacher. When students are unwilling to receive instruction from teachers, academic engagement and eventually proficiency decrease (McCormick et al., 2013).

Low TSRQ not only has an effect on students, but teachers are negatively affected as well (Mason, Hajovsky, McCune, & Turek, 2017). Teachers who are unable to establish high quality relationships with students may be less willing to provide instructional supports that are critical to providing effective instruction, such as teaching strategies for approaching problems, mnemonic devices for remembering formulas, and pausing during explanations to allow students time to mentally code and store new information in long-term memory (Wu et al., 2010). A positive school environment resulting from high TSRQ can also support improved mathematics proficiency by helping to establish social norms that make learning socially acceptable amongst students in the classroom setting (Wu et al., 2010). TSRQ sets the tone for the school environment and heavily influences how students perform in subjects such as reading and mathematics during classroom time (Pianta et al., 2012). Just as TSRQ can impact learning, what teachers believe about a student’s academic ability is also important.

**Teacher Beliefs**

Teachers’ beliefs about the ability of their students to learn are important to the academic achievement of their students, especially in mathematics (Ferguson, 2003). When teachers approach the instruction of students, especially minorities, from a deficit perspective, they are less likely to use effective teaching strategies or find creative ways to
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Teach (Flores, 2007; Schunk, 2012). Teachers who believe in the academic ability of their students change their teaching behaviors by spending more time explaining difficult concepts, demonstrating more care, and presenting curriculum beyond the scope of the course to help prepare them for more advanced coursework (Ferguson, 2003; Flores, 2007). When teachers do not believe their students have the aptitude or desire to learn, their teaching behaviors are less likely to change and can contribute to low academic achievement and low mathematics proficiency (Flores, 2007). Another factor that contributes to low mathematics proficiency is parental beliefs about mathematics.

**Parental Beliefs**

Parental beliefs about mathematics performance can have a negative influence on mathematics proficiency (Lee & Bowen, 2006). When parents communicate that not being proficient in mathematics is okay because they are not a “mathematics person,” it can negatively affect a child’s beliefs about their mathematics ability and ultimately their performance in mathematics (Rattan, Good, & Dweck, 2012). The subtle messages that adults send to their children can communicate a social acceptance of not being proficient in mathematics. Parents typically acknowledge that learning mathematics is important, but many are unable to articulate why mathematics beyond basic arithmetic is important. This may contribute to a culture where having a low proficiency in anything beyond arithmetic is socially acceptable (Rattan et al., 2012). Unfortunately, this limited understanding of the importance of more advanced mathematics, such as algebra, trigonometry, and calculus, may contribute to the low performance of US students in mathematics (Ma, 2001). Parents sometimes also believe that they must know how to perform more complex mathematics problems themselves to encourage their children to take more advanced mathematics (Ma,
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2001). However, parents can encourage their children by identifying resources that will provide the help they may be unable to deliver.

Another factor related to parental beliefs is the generational transfer of attitudes and behaviors from parents to children (Glass, Bengtson, & Dunham, 1986). Students spend the majority of their lives with their families, and thus family norms and beliefs have the potential to be a tremendous influence on their beliefs and attitudes toward mathematics proficiency. According to Glass et al. (1986) and Kalmijn (2015), both the beliefs and attitudes of family members are related to the beliefs and attitudes of their children. In particular, familial beliefs about opportunity and upward mobility pathways can result in positive or negative effects on their children’s academic achievement and proficiency (Carter, 2006; Ford, Grantham, & Whiting, 2008; Fordham & Ogbu, 1986). Fordham and Ogbu (1986) determined that African American student performance is influenced by how strongly the immediate family and community believe that academics will result in high paying jobs and community acceptance. Community beliefs about the fairness of the academic opportunity pathway have not always been strong, which affects how students engage, disengage, or cope with academic work and develop proficiency (Curry, Jean-Marie, & Adams, 2016). Muenks, Wigfield, and Eccles (2018) showed how the expectancy beliefs of parents about academics influence a child’s academic performance. Although there is some evidence that transference of beliefs and attitudes from parents and the community affects the academic proficiency of students, there are no statistically significant results that show a strong correlation (Muenks et al., 2018). Parental beliefs about mathematics contribute to a student’s mathematics proficiency; however, students’
personal beliefs about their academic identity also play a direct role in their mathematics proficiency (McGee & Pearman, 2014).

**Academic Identity**

Academic identity can be conceptualized in a number of ways. One concept that may be relevant to how African American primary and secondary students form their academic identities is racial centrality. Racial centrality is a construct that describes the extent to which a person defines him or herself normatively regarding race (Sellers, Smith, Shelton, Rowley, & Chavous, 1998, p. 25). Racial centrality has been identified as a precursor to the academic identity of African American students, as it helps buffer adolescent children from negative peer pressure and racial discrimination in the classroom (Butler-Barnes, Varner, Williams, & Sellers, 2017). Nasir, McLaughlin, and Jones (2009) identified two configurations of racial academic identity: street savvy versus school-oriented and socially conscious. The street-savvy configuration is associated with students’ pattern of dressing and not caring about education or societal rules. The school-oriented and socially conscious configuration is associated with students who have a strong sense of and connection to the local and national community and a sense of being a student. Of the two configurations, school-oriented identities were predictive of academic achievement and engagement (Nasir et al., 2009). The formation of academic identity cannot be solely attributed to racial centrality; therefore, this construct was used as a conceptual framework to understand how African American students may form an academic identity and how academic self-efficacy might contribute to low mathematics proficiency.
Academic Self-efficacy

Academic self-efficacy leads to resilience which can mitigate low mathematics proficiency by helping students develop the attributes commonly found amongst good students. Academic self-efficacy, those self-efficacy beliefs about academic functioning, are defined as a personal belief in one’s capability to organize and execute courses of action required to attain designated types of performances, also described as task-specific self-confidence (Bandura, 1997). Students reference their performance in classroom settings as an indirect measure of their academic self-efficacy in content areas such as mathematics (Schunk & Meece, 2006). In subjects such as mathematics, where it is important to persevere when facing difficult problems, academic self-efficacy is needed to develop fluency and proficiency. Mathematics fluency is developed through familiarity and proficiency through practice (Burns, Ysseldyke, Nelson, & Kanive, 2015). In today’s classrooms, teachers have limited time to help their students understand many mathematics concepts in depth (Zimmerman & Kitsantas, 2005). The act of developing proficiency typically requires practice beyond the classroom, and students typically leave the classroom without developing fluency. This can result in students being unsuccessful at completing homework, causing their self-efficacy in mathematics to diminish (Zimmerman & Kitsantas, 2005). This challenge is further exacerbated in low-SES communities, where many students do not have structured homework time or lack a safe place to complete homework and get effective homework help (Cosden, Morrison, Albanese, & Macias, 2001). Developing proficiency and persistence in mathematics requires that students have positive academic self-efficacy and a willingness to attempt mathematics computations slightly beyond their existing skillset (Zimmerman & Kitsantas, 2005). If children are not
self-efficacious about mathematics, they could develop attitudes and behaviors that reduce academic engagement and increase low proficiency in mathematics.

**Academic Engagement**

The development of academic self-efficacy in students can also affect academic engagement, another precursor to mathematics proficiency (Liu, Zhen, Ding, Liu, Wang, Jiang, & Xu, 2018; Skinner, Wellborn, & Connell, 1990). If students are self-efficacious in performing particular mathematics tasks, then they are more likely to be engaged during related mathematics instruction and practice. Student engagement is a function of relatedness, autonomy, and competence and is a precursor to academic proficiency (Skinner & Pitzer, 2012). If students lack academic self-efficacy, they typically exhibit low engagement (disaffection) and employ coping mechanisms, which can be divided into the following categories: problem-solving, help-seeking, and escape (Skinner & Pitzer, 2012). If students overuse escape-oriented coping mechanisms, they become demotivated and cease to engage in exercises designed to increase mathematics proficiency (Ramdass & Zimmerman, 2011; Skinner & Pitzer, 2012). Students from low-SES backgrounds can also become disengaged after comparing themselves to more proficient peers, with two pathways that can lead to the same outcome. If students compare themselves to a peer that understands concepts at a deeper level than they do, they may assume the peer is smarter. Alternatively, if a student compares himself to a peer and determines that the peer does not understand, then he may reduce his effort to be accepted socially. In either scenario, the outcome is students that are less academically engaged and less willing to engage with the mathematics curriculum.
Another causal factor of low mathematics proficiency is the quality of the curriculum. High quality teachers are important, but it is equally important for teachers to have access to meaningful curricula and appropriate instructional materials (Lubienski, 2002; Schoenfeld, 2002). The characteristics of high quality curricula are mathematics units that are scaffolded, provide multiple examples that are rich and meaningful to students, and provide opportunities for student collaboration and adequate practice (Lubienski, 2002). The curricula should cover the five mathematics strands of numbers/operations, geometry, measurement, data analysis, and algebra/functions (Lubienski, 2002). Teachers who provide instruction for students from low-SES backgrounds should also utilize curricula that cover facts and concepts, skills and procedures for solving routine problems, reasoning skills for solving unique problems, and communication of mathematics ideas (Lubienski, 2002). When teachers use curricula that cover the high quality characteristics, five strands, and problem-solving strategies, they ensure the curriculum is of sufficient quality for students regardless of SES background (Lubienski, 2002). Not only does using this approach ensure that the curriculum is high quality, it also ensures that mathematics concepts are represented in a way proven to increase mathematics proficiency. The Common Core Mathematics Standards are the most recent attempt at ensuring equitable access to a high quality nationwide mathematics curriculum.

High quality mathematics curricula for students from low-SES backgrounds and different racial groups also require equitable approaches to providing instruction.
Lubienski’s (2002) study on the achievement gap in mathematics concluded that mathematics instructional practices differed by racial groups. The majority of African American students in the study were taught that mathematics is learned through memorization and that there is only one way to solve mathematics problems. In contrast, White students in the study were taught that mathematics is learned through practice and that problems could be solved in multiple ways. The methods used to teach African American students mathematics led to low proficiency, though the instruction provided to White students led to higher mathematics proficiency (Lubienski, 2002). These two approaches contributed to a considerable difference in how the two groups approached solving mathematics problems and resulted in mathematics proficiency differences.

Similar differences were observed when technology such as computers and calculators were used as instructional tools. During class instruction, African American students were taught to use computers and calculators for practice drills and to play games; although, White students were taught to use the same tools for problem-solving (Lubienski, 2002). As an example, calculators can be used for computation or to visualize and manipulate equations (National Research Council, 2001). When calculators are incorporated into instruction, they can be used as a way of gaining a deeper understanding of mathematics properties (National Research Council, 2001). Computers can also be powerful instructional aids for teaching mathematics. Most computers have the same capability as calculators, but they also allow students to use specific mathematics programs to explore more abstract elementary concepts such as ratios and proportions. When calculators and computers are only used to conduct practice drills and play mathematics games, it reinforces the belief that mathematics can be learned by simple memorization and
that there is only one approach to solving problems (Lubienski, 2002). These beliefs lead to limited problem-solving strategies and suboptimal use of technology, which limits African American students’ ability to develop proficiency in mathematics and contributes to the mathematics achievement gap between White and African American students (Lubienski, 2002). Even after teacher quality, mathematics curricula, and mathematics instruction have been adequately addressed, mathematics anxiety can contribute to differences in mathematics proficiency outcomes.

**Mathematics Anxiety**

Mathematics anxiety is an adverse reaction to mathematics or a negative reaction when one is asked to perform mathematics (Maloney & Beilock, 2012). The causes of mathematics anxiety have been linked to the transference of anxiety from teachers and/or parents during mathematics instruction, or a student’s perception of the classroom as not being a caring and nurturing environment (Chang & Beilock, 2016). The mechanism of action of mathematics anxiety on achievement is a diminished capacity of working memory during mathematics anxious conditions, such as instruction and assessment (Chang & Beilock, 2016; Maloney & Beilock, 2012). The lack of availability of working memory inhibits children from enacting advanced problem-solving strategies during mathematicially anxious conditions, especially those with more highly developed working memory. In the early stages of understanding the relationship between mathematics anxiety and mathematics proficiency, only adults were thought to be affected (Maloney & Beilock, 2012). In recent years, researchers have discovered sufficient evidence to support the presence of mathematics anxiety in elementary students as early as first grade (Chang & Beilock, 2016; Ramirez, Chang, Maloney, Levine, & Beilock, 2016). Recent international
studies also show that the relationship between mathematics anxiety and mathematics proficiency is experienced worldwide (Chang & Beilock, 2016). Thirty-three percent of students who took the Programme for International Assessment (PISA) reported feelings of helplessness and anxiety during the assessment (Chang & Beilock, 2016). Fourteen percent of the variance in mathematics performance on the PISA can be attributed to mathematics anxiety when students are compared across countries (Chang & Beilock, 2016). When children experience the physiological indicators of mathematics anxiety, such as sweating, feelings of nervousness, and negative comparison to peers (Galla & Wood, 2011; Schunk, 2003), these indicators can provide subtle cues to children about their ability (Galla & Wood, 2011) and subsequently cause a student not to identify with being a good mathematics student.

**Summary of Causes and Factors of Low Mathematics Proficiency**

The triadic reciprocity framework informed my understanding of how the causal factors can represent more than one type of interaction and impact learning in the context of mathematics. The 15 underlying causal factors identified and explored with this method all vary in how much they influence mathematical proficiency among students from low-SES backgrounds. After examining the articles related to the 15 causal factors of low mathematics proficiency, the school setting had the most direct effect on mathematics proficiency, specifically the social norms, schoolwork, and school facilities. Home environments are where many children discuss and practice mathematics. In many low-SES minority homes, children’s ability to discuss and practice mathematics is typically not the same as their higher-SES White counterparts (Rattan et al., 2012). This has been attributed to differences in parental education, the amount of self-care after school, and parents’
relationships with teachers (Halpern, 1992; Kane, 2004; Lauer et al., 2006). The most direct opportunity to influence mathematics proficiency in the home environment is during homework time. However, interactions that can have a positive effect on mathematics proficiency depend, in part, on the aforementioned factors in the home.

Other key causal factors that influence mathematics proficiency are teacher quality, stereotype-threat, and OST academic enrichment. Several studies provide strong evidence that teacher quality is directly related to mathematics proficiency (Hanushek & Rivkin, 2010; Hanushek et al., 2005; Peske & Haycock, 2006). Although there is evidence of a strong relationship, I do not have the access or resources required to study this construct. There is considerable evidence that stereotype-threat greatly influences mathematics proficiency among students from low-SES backgrounds. Stereotype-threat has been shown to cause lower performance in mathematics assessments among African American and female students and contributes to low mathematics proficiency (Okagaki, 2001; Steele et al., 2002; Steele, 1997). However, stereotype-threat is most likely to influence the results of mathematics assessments when African American students are told they are being compared to White students. The purpose of this research study was to improve mathematics proficiency, not performance on assessments. Therefore, stereotype-threat was not studied as part of this research study. OST environments, such as youth centers, are settings that can also affect mathematics proficiency. When children from low-SES backgrounds do not participate in OST academic enrichment programs, gaps in mathematics proficiency widen. The construct of academic enrichment during OST is ideal for a research study because it is a causal factor that can be studied in the youth center setting. Of these contributing factors, OST academic enrichment is a promising way to
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deliver an intervention for mathematics.

The factors and causes associated with TSRQ, teacher beliefs, parental beliefs, academic identity, academic self-efficacy, academic engagement, mathematics curriculum, and mathematics anxiety were the next articles that were examined. TSRQ has the most direct relationship to mathematics proficiency outcomes. High TSRQ increases mathematics engagement, and mathematics engagement mediates mathematics proficiency (Wu et al., 2010). Although increasing TSRQ would likely improve mathematics proficiency, this is would be difficult to study in an after-school program at a neighborhood youth center. Children who have a strong academic identity have a greater chance of being successful because they are more engaged and persistent in school (Skinner & Pitzer, 2012). Since racial centrality helps buffer African American students from student identities that are contrary to mathematics proficiency (Nasir et al., 2009), it could be studied in children at the youth center. I decided not to study this construct because there were other causal factors that have a more direct relationship to mathematics proficiency. Academic self-efficacy is also a contributing factor to mathematics proficiency. Low academic self-efficacy can cause students to become disengaged and lead to the development of maladaptive and avoidant coping behaviors such as mathematics anxiety (Ramdass & Zimmerman, 2011; Skinner & Pitzer, 2012). Low academic engagement in mathematics contributes to low mathematics achievement. Mathematics engagement is important during teacher instruction and home practice, so when children become disengaged it has a direct effect on mathematics proficiency (Skinner & Pitzer, 2012). Because of the relationship of mathematics engagement to other constructs, such as mathematics anxiety and the ability to study it in the youth center setting, it was included
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in the needs assessment study. Another factor that contributes to low mathematics proficiency is the quality of instructional materials. Instructional materials are what teachers use, primarily during instructional time, to model and reinforce mathematics concepts and help students gain proficiency. Instructional materials used in the classroom were not studied because it requires teacher participation and takes place in the school environment. Finally, mathematics anxiety is a construct that measurably reduces a child’s performance during mathematics instruction, practice, and assessment. The effect of mathematics anxiety on proficiency related to mathematics practice is an area that overlaps with OST academic enrichment. This relationship, in addition to the relationship to mathematics engagement and academic self-efficacy, makes it an ideal construct to study at the youth center. Since mathematics anxiety, mathematics engagement, and academic self-efficacy are interconnected and have a direct relationship to mathematics proficiency, these three constructs will be evaluated in a needs assessment study.

The next step in this research is an empirical study to determine levels of mathematics anxiety, mathematics engagement, and academic self-efficacy among children at the youth center. The conceptual framework depicted in Figure 1.2 shows how academic self-efficacy can affect mathematics proficiency through the mediating variables of mathematics anxiety and mathematics engagement.
The next step in this project was to determine the mathematics anxiety, academic self-efficacy, and mathematics engagement levels of children who attend the youth center.

*Figure 1.2 Conceptual framework of the variables that contribute to mathematics proficiency (Skinner & Pitzer, 2012).*
After conducting a literature review to determine the factors that contribute to low mathematics proficiency, it became clear that there are multiple causes. The contributing factors that have the potential to be addressed during OST are mathematics anxiety, mathematics engagement, and academic self-efficacy. The following needs assessment study was designed to determine the level of mathematics anxiety, mathematics engagement, and academic self-efficacy of youth center children and which of those factors might be most important to improve during OST. Results from the needs assessment study were used to determine an appropriate intervention to implement at one neighborhood youth center. This chapter describes a needs assessment study that was conducted at two youth centers in Baltimore City and includes sections on the context of the study, a statement of purpose, method, findings, discussion, and recommendations.

**Context of study**

The needs assessment study was conducted with children from two youth centers located in Baltimore City that serve approximately 75 school-aged children each year. Of those, approximately 35 attend elementary school, with the remaining children attending middle or high school. The children live in two different neighborhoods that are within five miles of each other.

Youth center children that participated in the needs assessment study all attended a Title I school with low National Assessment of Educational Progress (NAEP) and PARCC assessment scores. Title I status of the schools was determined by identifying the neighborhood partner school and comparing it to the Maryland State Department of Education’s (MSDE) list of Title I schools. The mathematics proficiency of children at the
two neighborhood schools was determined by examining state NAEP and PARCC results (MSDE Progress Report, 2016; NAEP Baltimore City Report Card, 2015). The individual assessment results of children who attended the youth center were not available. However, all children who attended the youth center were enrolled at their neighborhood school.

Each youth center was staffed by a center director and at least two program assistants. Occasionally, centers had teen youth work as assistants. Each center had a partnership agreement with the neighborhood elementary and middle schools that allowed a youth center staff person to pick children up from school. Most of the elementary and middle school children went to the youth centers immediately after school, although high school student participation was typically less routine. Each youth center offered programming Monday through Friday, with dedicated time for homework, snack, playtime, and enrichment. Homework time lasted approximately one hour, and children worked on homework and worksheets with limited academic support. During snack time, children had 30 minutes to eat what, youth center staff said, may be one of only two meals they received for the day. After snack time, children went outdoors to play or play indoor games for approximately one hour. The last structured program that youth center children participated in for the day was an enrichment activity. Enrichment activities typically included crafts or life-skills workshops provided by third-party organizations. These activities were offered once per week after snack time, and children were allowed to choose their own enrichment activities. Soon after or during the last programmatic activity of the day, children’s parents would pick them up or they would walk home. For many neighborhood families, the youth center is a means of providing free aftercare and enrichment for their children. The lack of academic support during homework time at the youth center is similar to experiences
described by Halpern (1992), Kane (2004), and Lauer et al. (2006) that contribute to gaps in academic proficiency.

**Purpose**

The purpose of the needs assessment study was to determine the levels of mathematics anxiety, engagement, and academic self-efficacy of third through fifth grade children at two youth centers in Baltimore City. These constructs were explored by determining each participant’s level using validated surveys. The research questions for the needs assessment study were:

- Research question 1 (RQ1): What is the mathematics anxiety level of third through fifth grade children from the youth centers?
- Research question 2 (RQ2): What is the mathematics engagement level of third through fifth grade participants from the youth centers?
- Research question 3 (RQ3): What is the academic self-efficacy level of third through fifth grade children from the youth centers?

**Method**

The following section details the research design of the needs assessment study. The research design section is followed by sections on participants, measures and instrumentation, and procedures taken to conduct the needs assessment study, collect data, and perform data analysis.

**Research Design**

The needs assessment study was designed as a quantitative research study to determine the mathematics anxiety, engagement, and academic self-efficacy of youth center participants using the Modified Abbreviated Mathematics Anxiety Scale (mAMAS)
Participants. Twenty children were chosen for this research study. All of the children attended a Title I school in Baltimore City and participated in the free meal program at the youth center. Participants were not asked to report their race, but demographic information published by the BCPS System indicated that the school populations were greater than 80% African American (Department of Education EDFacts, 2018). All participants also spent at least two days per week at the youth center for OST programming. The participants were in grades 3, 4, or 5 when the needs assessment study was conducted.

Measures and instrumentation. Three different questionnaires were used to measure the constructs of mathematics anxiety, mathematics engagement, and academic self-efficacy. The following describes each instrument and how they were used to measure their respective construct.

mAMAS. Mathematics anxiety was measured using the mAMAS (Appendix A), a valid and reliable nine-question survey designed to determine mathematics anxiety in children and adolescents (Carey, Hill, Devine, & Szucs, 2017). The mAMAS measures two types of mathematics anxiety (evaluation anxiety and learning anxiety) and combines the two results for an overall mathematics anxiety score. The evaluation subscale is used to determine anxiety associated with taking mathematics quizzes and tests and the learning subscale is used to determine anxiety associated with learning mathematics. The mAMAS has children rank their responses using a five-point Likert scale and is then translated into the following levels of mathematics anxiety: (1) low anxiety, (2) some anxiety, (3)
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*moderate anxiety*, (4) *quite-a-bit of anxiety*, or (5) *high anxiety* (Carey et al., 2017, p. 7).

The internal consistency of the mAMAS is 0.89, which is considered very good, and both subscales have an internal consistency of 0.83, suggesting that the mAMAS is a reliable way to measure both learning and evaluation anxiety for children in grades 3 through 8 (Carey et al., 2017, p. 7). The confirmatory analysis also indicates that both scales of the mAMAS are a valid way to measure learning and evaluation anxiety (Carey et al., 2017).

*eSEI-5ps.* Mathematics engagement was determined by using the eSEI-5ps designed for elementary school children (Appendix B), a validated scoring scale designed to measure the cognitive and affective (psychological) engagement of children (Appleton, Christenson, & Furlong, 2008). The eSEI-5ps uses affective and cognitive engagement scores to determine the level of academic engagement. The six-factor model of the eSEI-5ps was used because confirmatory factor analysis showed that the six-factor model was a more valid and reliable instrument when compared to the four and five-factor models (Appleton et al., 2008). The six-factor model also has an internal consistency of 0.72, which is considerably better than the four and five-factor models (Appleton et al., 2008). Using the six-factor model increases the questionnaire to 35 questions, including two additional questions when compared to the five-factor model, and an additional seven questions when compared to the four-factor model. The measures of cognitive engagement include control and relevance of schoolwork, future aspirations and goals, and intrinsic motivation. Measures of psychological engagement include teacher-student relationships, peer support at school, and family support for learning. The questionnaire used to determine the engagement level of youth center children was a modified version of the student engagement instrument developed for children in elementary school (eSEI-5ps). Participants were asked 37
questions and recorded their responses using a five-point Likert scale that ranged from (1) *strongly disagree*, (2) *disagree*, (3) *in the middle*, (4) *agree*, and (5) *strongly agree*. The differences between the SEI and eSEI-5ps are age-appropriate vocabulary and an additional section that measures boredom and preparedness. Measures of boredom and preparedness were not scored in this survey because a scoring instrument was not available to interpret the scores.

**MSYQ.** Academic self-efficacy was determined by using a subscale of the MSYQ (Appendix C) that is considered valid and reliable (Scarupa, 2014). The reliability of the MSYQ subscale for academic self-efficacy is 0.71, which is considered acceptable by Hoover-Dempsey and Sandler (2005). The full questionnaire consists of eight questions that measure self-control, academic self-efficacy, persistence, and mastery orientation. Self-control is defined as a student’s ability to control their emotions and behavior, inhibit negative behavior, maintain attention and concentration, and wait their turn for what they want. Academic self-efficacy is defined as the student’s ability to effectively perform academic tasks. Persistence is defined as the student choosing to work toward the completion of a task in spite of obstacles, difficulties, or discouragement, and mastery orientation is a student’s intrinsic desire to complete work to learn and improve their skills without the need for external reward. Participants answered 14 MSYQ questions using a four-point scale that indicated (1) *not at all like me*, (2) *a little like me*, (3) *somewhat like me*, or (4) *a lot like me*. However, only the academic self-efficacy subscale score was used to determine whether children were academically self-efficacious because academic self-efficacy has the strongest relationship to academic achievement (Hoover-Dempsey & Sandler, 2005).
PROCEDURE. The following section describes the procedures associated with selecting participants, collecting data, and analyzing data for the needs assessment study. The procedure section is followed by a discussion of the findings from the needs assessment study.

**Participant selection.** Before beginning the needs assessment study, participants were selected as needs assessment study candidates if they spent at least two days per week at the youth center and were in grades 3, 4, or 5. Information about attendance and grade level was provided by youth center staff. Twenty-six children met the selection criteria. Parents of the 26 children were given fliers about the needs assessment study and could sign a consent form when picking up their child or return it at a later date. Twenty of the eligible participants and their legal guardian(s) consented to participate in the needs assessment study.

**Data collection.** The mathematics anxiety, student engagement, and self-efficacy questionnaires were administered to children from the youth center during the summer of 2018. Students were provided instructions on how to complete each questionnaire before taking them. All 20 participants were assembled in the youth center’s computer lab and completed each survey at their own pace. Children whose parent’s provided permission to participate were asked to sit in groups of four. After explaining the purpose of the questionnaires to participants, I asked if they consented to participate in the needs assessment study. None of the children declined to participate. Children were given pencils and a packet that included the three questionnaires. Questionnaires were grouped according to questionnaire type, then each of the three groups was assigned numbers from 1 to 20 to allow them to be grouped without identifying the participant. The first questionnaire completed was the full MSYQ, followed by the eSEI-5ps, and finally the mAMAS. I read the instructions
and questions for each questionnaire aloud, repeated the question, paused for approximately 30 seconds, and then read the next question. Participants were asked to raise their hands if they needed the question to be read again. There was a five-minute break between each questionnaire. After everyone finished completing their questionnaires, they were collected, checked for completion, and stored for scoring by me.

Data analysis. The data analyzed from the needs assessment study came from the mAMAS, eSEI-5ps, and MSYQ questionnaires. mAMAS questionnaire scores were averaged according to each subscale and compared to conversion values, which indicated the level of anxiety. Average values greater than two were considered mathematics anxious, and average values less than or equal to two were considered non-mathematics anxious (Carey et al., 2017). eSEI-5ps questionnaire data were also analyzed using a similar method. The eSEI-5ps uses the sum of each subscale and divides that value by the total possible score to determine the overall student engagement score. The values of each subscale were averaged, then compared to a conversion table to determine the degree of engagement in mathematics. Values greater than 4.0 indicated participants were engaged, values between 3.0 and 3.9 indicated moderate engagement, and values less than 3.0 indicated participants were not engaged (Appleton et al., 2008). Finally, MSYQ data were analyzed by averaging the scores from each question, according to each subscale, and comparing the averaged values to the conversion table. Values between 1.0 and 1.99 indicated low self-efficacy, values between 2.0 and 2.99 indicated moderate self-efficacy, and values between 3.0 and 4.0 indicated high self-efficacy (Hoover-Dempsey & Sandler, 2005).
Findings

Results from the needs assessment study are listed in the following order: mathematics anxiety questionnaire, student engagement questionnaire, and self-efficacy questionnaire. The results are then summarized and their implications for intervention are discussed.

**Mathematics anxiety**

Research question one examined whether participants were anxious about mathematics. Thirty-five percent of children from the youth center were anxious about learning new mathematics concepts, 50% of children were anxious about evaluation or test-taking, and 50% of children were anxious about performing mathematics problems (Figure 2.1). Since 50% of the children were mathematics anxious and 35% were anxious about learning mathematics, mathematics anxiety treatments should be incorporated into an intervention.
Figure 2.1. Results from the Mathematics Anxiety Questionnaires.

Mathematics engagement

Levels of mathematics engagement were determined through the eSEI-5ps, and the results can be found in Figure 2.2. There are two subscales for the eSEI-5ps: affective or psychological engagement and cognitive engagement. Since children with scores from 3.0 to 4.0 represent being moderately engaged and engaged respectively, anyone with a score of 3.0 or greater was considered engaged. Scores of 2.9 or below were not engaged. One child demonstrated moderate affective engagement, and none were engaged cognitively, resulting in 95% overall disaffection (Figure 2.2).
Figure 2.2. Results from the Mathematics Engagement Questionnaire.

Only one child scored a moderate level of affective engagement in mathematics. Scores for the remaining 19 participants indicated they were not cognitively engaged in mathematics. Since the results show that 95% of participants from the youth center were not engaged academically with mathematics, it was an indication that children at the youth center could benefit from a treatment to improve academic engagement in mathematics.

**Self-efficacy**

RQ3 focused on determining the level of participants’ academic self-efficacy. The social and emotional skills questionnaire measures self-control, academic self-efficacy, persistence, and mastery orientation. All subscales scores were averaged, and, according to the scoring guide, values from 1.0 to 1.99 were considered low, values from 2.0 to 2.99
were moderate, and values from 3.0 to 4.0 were high (Hoover-Dempsey & Sandler, 2005). Twenty percent of study participants scored in the low self-efficacy range, and 80% scored in the moderate to high self-efficacy range. Academic self-efficacy scores showed that 15% of children had low academic self-efficacy and 85% had moderate to high academic self-efficacy (Figure 2.3).

![Figure 2.3. Results from the Modified Self-Efficacy Youth Questionnaire.](image)

The results indicate that 40% of children had a moderate level of academic self-efficacy, 45% of children had a high level of academic self-efficacy, and only 15% of children had a low level of academic self-efficacy. The combined moderate and high academic self-efficacy scores total 85% and show that a large number of youth center children were academically self-efficacious.
Results

The results from the questionnaires indicated that children at the youth center could use additional support to reduce mathematics anxiety and increase mathematics engagement. Figure 2.4 below represents the number of children who had none, one, two, or all three of the factors that contribute to being proficient in mathematics (low mathematics anxiety, being mathematics engaged, and being academically self-efficacious). The combined survey results show that 90% of children had either one or two of the factors that contribute to mathematics proficiency, and only 10% had none of the factors. The percentage of children with none of the proficiency factors was 10%. Their scores indicated some mathematics anxiety, low engagement, and low academic self-efficacy. Forty-five percent of children demonstrated only one proficiency factor. They showed either no mathematics anxiety or moderate to high academic self-efficacy. The number of children with two proficiency factors was 45%. These children demonstrated both low mathematics anxiety and moderate to high academic self-efficacy. None of the children were found to have low mathematics anxiety, be engaged, and be self-efficacious in mathematics.

Figure 2.4. Combined Questionnaire Results.
Discussion

The high level of academic self-efficacy reported by the children stands out as an interesting finding. Based on the findings of Zimmerman and Kitsantas (2005), one would expect children who perform poorly to have low confidence about their ability in mathematics. Many children who attend the youth center have poor fluency in mathematics and have little access to mathematics homework help during OST. According to Cosden et al. (2001), these circumstances should have resulted in more participants with low academic self-efficacy. However, these children did not exhibit low academic self-efficacy. I suspect the children’s level of belief in their ability to do mathematics exceeded their actual skill level when the questionnaire was given. I have observed this mismatch between academic self-efficacy beliefs and ability during several years of interactions with children at the youth centers, across the domains of both academics and athletics. Pajares and Kranzler (1995) demonstrated a similar mismatch between self-efficacy beliefs and general mental ability related to mathematical problem-solving. The levels of mathematics anxiety and engagement are consistent with the participants’ low proficiency in mathematics. I did not expect there to be any mathematics anxiety, so this result was surprising. The evaluation mathematics anxiety results from this assessment were consistent with results reported by Chang and Beilock (2016). They examined evaluation-related mathematics anxiety across PISA countries and attributed at least 14% of the variance in mathematics performance on the international examination to mathematics anxiety. The results also indicated that mathematics anxiety may contribute to low mathematics proficiency in these children. Additionally, I suspected there to be low engagement in mathematics during instruction or when practicing using traditional methods. Ramdass and Zimmerman (2011)
attributed low academic engagement among students from low-SES backgrounds to peer comparison. I have witnessed peer comparison amongst these children during academic enrichment time at the youth center, so this could be one explanation for their low level of engagement. After examining the results, anxiety and engagement are likely contributors to their performance in mathematics. Conducting research to understand more about the relationship between their academic self-efficacy and mathematics proficiency is beyond the scope of this research project, so only mathematics anxiety and mathematics engagement will be the focus of the intervention.

**Conclusion**

Data gathered during the needs assessment study indicated that a large number of youth center children in grades 3 through 5 felt mathematically anxious and academically disengaged. However, a large percentage of children felt academically self-efficacious. The children at the youth center may thus benefit from an intervention that could be implemented at the youth center, designed to help decrease mathematics anxiety and increase mathematics engagement.

Although youth centers in urban settings are effective at providing a safe and nurturing environment for children (Carruthers & Busser, 2000; Halpern, 1992; Pettit, Laird, Bates, & Dodge, 1997), their potential to serve as suitable environments for OST academic enrichment deserves further study. Once youth center children’s mathematics anxiety, mathematics engagement, and academic self-efficacy levels were determined, the results were used to conduct a literature review to learn more about interventions that were used to change these constructs. The literature review in the next chapter explores and identifies interventions that decrease mathematics anxiety and improve mathematics
engagement that could be implemented in the youth center with minimal effort from youth center staff.
Chapter 3 – Review of Intervention Literature Related to Mathematics Anxiety and Engagement

The youth center setting was an ideal environment to provide an intervention designed to decrease mathematics anxiety and increase mathematics engagement. One characteristic that made the youth center an ideal location for this research study was that many of the elementary school-age children who attended the local Title I school attended the youth center and came from low-SES backgrounds. Another characteristic of the youth center that made it ideal was the amount of programming time devoted to academic enrichment. Since homework time was already an integral part of their programming, tailoring an intervention that met the needs of children was only a matter of restructuring the time devoted to completing homework. The youth center staff’s relationships with parents and other community members also provided access to information about what would be best to help youth center children succeed in mathematics.

The purpose of this literature review was to identify interventions with the potential to decrease mathematics anxiety and improve mathematics engagement of elementary students from low-SES backgrounds and to inform the development of an effective intervention for elementary school-aged children attending a youth center in Baltimore City. The underlying causes of low mathematics proficiency identified in chapter one included factors associated with the reciprocal interactions between the person, behavior, and environment. Although academic self-efficacy is a contributing factor to low proficiency in mathematics, it was not a factor for children at the youth centers. Findings from the needs assessment study confirmed that study participants exhibited mathematics anxiety and were disengaged from mathematics. Therefore, mathematics anxiety and
mathematics engagement interventions were the focus of this literature review.

This chapter is divided into three sections. The first two sections examine the literature regarding interventions meant to decrease mathematics anxiety and those designed to increase mathematics engagement, and they are followed by a third section that describes conclusions. The section on mathematics anxiety interventions examines how expressive writing, cognitive modeling, and computer adaptive programs could be used to decrease mathematics anxiety. Section two discusses interventions designed to increase mathematics engagement, including developing a positive academic identity, computer-aided instruction, parent involvement, parent-teacher communication, peer-assisted learning groups, goal setting, and teacher relationship quality. Finally, the conclusion provides a rationale for selecting the chosen intervention and discusses the argument for the proposed intervention and the theory of change. The conclusion also summarizes the literature on interventions and recommends an intervention that could be implemented at the local youth center.

Literature that featured research on interventions in peer-reviewed journals that were conducted in the United States was given priority over other sources. Although interventions that took place in schools or OST settings are discussed, special consideration was given to interventions that addressed low mathematics anxiety and mathematics engagement that could be implemented at youth centers during OST.

**Interventions designed to decrease mathematics anxiety**

Expressive writing, cognitive modeling, and computer adaptive programs have all been shown to decrease mathematics anxiety. Mathematics anxiety is described as feelings of worry and fear about mathematics that are accompanied by physiological responses such
as tension, distress, and mental disorganization (Ma & Xu, 2004). According to Ma and Xu (2004), mathematics anxiety typically becomes persistent around eighth grade, but credible examples of mathematics anxiety have been observed as early as third grade.

*Expressive writing*

Expressive writing has been shown to effectively reduce mathematics anxiety (Maloney et al., 2013; Park et al., 2014). Expressive writing, used as a mathematics anxiety intervention, is a technique that allows students to express their negative feelings about mathematics through writing just before participating in a complex mathematics task. In the Park et al. (2014) study, students in the treatment group were asked to briefly write about their feelings before taking a mathematics exam. Students who used words that were related to their emotions about taking the exam scored better on the exam. Park et al. (2014) concluded that high mathematics anxious (HMA) students performed better than their HMA counterparts in the control group. In an expressive writing intervention conducted by Hines, Brown, and Myran (2016), 93 high school students showed a reduction in general and mathematics anxiety, but no change in physical anxiety, when compared to the control group. Both research studies showed a reduction in mathematics anxiety. In practice, when teachers ask students to use expressive writing techniques to write about how they feel about an upcoming mathematics exercise, HMA students show considerable increases in mathematics performance (Park et al., 2014). The mechanism of action is believed to be an increase in the amount of available processing capacity in working memory that is freed through expressive writing (Park et al., 2014). Expressive writing exercises are practical because they can be administered by teachers without any preparation or follow-up with students, but successful implementation requires training.
(Maloney et al., 2013). Expressive writing also appears to be more effective at treating evaluation-related mathematics anxiety and is an effective way to reduce evaluation-related mathematics anxiety; however, cognitive modeling has also been proven effective at reducing learning-related mathematics anxiety (Supek, Iuculano, Chen, & Menon, 2015).

**Cognitive modeling**

Cognitive modeling is a combination of modeled explanation and demonstration with a verbalization of the model’s thoughts and rationale for modeling the activity (Schunk, 2012). Cognitive modeling exercises include interventions that train students to transition from HMA to low mathematics anxious behaviors, such as cognitive tutoring (Supek et al., 2015). Cognitive tutoring is an intervention targeted at changing the neural response of mathematics anxious students to not view mathematics in a threatening light. Cognitive tutoring works by targeting the amygdala to reduce learning-related mathematics anxiety. The amygdala is part of the brain that helps regulate fear, and it demonstrates hyperactivity in HMA individuals when they are asked to perform complex mathematics tasks (Supek et al., 2015). Supek et al. (2015) tested an intervention that used cognitive tutoring as the cognitive modeling method. The intervention provided 46 elementary students with specialized tutoring in mathematics three days a week for eight weeks. Participants were matched one-to-one with tutors who taught increasingly difficult arithmetic problems using board games, flashcards, and computer games. The cognitive tutoring included a combination of conceptual instruction with expedited retrieval of arithmetic facts. HMA participants in the treatment group showed increases in mathematics performance and decreased activity in the amygdala (Supek et al., 2015). When functional magnetic resonance images (fMRI) of amygdala activity of high mathematics
anxious students were compared to the fMRI activity of low mathematics anxious students after the intervention, the fMRI amygdala responses of high mathematics anxious students were at normal levels (Supekar et al., 2015). These results provide a physiological explanation for the effectiveness of cognitive modeling on mathematics anxiety. The suspected mechanism of action is that students’ anxiety decreased due to an increased understanding of how to perform addition and subtraction operations (Supekar et al., 2015). Interventions designed to decrease mathematics anxiety via cognitive modeling can also include mindfulness exercises.

Mindfulness techniques are a form of cognitive modeling that could be used to treat mathematics anxiety. Mindfulness is defined as an awareness of one’s emotions, thoughts, and experiences on a moment-by-moment basis (Cullen, 2011; Geist, 2015). Mindfulness techniques have been used in classrooms by teachers to help students reduce anxiety and become more focused before starting lessons (Diamond & Lee, 2011; Flook, Smalley, Kitil, Galla, Kaiser-Greenland, Locke, & Kasari, 2010). Helping students reduce anxiety and become more focused before instruction could prove to be important when working in communities with high incidences of students who must care for themselves after school (Mendelson et al., 2010). Flook et al. (2010) designed a mindful awareness practices (MAPs) program to determine whether mindfulness practices could increase executive function, which is key to self-regulation and managing anxiety (Jain & Dawson, 2009). Their student population was similar in number and grade to the Baltimore City youth center. Flook et al. (2010) used games and age-appropriate exercises to address sensory awareness, awareness of others, and awareness of the environment. They conducted a randomized control study of 64 second and third graders for eight weeks and analyzed data
collected using preintervention and postintervention questionnaires to determine that the MAPS intervention was associated with improvements in behavioral regulation, metacognition, and overall executive function (Diamond & Lee, 2011; Flook et al., 2010). Slopen, McLaughlin, and Shonkoff (2014) conducted a meta-analysis of published interventions designed to improve cortisol regulation in children to determine the efficacy of recent interventions. They found 19 research studies that used randomized controlled or quasi-experimental methods. All 19 of the studies measured cortisol levels in participants’ bloodstreams to determine the amount of stress present in children. Of the 19 interventions, 18 reported changes in cortisol levels after the interventions (Slopen et al., 2014). The types of interventions ranged from parent training to child-focused education and training. Since increased cortisol levels are also associated with anxiety, it is reasonable that a reduction in cortisol levels during mathematics anxious situations would also help reduce mathematics anxiety. Evidence from these studies suggests that mindfulness techniques may also be an effective way to treat mathematics-related performance anxiety.

Mindfulness techniques range from relaxation techniques to physical exercise, but the techniques most closely associated with treating mathematics anxiety are relaxation techniques (Bellinger, DeCaro, & Ralston, 2015; Khng, 2017). One consequence of mathematics anxiety is reduced executive function when performing mathematics tasks, and relaxation techniques have proven to help students cope with mathematics anxious situations (Bellinger et al., 2015; Khng, 2017). Mindfulness relaxation techniques involve helping students focus their thoughts on the present moment (through short breathing or body scanning exercises) and become more aware of their present feelings. Interventions involving the use of mindfulness techniques to improve academic achievement have
primarily been used with students in middle school through college (Ahmed, Trager, Rodwell, Foinding, & Lopez, 2017). However, Khng (2017) used the mindfulness technique of deep breathing to reduce the effects of evaluation-related mathematics anxiety on elementary students. Khng’s (2017) intervention had 122 participants and used a treatment and control group to determine the efficacy of deep breathing techniques with mathematics anxious students under the anxiety-inducing circumstance of a mathematics test. Khng (2017) had students complete deep breathing exercises before and during an exam. Results suggested that students in the treatment group felt considerably less mathematics anxiety than students in the control group. Bellinger et al. (2015) found similar results in an intervention conducted with college freshmen using dispositional mindfulness, a keen awareness of one’s thoughts and feelings in the present moment. They used the dispositional mindfulness questionnaire preintervention and postintervention to measure participants’ mindfulness state. After analyzing questionnaire results and comparing them to statewide anxiety levels, they reported that dispositional mindfulness did have an indirect effect on test and quiz outcomes that could account for 38.4% of the variability in students’ grades. Bellinger et al. (2015) concluded that dispositional mindfulness does mediate evaluation-related mathematics anxiety. Since there are not many research studies on using mindfulness techniques to reduce mathematics anxiety in elementary students, and none could be found that address mathematics anxiety during OST, this is an area that could benefit from further research. Interventions with adolescent students show that providing students with a 30-second to 15-minute mindfulness exercise before performing mathematics results in improved mathematics performance (Brunyé, Mahoney, Giles, Rapp, Taylor, & Kanarek, 2013; Khng, 2017). Mindfulness relaxation
exercises have also been used to reduce stereotype-threat in stereotype-threatened conditions (Weger, Hooper, Meier, & Hopthrow, 2012).

Workshops on developing a growth mindset, another form of cognitive modeling, have also proven to be an effective intervention for decreasing mathematics anxiety (Good et al., 2003; Mowbray, 2012). Growth mindset is a term coined by Carol Dweck (2008) to characterize one of two learning perspectives. The growth mindset perspective is when people believe that intelligence is not fixed but can be developed through hard work and perseverance. The alternative perspective is a fixed mindset characterized by beliefs that intelligence is fixed and cannot be improved, and that a person is either born with intelligence or not. Growth mindset interventions involve having students participate in cognitive tutoring, workshops, and self-paced gaming programs (Aronson, Lustina, Good, Keough, Steele, & Brown, 1999; Dweck, 2008; O'Rourke, Haimovitz, Ballweber, Dweck, & Popović, 2014). These workshops focus on teaching students about parts of the brain, how the brain works, learning, and how to apply growth mindset concepts to school. The goal of growth mindset workshops is to help both students and teachers understand that learning and intelligence are not fixed and can be developed by exercising the brain like a muscle (Dweck, 2008). Workshops range in duration from a few hours to several days and vary in effectiveness based on duration. The effects of a two-hour workshop typically reduced mathematics anxiety for approximately nine weeks (Boaler, 2013; Dweck, 2008). These workshops have been effective at reducing mathematics anxiety by helping students understand the plasticity of the brain and their ability to improve their mathematics performance through productive struggle (Bugden, DeWind, & Brannon, 2016). O'Rourke et al. (2014) incorporated growth mindset principles into the rewards system of a
mathematics computer game and reported some evidence of increasing engagement and developing growth mindsets. Children in the intervention group spent at least two minutes longer playing the game compared to the control group (O’Rourke et al., 2014). Computer adaptive interventions that are designed to develop a growth mindset, such as Brainology, have been used to reduce mathematics anxiety and increase mathematics proficiency in third through sixth grade students both during the school day and during OST (Jansen, Louwerse, Straatemeier, Van der Ven, Klinkenbert, & Van der Maas, 2013). Although results from the O’Rourke et al. (2014) study and Brainology’s computer-aided instruction platform both demonstrate the potential for self-directed learning of growth mindset principles, this is an area that could benefit from more research to determine the effectiveness of using computer-aided instruction to decrease mathematics anxiety. Students and teachers who have committed to developing a growth mindset have seen dramatic improvements in academic achievement (Dweck, 2008). Dweck (2008) demonstrated how the use of a computer-based platform could be used as a treatment and delivered via workshop. Research study participants were divided into treatment and control groups to determine whether the intervention changed mathematics proficiency. Dweck (2008) reported that when teachers and children participated in the workshops, their mathematics scores increased by 18% compared to the control group. Growth mindset is a promising type of cognitive modeling, but tutoring is the most widely utilized.

The final form of cognitive modeling discussed in this section is in-person tutoring, one of the most common forms of OST interventions for mathematics. Tutoring is typically when a more experienced person teaches a less experienced individual how to accomplish a task outside of typical instruction time. In the case of mathematics, tutoring can occur one-
to-one or one-to-many in several settings. In studies conducted by Baker, Rieg, & Clendaniel, (2006), the most effective OST tutoring programs are when students and tutors are matched one-to-one or one-to-two for at least one and a half hours of contact time over a 10-week period. In-person tutoring can be effective at decreasing mathematics anxiety by increasing a student’s proficiency in mathematics (Cargnelutti, Tomasetto, & Passolunghi, 2017). However, the effectiveness depends on several key factors: low tutor-tutee ratios, high tutor and tutee attendance, tutor-teacher communication, tutor training, effective matching, and adequate breaks (Baker et al., 2006). Although in-person tutoring is an OST intervention for reducing mathematics anxiety that shows promise, computer adaptive programs could also be an effective way to deliver personalized tutoring.

**Computer adaptive programs**

Computer adaptive programs (CAP) are a form of personalized computer-aided instruction (CAI) that have been used to treat mathematics anxiety. Adaptive programs use preprogrammed computer-generated questions to determine individual mathematics ability, adjust the difficulty level of problems, and enable students to experience high rates of success with mathematics (Jansen et al., 2013). The ability of computer programs to assess and adjust the presented mathematics content is a typical characteristic of CAI programs that are adaptive (Brasil, Jeong, Ames, Lawanto, & Yuan, 2016; Räsänen, Salminen, Wilson, Aunio, & Dehaene, 2009; Slavin & Lake, 2008). Adaptive CAI interventions have been used to treat mathematics anxiety, but are also effective at improving the cognitive physiological processes in the intraparietal sulcus involved in computation (Räsänen et al., 2009). Räsänen et al. (2009) used CAPs to improve the number skills of 30 kindergarten children during a 15-minute per day intervention that lasted three weeks. The CAPs used in
this research study utilized algorithms that would automatically adjust to keep students near a performance rate of 75%. After analyzing pre and posttest results from the number comparison task and comparing data from treatment and control groups, Räsänen et al. (2009) concluded that there were moderate effects of the intervention on number comparison tasks. In the Brasiel et al. (2016) research study, a sample size of 44,479 students was used, but only 10% met the full usage requirements of the CAP being evaluated. They determined that the CAP interventions used for their elementary school students met the effect size criteria established by Cheung and Slavin (2013), although the CAP interventions for middle and high school students were mixed. One additional lesson learned from this study was that teachers had a difficult time incorporating CAI interventions into their normal instructional time (Brasiel et al., 2016). This is an indication that CAIs that utilize CAPs might be better suited for OST settings. The CAPs that specifically focus on improving mathematics proficiency have been used in both classroom and OST settings, but there is more research on interventions that have taken place in classrooms compared to OST settings. Treatments in classrooms typically take place over at least three weeks and have shown some evidence of decreasing mathematics anxiety in elementary school-aged students to a moderate but statistically significant degree (Jansen et al., 2013). Since CAPs are effective at increasing mathematics engagement and show some evidence of decreasing mathematics anxiety in minority and low-income students, they are potential candidates for an intervention that impacts both mathematics anxiety and mathematics engagement.
Section summary

There are several interventions that have been developed to treat mathematics anxiety in student populations ranging from elementary to postsecondary school. The interventions examined in this literature review included expressive writing, cognitive modeling, and computer adaptive programs. Expressive writing and computer adaptive interventions were primarily used in classroom settings, and examples of effective cognitive modeling interventions, such as mindfulness and growth mindset training, were used both in classroom settings and during OST (Bellinger et al., 2015; Khng, 2017; Maloney et al., 2013; Park et al., 2014). Considering where previous studies have demonstrated success and where there is an opportunity to contribute to research, the one with the most promise for use with elementary school students during OST was cognitive modeling. Determining which cognitive modeling method to implement will be addressed in the following section on intervention selection.

Interventions designed to increase mathematics engagement

This section of the literature review focuses on research and interventions designed to improve mathematics engagement. Topics include ways to improve academic identity, use of computers to aid instruction, increasing parent involvement and parent-teacher communication, use of peer-assisted learning groups, use of goal setting techniques, and improving teacher-student relationship quality.

Improving academic identity

The construct of academic identity affects engagement in mathematics (Ellis, Rowley, Nellum, & Smith, 2018). Academic identity, especially in students of color, is closely tied to racial and social constructs that also influence academic engagement (Ellis
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et al., 2018; Givens, Nasir, Ross, & McKinney, 2016; Legette, 2018). Research on how African American males are affected by stereotypes indicates that there are three prevailing stereotypes that they must overcome to have positive academic identities: anti-intellectual and anti-school beliefs, beliefs about criminal involvement, and emotional disconnection from familial roles and duties (Givens et al., 2016). Each of these stereotypes, especially anti-intellectual and anti-school stereotypes, is antithetical to the attributes needed to form a positive academic identity.

Research by Givens et al. (2016) on how to combat the development of negative academic identities shows interventions that focus on combating negative stereotypes based on the concepts of identity resources and identity constellations are effective at changing academic identity. Identity resources are materials that are infused into the learning environment that students can identify with and incorporate into their identity. Identity constellations are attributes associated with identity that can impact other aspects of identity (Givens et al., 2016). An example is that being academically proficient in mathematics may associate a student with being a nerd, which typically is not associated with being a student-athlete. The constellation of identities has interactions that affect identity associations desired by the student. Researchers have attempted to impact identity resources and constellations by conducting discussion groups that focus on talking about feelings and expanding the definition of manhood beyond stereotypes for African American boys (Givens et al., 2016; Love, 2004; Milner, 2013). African American boys who successfully develop their constellation of identities and make appropriate associations between them stand a greater chance of developing a positive academic identity and can become more engaged in subjects such as mathematics (Givens et al., 2016).
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Interventions that combat negative academic stereotypes include forming social groups that help develop a mathematics identity and providing examples of racial members who are successful in the academic field of interest. One example of an intervention that helps combat negative academic stereotypes is the formation of OST mathematics groups called mathematics circles (Kennedy & Smolinsky, 2016). Mathematics circles are afterschool clubs that take place on or near a location where mathematics is the professional practice, where students are exposed to the use of language and practices that are specific to the discipline of mathematicians (Kennedy & Smolinsky, 2016). The research study included 24 middle school African American and Hispanic students from a Title I school and was designed as an intrinsic case study. The case was a mathematics circle designed for low-income minority youth. It was facilitated by the faculty of a university’s mathematics department for 24 90-minute sessions. Participants were introduced to three topics during circle time: “Math is magical, math is logical, and math is fun.” They also discussed these topics and developed a camaraderie, which was essential (Kennedy & Smolinsky, 2016). Research methods included quantitative and qualitative data collection and analysis to determine the efficacy of the intervention. Kennedy and Smolinsky (2016) reported that the mathematics circle intervention was very effective at improving the mathematics identity of a cohort of primarily African American middle school boys from low-SES backgrounds. The key factors that made this intervention successful were the positive social connection between the boys and increasing mathematics engagement via fun mathematics games (Kennedy & Smolinsky, 2016).

Another intervention that is effective at increasing mathematics engagement via academic identity is providing examples of academic achievement and contributions
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beyond stereotypical portrayals of children of color (Banks & Banks, 2010; Banks, Cookson, Gay, Hawley, Irvine, Nieto, & Stephan, 2001). An example of changing stereotypes about African American males is to provide examples of people who break current stereotypes of academic identity. In her research study to understand the importance of race- and gender-matched role models, Zirkel (2002) suggested that it is especially important for children of color to have role models they can identify with to provide them with career examples that help them visualize what they might become in the future. Zirkel (2002) used the analyzed results from a combination of student questionnaires, student diaries, teacher evaluations, and parent interviews to determine the importance of race- and gender-matched role models. She reported that role models motivated students in the study to increase their academic engagement for at least 24 months (Zirkel, 2002). Though this research study was conducted as a school-based intervention, it could be adapted to the OST setting.

Interventions that focus on culturally responsive teaching help students of color by training teachers to learn from the cultures of their students and develop lesson plans that are relatable and empowering, which improves academic engagement (Banks, 2010; Banks et al., 2001). McGee and Pearman (2014) conducted a research study that used a narrative analysis method and life-story interview format to help students provide rich descriptions of their school experiences and future outlook. After using axial coding to categorize the responses as risks/challenges and supports/protective factors, they determined that mathematically high achieving African American male primary and secondary students had several factors that were common among them. They had families that encouraged their academic success, recognition for being talented, and high teacher expectations. These
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Factors are essential to forming a strong mathematics identity, and two of them, recognition and high teacher expectations, can be introduced by teachers early during the elementary school years (McGee & Pearman, 2014). Culturally responsive teaching could be important to children at the youth center because over 90% are African American. Since this teaching primarily takes place in classroom settings, it is difficult to ascertain whether the children’s teachers use culturally responsive methods to teach them mathematics. However, some aspects of establishing a positive academic identity may be feasible in the youth center. Identity as a whole, and especially academic identity, is critically important to academic engagement and achievement overall (Givens et al., 2016).

**Computer-aided instruction**

Another intervention that helps form academic identity and improve engagement is practicing mathematics in a fun way (Gros, 2015). Interventions that use CAI to increase engagement in mathematics are promising for students from low-SES backgrounds (Cole & Griffin, 1987; Foster et al., 2016; Laffey et al., 2003; Page, 2002). CAI includes practice using drills and games, as well as instruction using tutorials, but the most engaging forms of CAI use gamified mathematics content to facilitate instruction and learning (Gros, 2015). Gros (2015) notes that educational games that provide clear goals, challenges, and feedback are important to improving motivation and engagement (p. 15). Effective mathematics CAI interventions typically have six characteristics: self-paced instruction, opportunities to respond, instructional pacing, immediate feedback to responses, engagement, and progress reports (Skinner et al., 2009). Most game-based mathematics content is embedded in an environment that requires the user to navigate his or her way through story-based scenarios and solve problems that increase in difficulty during
gameplay. Gamifying content is defined by Brigham (2015) as using “game design elements in a non-game context” (p. 473). Gamified elements usually include leaderboards, badges, and a points system (Brigham, 2015). Game-based learning interventions have been used in classrooms as a way to improve mathematics engagement for over 40 years and have proven to be effective at increasing motivation in disaffected students (Brigham, 2015). In an intervention conducted by Spires, Lee, and Lester (2012), teachers used game-based practices to teach science modules in the classroom, which they showed to be an effective way to increase engagement in science among eighth grade students. The details of the study were not discussed in the article; however, they reported that game-based platforms such as Crystal Island and Civilization III could be used to increase the long-term retention of science and history facts over standard teaching methods (Spires et al., 2012).

CAI interventions are also used during OST to improve mathematics fluency by reinforcing mathematics facts through gamified practice. Web-based computer programs, such as IXL and Kahoot!, are examples of gamified CAI platforms that use quiz show-style questions to increase mathematics proficiency by using more engaging methods for practice. Mathematics fluency is a precursor to proficiency, and mastering mathematics facts leads to fluency, so improving mathematics facts is important. Kiger, Herro, and Prunty (2012) examined the learning outcomes of an intervention where 46 third graders’ use of paper-based flashcards was compared to 41 third graders’ use of computer-generated flashcards such as those provided by Quizlet. The effect size of the intervention was consistent with the 0.17 effect size determined by Cheung and Slavin (2013), which indicated the intervention had a moderate effect on proficiency with multiplication. Results
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from the Kiger et al. (2012) study are particularly relevant for this research study because the student participants were similar in grade to the youth center population. Another example of a CAI platform that provides gamified practice but incorporates instruction is Khan Academy. Khan Academy is a web-based platform that offers free access to instructional videos, practice problems, and quizzes in mathematics, science, and other subjects for students in grades kindergarten through twelve. Khan Academy is primarily used as an OST enrichment tool that allows coaches, such as parents and teachers, to assign subjects and topic areas to individual children or create content for a group of children. Khan Academy also includes gamified elements, such as digital badging, streaks, leaderboards, and points, to increase engagement. Overall, CAI learning programs that involve role-play, gamification, and quizzes are a good way to use technology to engage disaffected students and provide meaningful mathematics enrichment during OST. In several studies, the increases in mathematics outcomes were attributed to students’ use of technology in a domain where the use of paper and pencil drills is typical (Bakker, Van den Heuvel-Panhuizen, & Robitzsch, 2015; Fletcher-Flinn & Gravatt, 1995; Li & Ma, 2010). Bakker et al. (2015) found that the use of mini-game modules used to help students in grades 1 through 3 was successful at teaching multiplicative reasoning ability in the OST environment when followed up with a review at school.

It is possible that the success of CAI interventions is due to novelty effects when the introduction of a new tool or process is the reason for change instead of the effectiveness of the new tool or process. Novelty effects typically diminish with continued exposure to the intervention, revealing little to no measurable change between the intervention and standard mathematics instruction with students who are on or above grade level in
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mathematics (Li & Ma, 2010). However, CAI interventions have proven to be effective at increasing engagement in populations of student groups with low numeracy skills without wearing off (Praet & Desoete, 2014; Räsänen et al., 2009). Räsänen et al. (2009) used results from number comparison tasks to compare data from treatment and control groups and then concluded that there were moderate effects of the intervention on number comparison tasks. Preschool children with low numeracy skills doubled their subitizing ability by practicing numeracy skills using two computer games for up to 15 minutes per day during the three-week intervention. Taken as a whole, CAI interventions that include gamified elements could be a viable intervention for children at the youth center.

**Parental involvement**

Considering the amount of time students spend in out-of-school settings, including their homes, the impact of parental involvement on mathematics engagement should be examined. Parental involvement is viewed as a critical component of supporting student academic engagement (Gadsden & Dixon-Roman, 2017; Galindo & Sonnenschein, 2015; Jeynes, 2005; Sheldon, Epstein, & Galindo, 2010). There is no consensus on one definition of parental involvement, but the consistent indicators of involved parents are rule setting in the home, school participation, teacher-parent communication, and parent-student communication about academics (Sheldon et al., 2010). If parents exhibit authoritarian behaviors, commonly known as strict parenting (demanding but not responsive), instead of authoritative behaviors, characterized by high expectations and support, students can become disaffected instead of engaged and motivated (Bempechat & Shernoff, 2012). Interventions that have been designed to increase parent involvement have improved relationships and communication between parents and teachers (Jeynes, 2005). Sheldon et
al. (2010) conducted an analysis of 39 participating elementary, middle, and high schools that were part of a national network. Each participating school was asked to report on the effectiveness of implementing 15 community practices designed to increase mathematics proficiency. The schools that implemented at least 10 of the community practices saw an increase in proficiency. In particular, elementary schools experienced a 3.4% increase in the number of proficient students. Interventions focused on improving relationships between teachers and parents also improve student engagement (Kraft & Rogers, 2015; Osefo, 2016; Quin, 2017; Sheldon et al., 2010). This includes helping teachers understand the cultural characteristics of the families they serve, changing the focus of parent-teacher conferences from reporting to collaborating (Wu et al., 2010), and making school a more inviting environment for parents (Epstein et al., 2018).

In many US schools that serve minority students from low-SES backgrounds, the teachers are not from those communities; the teachers are often from a middle-SES background and are of a different race or ethnicity (Wu et al., 2010). This creates situations where teachers may have trouble understanding the behaviors exhibited by their students and parents, which could lead them to interpret unfamiliar behaviors and attitudes as negative and result in student and parental disaffection. Chavkin (1993) argues that minority parents can become less engaged when they feel intimidated by teachers, and teachers in the study interpreted the parents’ actions as disaffection. Interventions developed to change teacher beliefs and attitudes toward parents and improve school culture involved having regular community events that provided an opportunity for parents and teachers to socialize in a non-threatening setting (Osefo, 2016; Sheldon et al., 2010). Sheldon et al. (2010) conducted a research study with 39 schools to determine the effects
of family involvement on mathematics proficiency. Descriptive analysis was conducted to characterize the sample by levels of mathematics proficiency and identify other key variables. After conducting a regression analysis, they reported that when family involvement activities are implemented with fidelity, the mathematics proficiencies of children in those households increased (Sheldon et al., 2010). Family involvement activities have been shown to build relationships between parents and teachers, which in turn resulted in increased engagement and achievement in mathematics (Chavkin, 1993).

**Parent-teacher communication**

Interventions developed to increase student engagement via parent involvement also have focused on improving communication between parents and teachers. Kraft and Rogers (2015) implemented an intervention designed to reduce the dropout rate of high-school students from low-SES backgrounds by increasing parental involvement. Teachers were instructed to send a short message to parents each week during the intervention that informed the parent of their child’s academic performance. The findings from the research study indicated that encouraging conversations between parents and students results in improved academic engagement and, ultimately, increased student retention. When teachers sent parents negative messages about the child, the parent-child conversations were more punitive, which sometimes resulted in lower academic engagement (Kraft & Rogers, 2015). Conclusions from the Kraft and Rogers (2015) research study provide support for the relationship between positive communications between teachers and parents and increased academic engagement.

Although increasing communications with parents can increase academic engagement and mathematics proficiency, there is little, if any, time to provide ongoing
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communications with the parents of every child (Kraft & Rogers, 2015). In an intervention where the primary mode of communication with parents was texting, it took an average of 30 minutes to send messages for 15 students (Ho, Hung, & Chen, 2013). Parents felt more connected and better able to support their children, but it would be difficult for teachers to implement this as a long-term strategy for increasing mathematics engagement. The teachers who participated in this research study thought this could be an effective means of increasing parental involvement and student engagement. However, they thought that school district policies about cellphone use would limit the implementation of texting as an intervention.

Ultimately, parents must be made to feel welcomed, understood, and valued as the first step to increasing parental involvement and ultimately increasing student engagement (Osefo, 2016). Communication is an important aspect of parental involvement, and policies and practices must be developed to facilitate more positive and collaborative interactions between parents and teachers to create a more engaged school culture for students. Conducting an intervention that included parents was a consideration for this research study since the youth center has periodic meetings with families to encourage parental support and communicate updates to programming and schedules. However, many parents did not attend meetings on a regular basis, so an intervention that focused on parents would have depended on my ability to engender more participation with parents versus children.

**Peer-assisted learning groups**

Interventions that encourage learning via peer groups have also been shown to increase mathematics achievement through more engaging interaction between peers (Baker, Gersten, Dimino, & Griffiths, 2004; Esmonde, 2009; Fuchs, Fuchs, & Karns, 2001;
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Maheady, Harper, & Mallette, 2001; Rohrbeck, Fantuzzo, Ginsburg-Block, & Miller, 2003; Slavin, 2011; Topping, 2005). Peer-assisted learning (PAL), a form of cooperative learning, can be summarized as an instructional method in which students are placed in small groups to help one another learn. The most effective PAL interventions consist of four components: a small group of two to six students, a problem to solve as a group, individual accountability, and an incentive that rewards the learning of everyone in the group (Slavin, 2011). PAL promotes engagement, social skills, and cognitive development. The prevailing theory about how PAL works is that group cohesion and achievement gains are contingent upon a common goal and reward (Fuchs et al., 2001; Slavin, 2011). PAL interventions can promote academic gains in knowledge development by helping children elaborate on ideas and concepts during engaging group discussions. When students are engaged and motivated to support the learning of members of their group, and when group roles are reciprocal, higher ability students and lower ability students both demonstrate gains in achievement due to elaboration (Slavin, 2011).

Classrooms that implement PAL also see increases in engagement, collaboration, and goal setting (Baker et al., 2004; Esmonde, 2009; Fuchs et al., 2001; Maheady et al., 2001; Rohrbeck et al., 2003). Esmonde (2009) conducted a research study to determine the types of roles formed by secondary students in PAL groups and the equity of those roles. She found that students adopted four roles for mathematics tasks that involved work practices of collaboration, individual work, and helping. Only children who adopted the expert role were the most engaged for group quizzes. Mathematics engagement was more equitable amongst members of the group for group presentations (Esmonde, 2009).
A research study conducted by Baker et al. (2004) included 400 elementary students from low-SES backgrounds in southeastern US states. Participants in the PAL intervention were placed in dyad groups and took turns as coach and player. Baker et al. (2004) used a modified version of the Concerns-Based Adoption Model as a multi-method way of determining the efficacy of PAL. Three types of data were collected and analyzed as part of this method: Semi-structured interviews, classroom observations, and surveys. After analyzing the data, Baker et al. (2004) reported that using PAL dyad groups were effective at increasing student engagement in mathematics and mathematics-related practice and proficiency. They also determined that this PAL intervention increased a teacher’s ability to be more innovative during instruction time and persisted beyond the initial dosage due to its alignment with school district policies. PAL groups have been effective in school settings, but it was unclear whether the same outcomes were possible in the youth center setting. Another method of increasing mathematics engagement and proficiency with more potential during OST was goal setting.

Goal setting

Interventions focused on goal setting have also been used to increase engagement and improve mathematics proficiency (Buzza & Dol, 2015; Furner & Gonzalez-DeHass, 2011; Olympia, Sheridan, Jensen, & Andrews, 1994; Turner & Patrick, 2004). Goal setting in classroom environments is when students are instructed to develop a goal or set of goals associated with a specific lesson. In the context of a mathematics classroom, the teacher may provide instruction for a unit on dividing two-digit numbers by single-digit numbers. Students in this class would be instructed to develop a goal that explains what they hope to learn by the end of the unit.
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When goal setting is implemented with fidelity, engagement with mathematics content increases (Furner & Gonzalez-DeHass, 2011). High fidelity implementations require that teacher facilitators be trained in guiding students through the process of developing well-defined goals. Furner and Gonzalez-DeHass (2011) conducted a review of literature to better understand how the instructional practices of teachers influence their students’ goal-setting behaviors and mathematics anxiety. They reported that, in addition to receiving training, teachers must also understand the conceptual merit of goal setting. Developing a conceptual instead of a procedural understanding helps ensure implementation fidelity and the sustainability of goal-setting practices (Furner & Gonzalez-DeHass, 2011). Students can also learn goal-setting techniques by participating in self-guided workshops during OST (Martin, 2008). However, Buzza and Dol (2015), did not find a statistically significant change in mathematics engagement over time. They conducted their research study with 12 high-school students with learning difficulties and had them complete a questionnaire that helped them write their goals each week. Results from the research study indicated that only the quality of written goals increased by the end of the intervention, not mathematics engagement (Buzza & Dol, 2015). When a similar goal-setting writing intervention was conducted with boys from a different demographic background, 53 high-school boys from a high-SES background, the intervention was more effective at increasing mathematics engagement (Martin, 2008). Effective goal-setting workshops require students to construct written responses about the mathematics modules to reinforce their learning through reflection (Martin, 2008). Researchers from both studies indicated that student attendance and implementation fidelity are important for the efficacy of goal-setting interventions of this type. Since the Buzza and Dol (2015) research study
showed limited effectiveness at changing mathematics engagement and focused on a different target population, it is difficult to determine whether goal-setting interventions would be effective with students from low-SES backgrounds.

**Teacher relationship quality**

Teacher-student relationship quality (TSRQ) has been shown to mediate low academic achievement in school (Wu et al., 2010). Interventions developed to improve TSRQ include in-person conferences with students (Murray & Malmgren, 2005), child-centered play therapy (Wu et al., 2010), and school counselor consultations (Murray & Malmgren, 2005). In-person conferences have been implemented in many ways, but the most common include structured weekly meetings, goal-centered conversations, encouragement, and tracking of positive communications (Ray, 2007). The results from studies of in-person conferences show that when teachers devote approximately 10 minutes twice per week to meet with and listen to students talk about topics of their choice, teachers gain greater insight into the lives of their students and develop empathy for them (Driscoll & Pianta, 2010; Murray & Malmgren, 2005). The focus of conferences is to listen to students, help name their emotions as they discuss their interests, and provide encouragement. These practices communicate that teachers care and are listening, and they result in a bond between both parties (Murray & Malmgren, 2005). Murray and Malmgren (2005) provided an intervention for 48 African American high-school students from low-SES backgrounds. The teachers that participated in the research study were instructed to meet with their assigned students once per week to discuss the student’s academic goals. Teachers were also instructed to identify areas to praise the students throughout the week, and finally to call them at home up to two times per month to share the student’s progress.
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in school. Murray and Malmgren (2005) found this type of intervention showed evidence of being effective at increasing academic engagement and achievement. Another type of TSRQ intervention that involved school counselors was also explored.

Counselors can consult with teachers to identify students who could benefit from child-centered play therapy (CCPT) to improve TSRQ (Ford et al., 2008; Ray, 2007). CCPT is when a counselor uses regular sessions with the child during the school day to have him play with a variety of toys to express his feelings about the teacher, then help the child develop a strategy for improving the relationship with the teacher. This technique has been effective at improving academic achievement related to negative TSRQ (Ray, 2007). In the Ray (2007) intervention, the counselor met with a teacher for 10 minutes per day once per week to discuss the case, provide management techniques, and monitor the relationship until it improved. Participants were randomly assigned to one of three treatment groups and the preintervention and postintervention questionnaires were analyzed separately using the Index of Teaching Stress Total Stress Score to evaluate the test variables. Results indicated that teacher-student stress was markedly reduced after the intervention. Ray (2007) argued that this could be a successful intervention, but noted that teachers in the study were apprehensive about seeking the help of a counselor before going to a fellow teacher or principal. Furthermore, Ray (2007) cautioned that the effectiveness of CCPT may vary if used as a large-scale method to improve TSRQ.

Interventions that target the improvement of TSRQ range from child-centered conferences to support from guidance counselors. Of the four interventions that used TSRQ to improve mathematics engagement, CCPT would be easiest to implement in youth centers. Although using school counselors to help teachers reconcile negative student-
teacher interactions can only happen at schools and be facilitated by school counselors, an adaptation of using school counselors could be implemented at youth centers. Conceivably, the adaptation could use youth center staff counselors to help children understand their feelings toward their teachers and offer techniques that children and parents could use to improve the child’s relationship with their teachers. CCPT is a technique that could be implemented at youth centers but would need to be facilitated by a youth center counselor instead of a school counselor. The youth center that will be included in this research study does not have permanent counselors on staff, so this would be difficult to implement as an intervention.

**Intervention Selection**

The literature on decreasing mathematics anxiety and increasing mathematics engagement reviewed in this chapter included several interventions that would be appropriate for the youth center participants and could be implemented during OST. Interventions that could decrease mathematics anxiety include expressive writing, cognitive modeling, and computer adaptive programs. Expressive writing could be used before children began working on mathematics exercises during OST. Cognitive modeling exercises, such as mindfulness techniques, could be used to help prepare children to do mathematics homework or control their anxiety after learning mathematics. Finally, computer adaptive programs could be used to help decrease mathematics anxiety during OST by developing fluency.

Although expressive writing interventions showed some evidence of being effective, they were most effective immediately before in-class mathematics instruction or before a mathematics exam (Park et al., 2014). Since it would have been difficult to design an OST
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intervention in concert with the classroom setting, I decided not to pursue this as a possible intervention. The computer-adaptive interventions examined in this literature review were primarily used during in-school instruction to decrease mathematics anxiety via increased mathematics fluency. Since computer adaptive programs are not specifically designed to decrease mathematics anxiety and there are other interventions designed to have a direct effect on reducing mathematics anxiety, a computer adaptive intervention was not chosen for this research study. At the time of this study, the Khng (2017) study was the only published intervention where mindfulness was specifically used to treat mathematics anxiety for children in primary school. Because of the connection between working memory and academic performance, mindfulness techniques showed promise as a mediator for increasing the capacity of working memory in children under mathematic anxious circumstances (Diamond & Lee, 2011; Flook et al., 2010). Not only have mindfulness practices shown evidence of efficacy, but they are relatively easy to implement with children in primary school (Khng, 2017). Researching the effectiveness of mindfulness techniques to help reduce mathematics anxiety also had the potential to contribute to new approaches in the field of mathematics anxiety research, so mindfulness practices were chosen as the intervention to treat mathematics anxiety for this research study.

The second set of interventions focused on increasing mathematics engagement during OST. Mathematics engagement interventions that were appropriate for the youth center included developing an academic identity, CAI, increasing parent involvement, peer-assisted learning groups, and goal setting. Though the majority of these interventions were designed to be conducted in the school setting, they could also be implemented during OST if adapted for the youth center setting. Developing an intervention to increase academic
identity as a mathematics student was effective at increasing engagement (Givens et al., 2016) but required close coordination with each students’ mathematics teacher. Increasing parent involvement was also effective (Kraft & Rogers, 2015; Quin, 2017), but the effectiveness seemed to be based more on extrinsic motivation. PAL could be effective in OST settings (Baker et al., 2004) but requires extensive planning and facilitation by a trained adult. Finally, goal setting was also effective (Furner & Gonzalez-DeHass, 2011), but not as effective as other interventions designed to increase engagement in mathematics. Of the interventions examined, an intervention that used CAI to increase mathematics engagement had the greatest likelihood of improving mathematics engagement during OST. Interventions that used CAI to increase mathematics engagement, such as those evaluated in the Kiger et al. (2012) and Spires et al. (2012) studies, demonstrated great promise during classroom instruction and could be easily adapted to the OST setting.

**Program and Platform Selection**

After selecting mindfulness techniques to reduce mathematics anxiety and CAI to increase mathematics engagement, I needed to determine a method for delivering the intervention. The following explains my rationale for selecting programs and platforms for the intervention.

Two platforms were identified as candidates for mathematics anxiety interventions, the Growth Mindset curriculum from Khan Academy and the How iDecide Mindful Choices curriculum. Both platforms provided cognitive modeling and were candidates because they could be used to reduce mathematics anxiety, are designed for elementary school children, are computer-based, and could be administered quickly. However, they treat mathematics anxiety using different mechanisms of action. After examining the
intervention research studies and computer-based resources that were available to provide training in growth mindset and mindfulness, the Mindful Choices program was the better choice. Mindfulness practices appeared to have a more direct relationship to mathematics anxiety than developing a growth mindset (Flook et al., 2010; Khng, 2017). Also, Flook et al. (2010) used multivariate analysis of teacher and parent reports to demonstrate that children who use mindfulness exercises before performing mathematics exercises appear to free-up working memory, which may reduce mathematics anxiety. From an implementation standpoint, the Mindful Choices curricular materials were free to use, they included video examples designed for elementary students, and they could be administered quickly. Mindful Choices also included training materials for teachers.

The Mindful Choices exercises were developed by an organization called How iDecide and are designed to reduce stress, increase self-control, and sustain attention for students in grades kindergarten to 12 during the school day. Participating in relaxation exercises before performing mathematics has been proven to reduce mathematics-induced anxiety by Khng (2017). How iDecide has structured the Mindful Choices curriculum into two categories, exercises for primary students and exercises for secondary students. Since my student population was primary students, I chose from the list of 11 possible mindfulness exercises in the elementary curriculum. I chose exercises that were the easiest to explain and understand, could be completed within the first five minutes of the intervention, and that would be interesting to children at the youth center based on anecdotal feedback from children who attend the youth center. The exercises listed in Figure 3.1 were chosen based on these criteria.
**MINDFULNESS EXERCISE**

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<td>Arm Raises</td>
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<td>Match Breaths</td>
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<td>Match Breaths w/ Retention</td>
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<tr>
<td>Lazy 8</td>
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<tr>
<td>Sun Salutation</td>
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<td>Yes Breaths</td>
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*Figure 3.1. Listing of the mindfulness exercises for module 1 of the intervention.*

The sequence of mindfulness exercises was based on the level of difficulty as determined by How iDecide. Mindfulness interventions were shown to be effective when conducted at least five minutes, three days per week, for eight weeks (Brunyé et al., 2013; Khng, 2017; Supekar et al., 2015). Since a dosage of four times per week for six weeks results in the same exposure time as one of three times per week for eight weeks, the proposed dosage for this research study should result in similar outcomes to the interventions conducted by Brunyé et al. (2013), Khng (2017), and Supekar et al. (2015).

The mathematics engagement part of the intervention was conducted using two computer-based platforms: Khan Academy and Tivitz. Both platforms were used because no platform fully met all selection criteria independently. The first platform, Khan Academy, provides instructional videos and practice in a broad range of subjects, including numbers and operations for mathematics. Khan Academy is a web-based platform that provides free instruction and practice in mathematics, science, computer programming, and SAT preparation using instructional videos and practice problems that are self-paced. Khan Academy was chosen because it adheres to the six characteristics associated with effective mathematics CAIs (self-paced instruction, opportunities to respond, instructional pacing, immediate feedback to responses, engagement, and progress reports). In addition to
providing mathematics instruction, Khan Academy units also include practice exercises. I kept the associated practice exercises based on their potential to reinforce addition, subtraction, multiplication, division, and fraction concepts within the allotted amount of time for each intervention session because they are in alignment with the six characteristics of effective mathematics CAIs defined by Skinner et al. (2009).

In addition to meeting the six characteristics of effective CAIs, the platform also needed to be emotionally and cognitively engaging. Emotionally engaging academic activities should include enthusiasm, enjoyment, fun, and satisfaction (Skinner et al., 2009). Cognitively engaging academic activities should promote attention, focus, participation, and willingness to go beyond what is required (Skinner et al., 2009). Although Khan Academy exhibits the characteristics of effective CAIs, it does not meet all characteristics of emotional and cognitive engagement. Khan Academy does promote most cognitive engagement attributes, such as attention, focus, and participation, but may not promote the willingness of elementary students to participate beyond what is required. Anecdotal evidence from children at the youth center who have used Khan Academy indicated they only used Khan Academy when instructed by teachers. It is also unclear whether Khan Academy provides practice in a way that is culturally relevant to students from low-SES backgrounds. When evaluating Khan’s ability to promote emotional engagement using the video instructional modules, there is little evidence that the instructional modules alone would increase engagement in mathematics (Light & Pierson, 2014). Because of this uncertainty, it was necessary to augment the instructional features of Khan Academy with a platform that focused on gamified mathematics practice.
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When considering which emotionally engaging platform to use, I used logistical criteria such as being low cost, providing modern gameplay and accurate problem sets, being easy to implement, allowing for the adjustment of difficulty levels, being able to be completed within 10 minutes, and allowing each child’s participation to be monitored, in addition to the six characteristics of effective CAIs (Skinner et al., 2009). After comparing the 10 platforms to the criteria for being emotionally and cognitively engaging, only Education.com, Prodigy, and Tivitz qualified. However, Prodigy did not meet all of the logistical criteria, as it takes at least 10 minutes to get started, has dated graphics, and the mathematics practice is not seamlessly integrated into the game. For these reasons, it was removed from consideration. After observing youth center children play a sample version of both Tivitz and the Education.com games, children were more willing to go beyond what was required with Tivitz games, as demonstrated by children stopping on their own after the assigned Education.com games but needing to be told to stop when playing Tivitz. Tivitz also provides more focused practice with numbers and operations than Education.com games. Therefore, Tivitz was chosen as the second half of the engagement part of the intervention.

Tivitz is designed to help children in grades kindergarten through 9 practice number operations and critical thinking skills through gameplay by combining features of video games with strategy-based board games, such as chess. Children compete against the computer, a friend, or an online opponent to move their pieces from their side to their opponent’s side of the electronic game board. Each piece is assigned a numeric value, and each player scores by placing their piece with a set value on a space that either adds, subtracts, multiplies, or divides the value of each piece. For example, if a piece with a
value of five is moved to a final space that adds 10, the player earns a score of 15. If a second piece with a value of six is moved to a final space that subtracts two, the player earns a score of four. The final score of each game is tallied by the child adding the values of the final spaces and entering them into the electronic scorecard. Tivitz has nine levels, and each one corresponds with a student’s grade level. Tivitz limits gameplay to addition, subtraction, multiplication, division, and fractions. Much like Khan Academy, the game levels in Tivitz can be mapped to the Common Core State Standards for mathematics. I assigned each student a starting level in Tivitz based on their results from a placement assessment using iReady. The Tivitz grade level corresponded to the same grade level used for Khan Academy. Intervention participants were given 10 minutes each day to practice mathematics using Tivitz. The combined exposure time to Khan Academy and Tivitz equaled 80 minutes per week. This exceeded the 25-minute per week minimum exposure time to CAI recommended by Cheung and Slavin (2013). Incorporating the gameplay of Tivitz into the intervention should have helped provide gamified practice of the concepts learned through Khan Academy. The combination of both CAI platforms allowed me to deliver a mathematics engagement intervention to children in the youth center during OST.

**Theory of Change**

The model of triadic reciprocity is an essential component of social cognitive theory, and I chose it as the basis of my theory of change because it addresses how learning occurs by observing one or more models (Schunk, 2012). Subcomponents of cognitive skill learning include observational learning and cognitive modeling. Observational learning is when the observer displays new behaviors that would not have been exhibited before showing the model through the process of attention, retention, production, and motivation.
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(Schunk, 2012). Cognitive modeling uses modeled explanation and demonstration along with verbalization of the modeler's thoughts to communicate the expected actions (Figure 3.2).

**Cognitive Skill Learning**

**Observational Learning**

**Cognitive Modeling**

*Figure 3.2. Social Cognitivism Cognitive Skill Learning Model. Shows how observational learning and cognitive modeling are related to cognitive skill learning (Schunk, 2012).*

Cognitive skill learning provides a model for how mathematics anxiety can be decreased using mindfulness techniques. The child develops the cognitive ability to demonstrate the desired mental state through verbal explanation of the rationale and modeled demonstration (Schunk, 2012). Cognitive skill learning requires that a teacher explain and demonstrate a skill, students then receive guided practice, and the teacher checks for understanding. Although not explicitly stated by How iDecide, my observation is that the Mindful Choices curriculum uses cognitive skill learning to provide cognitive modeling for children experiencing anxiety. The Mindful Choices curriculum requires that participants learn the demonstrated relaxation techniques after they have been explained and demonstrated by a facilitator. Participants then receive guided instruction to perform each Mindful Choices exercise. The facilitator concludes the exercise by checking for understanding and re-models the exercise as needed. This follows Schunk’s (2012) example of cognitive modeling to perform the given exercises. The use of mindfulness techniques within this study can be categorized as cognitive skill learning because both
cognitive modeling and observational learning are used to implement the techniques correctly. After children are trained how to use the techniques, they are able to implement them on their own when in need. Since the purpose of the Mindful Choices curriculum is to help children become more aware of their emotional state and help them calm themselves, it was my hypothesis based on previous research (e.g., Diamond & Lee, 2011; Flook et al., 2010) that having participants practice the mindfulness exercises before receiving mathematics instruction or practicing mathematics would result in reduced mathematics anxiety.

Cognitive modeling, a subset of cognitive skill learning, also helps explain the primary mechanism that Khan Academy and Tivitz use to increase engagement. Cognitive modeling is operationalized through cognitive skill learning, which uses modeled explanation, demonstration, and verbal explanation to increase cognitive and emotional engagement (Schunk, 2012). Khan Academy demonstrates the use of cognitive modeling through the instructional videos and practice problems provided. Each mathematics topic is verbally explained, the solution is modeled, and students have an opportunity to demonstrate their learning by completing practice problems. Tivitz also uses cognitive modeling to increase engagement in mathematics practice using the same techniques. Participants are given a verbal explanation of how to play Tivitz and how practicing mathematics by playing Tivitz is designed to increase their proficiency in mathematics. The gameplay was modeled by a computer tutorial that illustrated possible movements and rules of the game. Though Tivitz is distinctly different from Khan Academy, participants must receive modeled instruction to ensure they use Tivitz correctly. Since elements of each part of the intervention can be represented by cognitive skill learning, which includes
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observational learning and cognitive modeling, it is an appropriate model to support the theory of change behind my intervention.

The directional hypothesis was that an intervention could be administered in an OST setting, such as a youth center, to decrease mathematics anxiety and increase mathematics engagement. The theory of change was that mathematics proficiency could be increased by decreasing mathematics anxiety using mindfulness exercises and increasing mathematics engagement using CAI (Figure 3.3).

<table>
<thead>
<tr>
<th>Activities</th>
<th>Intermediate Outcomes</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Mindfulness Exercises</td>
<td>• Decreased Mathematics Anxiety</td>
<td>• Increased Mathematics Proficiency</td>
</tr>
<tr>
<td>• Khan Academy Instruction</td>
<td>• Increased Mathematics Engagement</td>
<td></td>
</tr>
<tr>
<td>• Tivitz Practice</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 3.3. Theory of change model. Depicts activities associated with each module, their intermediate outcomes, and impact.*

**Conclusion**

The intervention was divided into three modules of activities to provide a comprehensive intervention to address both mathematics anxiety and mathematics engagement. This approach utilized cognitive skill learning as described from a social cognitive theoretical perspective to decrease mathematics anxiety and increase mathematics engagement. Module 1 addressed mathematics anxiety by using the Mindful Choices exercises to help elementary children practice mindfulness techniques. The design of module 1 was influenced by the relaxation techniques studied by Bellinger et al. (2015) and Khng (2017). Both interventions used mindfulness techniques before having children
perform mathematics exercises and found them to be effective at reducing mathematics anxiety. Module 2 and module 3 used two separate CAI platforms, Khan Academy and Tivitz, to address mathematics engagement. Module 2, CAI via Khan Academy, focused on providing instruction in mathematics. Module 3, CAI via Tivitz, provided participants an opportunity to practice what they learned from module 2. The design of modules 2 and 3 was influenced by the mathematics CAI intervention study developed by Gros (2015), and they were combined to be consistent with the six characteristics of effective CAI interventions suggested by Skinner et al. (2009). The combination of modules 1 through 3 were the basis of the intervention (Figure 3.4).

Ideally, one platform with the desired engagement and logistical characteristics would be preferred instead of using three different platforms, but there were none that met all of the requirements for an effective intervention. The intervention focused on decreasing mathematics anxiety and increasing mathematics engagement when working with numbers and operations involving addition, subtraction, multiplication, division, and fractions.

Figure 3.4. This figure provides an overview of the CAI intervention schedule for one of the six weeks. Details of modules 1, 2, and 3 are shown.
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In summary, a CAI platform with gamified mathematics content and cognitive modeling exercises allowed me to provide an intervention with the potential to decrease mathematics anxiety and increase mathematics engagement. Each platform was integrated into a custom website that helped me facilitate the delivery of mindfulness exercises, mathematics instruction, and gamified mathematics practice during the intervention. An evaluation of this planned intervention is described in chapter four.
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Chapter 4 – Intervention Procedure and Program Evaluation Methodology

After a review of various interventions that address mathematics anxiety and engagement among elementary students from low-SES backgrounds, mindfulness exercises and CAI mathematics practice were shown to have the potential to decrease mathematics anxiety and increase mathematics engagement, which should then contribute to increased mathematics proficiency (Bakker et al., 2015; Bellinger et al., 2015; Brigham, 2015; Brunyé et al., 2013; Khng, 2017; Kiger et al., 2012). This chapter details the research design and methods used to determine whether third through fifth grade elementary students from low-SES backgrounds became less mathematics anxious and more engaged in mathematics after participating in the proposed intervention implemented at a neighborhood youth center in Baltimore City during OST.

This intervention, called Navigating Numbers, was organized into three modules. Module 1 was designed to treat mathematics anxiety using a relaxation technique called mindfulness. Module 2 was designed to provide mathematics instruction via Khan Academy, and module 3 was designed to provide mathematics practice using the Tivitz mathematics game (Figure 3.4). The total time for modules 1 through 3 was approximately 25 minutes each day of the six-week intervention. The research questions that were examined for the intervention are:

- RQ 1: Was the intervention completed with fidelity?
- RQ 2: Was completion of the intervention associated with a decrease in mathematics anxiety?
- RQ 3: Was completion of the intervention associated with an increase in mathematics engagement?
Research Design and Logic Model

The research questions were explored using a mixed-methods approach with a convergent parallel design in which the qualitative and quantitative strands were given equal importance when examining and explaining results from the research study. This was done by collecting quantitative and qualitative data during the research study, analyzing the results independently, then using results from both strands to formulate a conclusion. The convergent parallel design was chosen to provide a more holistic understanding of both quantitative and qualitative results due to the small sample size. The logic model in Figure 4.1 represents the inputs, activities, and outputs that outline the research study design.

![Logic Model](image)

*Figure 4.1. Logic Model Representing the Inputs, Assumptions, Resources, and Expected Outcomes of the Navigating Numbers Intervention.*
Process Evaluation

Evaluation of the process of implementation included the presentation of descriptive statistics derived from participation logs, CAI data, and an analysis of focus group data. Blended results from the convergent parallel design were used to determine whether the Navigating Numbers intervention was implemented as planned.

Outcome Evaluation

The proximal outcomes of the intervention were determined by measuring the data from the questionnaires, which were used to measure change and program effect. The constructs that were evaluated included mathematics anxiety and mathematics engagement, using questionnaires collected both preintervention and postintervention to determine any change. Outcome change was evaluated by comparing the prequestionnaire and postquestionnaire results and by comparing those results to focus group responses. Program effect on reducing mathematics anxiety and increasing mathematics engagement was determined by examining the results from both questionnaire results and focus group interview responses. Since the small sample size made statistically significant quantitative conclusions unlikely, the design also included a qualitative strand to help formulate conclusions about the intervention.

Strengths and limitations of design

The possibility of detecting mathematics anxiety and engagement were strengths of the proposed research design. Each module was designed to have a direct effect on mathematics anxiety or mathematics engagement, and these effects had the possibility of being observed through a combination of quantitative and qualitative data. Ultimately, this
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design had the potential to allow changes in mathematics anxiety and engagement to be detected.

Limitations of the evaluation design were the small sample size and short duration of the Navigating Numbers intervention. Other studies discussed in the literature review varied in sample size from six to thousands of participants, with durations from three weeks to 24 months. This intervention had a sample size of 11 children and a duration of six weeks. The sample size was limited by youth center enrollment and capacity, and the research study duration was limited by the programmatic constraints of the youth center during the COVID-19 pandemic. After calculating the minimum sample size for a paired sample t-test with an alpha of .05 and power of .95, I determined a sample size of at least 29 would be needed for an effect size of 0.7. This meant that the difference between my prequestionnaire and postquestionnaire results needed to be very large to detect any changes of statistical significance. Since the sample size was 11 participants, I use the Wilcoxon signed rank test instead of a paired t-test to determine changes between the preintervention and postintervention questionnaire results. I used the qualitative results to corroborate what was found in the quantitative results and triangulate by blending both types of results. This approach helped mitigate the challenge presented by a small sample size and increased my ability to accurately detect changes in mathematics anxiety and mathematics engagement.

In summary, the convergent parallel mixed methods design with cluster sampling was chosen because this approach allowed me to treat quantitative and qualitative data equally and better understand the results from a small sample size. In the context of this
research study, the term “blending” means that both the quantitative and qualitative results are compared, then interpreted together to develop the final statement of results.

**Method**

Both quantitative and qualitative data were used to answer the three research questions. RQ1, to what extent the intervention was implemented with fidelity, was answered by determining time on task and analyzing focus group feedback. RQ2 sought to determine whether the completion of the intervention was associated with a decrease in mathematics anxiety. Finally, RQ3 asked whether the completion of the intervention was associated with an increase in mathematics engagement. RQ2 and RQ3 were answered by interpreting preintervention and postintervention results from the validated instruments and analyzing responses provided during the focus group interviews.

**Participants**

The children who participated in this intervention were a mixture of boys and girls in third, fourth, and fifth grade students who attended a youth center in Baltimore City. All participants attended the neighborhood Title I elementary school. A total of 11 children participated in the study. Four of the participants were in third grade, three were in fourth grade, and four were in fifth grade. Six boys and five girls participated in the study.

**Measures**

Given the research questions, the measures of interest included fidelity, mathematics anxiety, and mathematics engagement. Participant grade levels were determined with the iReady mathematics assessment. Implementation fidelity was measured using tabulated time on task (ToT) observations during the mindfulness exercises and by using metadata from Khan Academy and Tivitz. Goh, Hannan, and Webster (2016)
found that direct observation was a valid way to measure implementation fidelity. Two instruments were used to measure the constructs of mathematics anxiety and mathematics engagement. The following describes the measures and instruments used to assign participants to their assessed grade level and answer each research question.

Determining mathematics grade level. Participant mathematics grade level was determined by using the iReady mathematics assessment. The iReady assessment’s content has been validated to identify the mathematics grade level of children in grades kindergarten through 12 (National Center on Intensive Intervention, 2014). I used iReady to assess four mathematics content areas (algebra and algebraic thinking, geometry, measurement and data, and numbers and operations) for children in grades 3 through 5. The computer-based adaptive assessment began with questions at each student’s grade level, then adjusted the level of difficulty based on the number of correct or incorrect responses (Curriculum Associates, 2012). Of the four content areas, only numbers and operations were used to determine the baseline mathematics grade level because they covered addition, subtraction, multiplication, division, and fractions. Scale score thresholds were used to determine grade level and categorize children as on or above grade level, less than one grade level below, or greater than one grade level below their current grade (Appendix G). Participant-specific unit assignments were based on the scale score results, which indicated the areas where they needed the most help.

Measuring implementation fidelity. Adherence was the primary measure of fidelity of implementation and included content, coverage, frequency, and duration as has been described by Cassata, Kim, and Century (2015). In the context of this study, content measured how many of the assignments from modules 1, 2, and 3 were completed.
Coverage measured whether the intervention reached the intended youth center population. Frequency is meant to measure the frequency of practice to learn in a given context. In the context of this intervention, frequency measured whether the content from all three modules were completed according to the intervention schedule. Finally, duration measured how long participants spent completing the assignments.

Observations are an acceptable way of determining the fidelity of implementation (Century, Rudnick, & Freeman, 2010), so observations of ToT were based on field notes recorded for modules 1, 2, and 3. ToT data for modules 1, 2, and 3 were measured using the student participation log in Appendix D to determine which exercises were completed when they were completed, and how many were completed. ToT for module 1 was determined by measuring how much time participants spent on each exercise. Table 4.1 is a depiction of mindfulness exercise schedule that shows the time required to complete each exercise once and the weeks when the exercises were performed by participants. In addition to making physical observations during the intervention, fidelity of implementation for modules 2 and 3, regarding Khan Academy and Tivitz participation, also measured adherence by examining how much time participants spent watching the assigned videos and completing the exercises after starting a module. These metrics were monitored using the metadata available via the administrator’s dashboard in Khan Academy and Tivitz. The units of measurement were average ToT for the assignments per week. Xhakaj, Aleven, and McLaren (2017) demonstrated that metadata tracked by CAI platforms such as Khan Academy and Tivitz, could be used to determine ToT for participants.

Table 4.1

*Mindfulness exercises schedule*
<table>
<thead>
<tr>
<th><strong>MINDFULNESS EXERCISE</strong></th>
<th><strong>Time (min:sec)</strong></th>
<th><strong>Monday - Thursday</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Arm Raises</td>
<td>1:32</td>
<td>Week 1</td>
</tr>
<tr>
<td>Match Breaths</td>
<td>2:38</td>
<td>Week 2</td>
</tr>
<tr>
<td>Match Breaths w/ Retention</td>
<td>2:41</td>
<td>Week 3</td>
</tr>
<tr>
<td>Lazy 8</td>
<td>2:12</td>
<td>Week 4</td>
</tr>
<tr>
<td>Sun Salutation</td>
<td>2:26</td>
<td>Week 5</td>
</tr>
<tr>
<td>Yes Breaths</td>
<td>1:16</td>
<td>Week 6</td>
</tr>
</tbody>
</table>

Indicators of ToT for modules 1, 2, and 3 were determined based on the completion times required for each exercise. Estimated completion times for module 1 exercises are listed in Table 4.1. Completion times for module 2 varied based on the recommended exercises for each participant. Although there were no completion times recommended by Tivitz, the exposure time used for module 3 was based on the minimum exposure times of 75 minutes for three weeks recommended by Slavin and Lake (2008) and Räsänen et al. (2009). Participants continued practicing the associated activities in each module until the allotted time for each module elapsed.

The qualitative measures of fidelity were documented by using the responses to interview questions 3, 6, and 9 (Appendix E): (3) Did your mind wander during the mindfulness exercises? (6) Did your mind wander when you watched any of the Khan Academy videos? (9) Did your mind wander when you played the Tivitz mathematics game? These questions were used to determine how much time participants spent actively attending to each module. The next measure was used to determine the effects of the intervention on mathematics anxiety.

**Measuring mathematics anxiety.** Mathematics anxiety was measured using the mAMAS questionnaire (Appendix A) and probed as part of the qualitative strand using focus group interviews. The mAMAS was the same questionnaire used to conduct the
needs assessment study, and details about the reliability and validity of the mAMAS questionnaire are described in chapter 2. Each question from the preintervention and postintervention questionnaires was scored using a five-point scale that ranged from low anxiety to high anxiety. If study participants scored moderate to high anxiety, they were considered mathematics anxious (Rimm-Kaufman & Hamre, 2010). Study participants with scores outside this range were not considered mathematics anxious. The following focus group questions listed in Appendix E were asked to help measure changes in mathematics anxiety: (1) Describe how you felt about mathematics before the mindfulness exercises. (2) Describe how you felt about mathematics after the mindfulness exercises. (10) Do you think that participating in these activities made you less nervous about mathematics?

Measuring mathematics engagement. Mathematics engagement was measured quantitatively using the Student Engagement Mathematics Scale (SEMS) (Appendix F), and qualitatively using focus group interview questions. The SEMS is a reliable and valid way to measure cognitive, emotional, and social mathematics engagement for students in students from third through eighth grades (Leis, Schmidt, & Rimm-Kaufman, 2015). The SEMS has been validated to be administered using 13 questions (Leis et al., 2015), which determine cognitive, emotional, and social engagement in late elementary students. Although the SEMS social engagement subscale questions were not relevant to this study, the full SEMS questionnaire was administered to ensure the validity of the questionnaire. Questions on the cognitive subscale included questions 1, 9, 10, and 13 (Appendix F). Questions, such as questions nine and 10 asked participants if today it was important to me that I understood the mathematics really well and I tried to learn as much as I could in mathematics class today respectively. The emotional subscale questions are 6, 7, 8, 11, and
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12 (Appendix F). Questions eight and 11 asked participants to score *I enjoyed thinking about mathematics today* and *learning mathematics was interesting to me today*, respectively. Each question from the prequestionnaire and postquestionnaire was scored using a four-point scale that ranged from *no, not at all true* to *yes, very true*. If study participants scored *often true* or *yes, very true* for at least 75% of subscale questions related to cognitive and emotional mathematics engagement, they were considered mathematically engaged (Rimm-Kaufman & Hamre, 2010). Focus group questions four through nine and 11 were used as qualitative measures of mathematics engagement (Appendix E).

**Procedure**

This section describes the procedure used to conduct the research study, including the procedures for selecting participants, collecting the data, and analyzing the data. The schedule for intervention delivery has been illustrated in Figure 3.4. The Navigating Numbers intervention was designed to be implemented by me for approximately 25 minutes per day, four days per week, for six consecutive weeks. The dosage was based on studies conducted by Slavin and Lake (2008) and Räsänen et al. (2009) that show statistically significant positive results after at least 25 minutes of CAI intervention per week for at least three weeks.

**Participant recruitment.** Participant recruitment was conducted by working with youth center staff to provide a student presentation during enrichment time, provide parents an informational flier about the study during pickup time, and deliver a presentation during one parent meeting. To inform children at the youth center about the research study, I provided a 15-minute presentation that covered the purpose of the research study, what they would be doing, and how it could benefit them. I also answered questions at the
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conclusion of the presentation. I worked with the youth center staff to be added to their
parent meeting agenda. The parent presentation covered the purpose of the study; an
overview of the intervention, eligibility, and their rights; and a question-and-answer period.
The parent meeting took approximately 30 minutes, and parents had the opportunity to
complete a consent form at the conclusion of the meeting. This method was effective for
recruiting participants for the needs assessment study and was an effective method of
recruitment for the intervention. All students who gave consent and met the selection
criteria were selected to participate in the research study. None of the students declined to
give consent. Each student was assigned an appropriate problem set according to their
recommended school grade level, as determined by a preassessment that was administered
before the intervention.

Research study participants were selected using a cluster sampling technique. The
target population for this intervention was third through fifth grade students who attended a
Baltimore City youth center with students from a neighborhood school with a Title I
population of over 80%. Students selected for the research study met the following criteria:
attended the youth center feeder school; were in third, fourth, or fifth grade; attended the
youth center at least Monday through Thursday; and planned to attend Monday through
Thursday during the intervention.

The anticipated sample size for the treatment group was between 10 and 15
children. The anticipated sample size was determined based on the number of third through
fifth grade students who attended the youth center and could be present at the youth center
during the COVID-19 pandemic. I attempted to recruit at least five participants from each
grade. The consent form explicitly stated the eligibility requirements for the study, and
parents who signed the consent form also confirmed that their child met the eligibility requirements of the study.

**Intervention.** To prepare for the Navigating Numbers intervention, I conducted a series of preparatory activities that included holding a youth center staff orientation, preparing the module interfaces and computers for use, determining participants’ mathematics grade level, and assigning mathematics problems to each participant. The youth center staff received an orientation that explained how I was going to administer the intervention and the importance of ensuring that participants did not use any of the intervention programs outside of the intervention to reduce the potential for spillover. The orientation provided a detailed overview of the logistics needed to implement the intervention smoothly.

An essential activity required before the intervention was to prepare the module interface and computers for use. In this context, the module interface is a website that was used as a central location for accessing the Mindful Choices, Khan Academy, and Tivitz websites. Since each of the intervention modules are independent web-based platforms, I needed an easy way for study participants to access each website without the inconvenience of launching each platform using separate web pages. Without a central website, it would have taken at least 10 additional minutes per day to implement the intervention. The website was created using a free online website builder called Wix. I created a homepage that described the study and one webpage for each of the three modules. The webpage for module 1 had six links, one that corresponded to each mindfulness exercise listed in Table 4.1. The webpage for module 2 had a link for Khan Academy, and the webpage for module 3 had a link for Tivitz. Study participants were able to go directly to their account from
their assigned computer. The web interface was called the Navigating Numbers Project and can be accessed using this web address:


I also assigned Khan Academy mathematics units to each participant prior to the start of the intervention. The appropriate mathematics grade level for each participant was determined by having each participant take the iReady diagnostic mathematics assessment at least seven calendar days before the intervention began. Unit assignments for Khan Academy and Tivitz exercises were assigned only for units where participants scored less than one grade level below their current grade level. Units that covered addition, subtraction, multiplication, division, and fractions where participants were on or above grade level or greater than one grade below grade level were not assigned because the differences in mathematics proficiency may not have been great enough to detect with this intervention.

The Navigating Numbers intervention began one week after the mathematics units were assigned to each participant. Each week began with me testing the functionality of the equipment and software. After the computers and software were ready for that week, I coordinated with youth center staff to escort participants to the computer lab.

The first module of the intervention was designed to treat mathematics anxiety using the mindfulness exercises listed in Table 4.1. The Mindful Choices exercises were administered by me at the beginning of each day of the intervention. Participants were directed to watch videos of the exercises together using a large monitor and were asked to follow the recorded instructions. Each exercise varied in duration from one to three minutes, but the first five minutes of each Monday through Thursday of the week were
allocated to module 1. Participants were instructed to repeat the mindfulness exercises until the entire five minutes had elapsed. After the study participants completed the daily mindfulness exercises, they were directed to start module 2 of the intervention.

The second module was designed to increase engagement by providing mathematics instruction via Khan Academy. To access Khan Academy, participants logged into module 2 using the Navigating Numbers website. Participants were instructed to begin by watching their assigned Khan Academy instructional videos. The combined runtime of videos for each day of module 2 was between 6-10 minutes, but participants were given 10 minutes to complete the module. After study participants completed module 2, they transitioned to module 3.

Module 3 was gamified mathematics practice using the Tivitz mathematics game. The purpose of module 3 was for participants to practice the concepts learned in Module 2 in a fun and engaging way. The exercises for modules 2 and 3 were assigned using the iReady mathematics grade placement assessment. Results from the assessment were used to assign grade-specific instructional Khan Academy videos and assign participants to grade-specific Tivitz practice levels. The assignments for both modules were meant to be complementary. Participants accessed the Tivitz platform by using the customized Navigating Numbers website, which allowed each participant to choose a game board according to their assessed grade level. After 10 minutes of playing the game, participants had to tabulate their results and report the results to me. The results were tracked using a leaderboard.

After modules 1 through 3 were administered the first week, the process was repeated each week for the duration of the six-week intervention. Children who were not
part of the intervention worked on other unrelated activities in a separate area of the youth center. At the conclusion of the intervention, all children from the youth center who did not participate in the intervention had an opportunity to participate in a version of the intervention where modules 1, 2, and 3 were administered by youth center staff during academic enrichment time.

**Data collection.** All participants were randomly assigned participant identification numbers that were used to track their assessments, intervention assignments, and assigned computer. Since each computer saved each participants’ user profile using cookies local to the computer, each participant was assigned a specific computer. I maintained a list of students and their assigned computers to ensure that each participant used the same computer for the duration of the intervention. This helped me match computers with participant identification numbers and collect their data from module 2 and 3 platforms. Participants’ activity on Khan Academy and Tivitz was recorded based on their unique participant identification number. This approach ensured that I had multiple ways of accurately collecting participant usage information to match data across platforms and modules. All data for modules 2 and 3 were stored in the cloud on the software platform. As a precaution to mitigate possible computer malfunctions, I allocated backup computers from my workplace for the entirety of the study. In the event of a computer malfunction, all data associated with the original computer would have been mapped to the new computer using the same de-identified user login information to ensure all data were assigned to the correct participant. However, no computer malfunctions were experienced during the intervention.
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The data were collected in multiple ways, including written observations using field notes, accessing Khan Academy and Tivitz metadata, and recording ToT in the student participation log (Appendix D). Student participation log data were transferred to a spreadsheet at the end of each week and stored on an external hard drive. Participant-specific notes were added to the log, and general notes about the intervention for that day were added to the notes section at the bottom of the log (Appendix D). Collecting data using spreadsheets and saving them as CSV files allowed me to quickly organize data into a common format that could be easily analyzed at the conclusion of the intervention. Each CSV file was combined into a master CSV file. Participant-specific and generic notes were later transferred to a word processing file for coding and analysis. After the last day of the intervention, both the postquestionnaire and focus group interviews were conducted. Focus group responses for RQ1, RQ2, and RQ3 were recorded using an electronic recording device and transcribed to a spreadsheet following the focus group interviews.

The data that were collected for RQ2 included responses to preintervention and postintervention mAMAS questionnaires and focus group questions one and two. Quantitative data were collected once before the intervention began and once after the intervention concluded. Responses to focus group questions were collected at the same time as the postquestionnaires, after the intervention. Questions from the mAMAS (Appendix A) were added to Survey Monkey, and participants completed the preintervention and postintervention questionnaires using Survey Monkey. All mAMAS questionnaires were administered at the youth center by the student researcher. An overview of the preintervention and postintervention questionnaires was provided by me at the beginning of each survey and each participant read and completed each question on
their own. Data from the Survey Monkey questionnaires were exported from Survey Monkey as CSV files and saved with the master CSV file for later analysis.

Data collection for research question three, mathematics engagement, involved collecting data from the prequestionnaire and postquestionnaire results from the SEMS (Appendix F) and recording focus group responses. As with the mAMAS questionnaire, questions from the SEMS were added to Survey Monkey, and participants completed the preintervention and postintervention questionnaires using Survey Monkey. All SEMS questionnaires were also administered at the youth center by the student researcher. Data from the SEMS were exported from Survey Monkey as CSV files and transferred to the master CSV file. The student researcher conducted both the preintervention and postintervention surveys for the mAMAS and SEMS on the same days. As with data collection for RQ2.

**Data analysis.** Since this research study was a convergent parallel mixed-methods design, quantitative data were analyzed concurrently with the qualitative data. However, each data strand was analyzed independently.

The data used to determine the fidelity of implementation were analyzed separately for modules 1, 2, and 3. Fidelity of implementation for module 1 required determining whether the scored values were within the low-, medium-, or high-fidelity ranges. The level of fidelity was determined based on the indicators listed in the first row of Table 4.2. The highest possible score was 24. High fidelity was defined as missing no more than two days during the intervention. Moderate fidelity for module 1 meant participants met the minimum exposure time by missing no more than six days. Any exposure time below 18 days was less than the recommended minimum exposure time of 2 minutes per day (How I
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Decide, 2018). The implementation fidelity exposure times were based on exposure times derived from Räsänen et al. (2009) and Slavin and Lake (2008).

Data from modules 2 and 3 were analyzed using a combination of the ToT entries in the student participation log (Appendix D) and platform metadata. Daily ToT entries in the student log were combined each week and compared to the platform metadata during the intervention to determine the total dosage time for the six-week intervention. The values for each participant were compared to the indicators of fidelity in Table 4.2 and then used to answer RQ1.

Table 4.2

*Indicators of fidelity by module*

<table>
<thead>
<tr>
<th>Module</th>
<th>Indicators of Fidelity (6 weeks total)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low</strong></td>
<td><strong>Moderate</strong></td>
</tr>
<tr>
<td>Module 1: Mindfulness Exercises</td>
<td>Score &lt; 18</td>
</tr>
<tr>
<td>Module 2: Khan Academy Instruction</td>
<td>&lt; 150 minutes</td>
</tr>
<tr>
<td>Module 3: Tivitz Practice</td>
<td></td>
</tr>
</tbody>
</table>

Determining the level of fidelity for modules 2 and 3 was slightly more complex. Since both modules 2 and 3 were designed to treat mathematics engagement, the ToT for both modules were combined to determine the fidelity of implementation. To account for this, the combined weekly dosage of both modules was used to determine the level of fidelity (Table 4.2). For modules 2 and 3, low fidelity was dosages of less than 150 minutes combined during the six-week intervention. Moderate fidelity was dosages between 150 and 413 minutes. Finally, high fidelity was a combined exposure time greater than 413 minutes for both modules during the six-week intervention. Low-, moderate-, and high-fidelity indicators for modules 2 and 3 were determined by averaging the effective
minimum and maximum exposure times for short-duration CAI interventions listed in Räsänen et al. (2009) and Slavin and Lake (2008) and comparing those times to the range of exposure times possible for this study.

The qualitative data used to determine implementation fidelity were analyzed by using the responses to focus group questions 3, 6, and 9 (Appendix E). The transcript of the focus group interview and field observation notes were compared to identify potential themes between the participants’ responses and what I observed during the intervention. Responses, such as “no, my mind did not wander,” were interpreted as being implemented with fidelity. Responses that indicated focusing on things other than the activity, such as “yes, my mind did often wander during the modules,” were interpreted as low implementation fidelity. Terms, such as “maybe or my mind sometimes wandered,” were interpreted as moderate implementation fidelity. After the qualitative data were analyzed, they were integrated with the findings from the quantitative data analysis resulting in final interpretations.

Quantitative data related to RQ2 were analyzed by examining the preintervention and postintervention mAMAS results. The preintervention and postintervention mAMAS results for mathematics anxiety were analyzed using the Wilcoxon Signed Ranked Test. Deciding whether the null hypothesis could be rejected was determined by comparing the test statistic to the critical value. Results from the mAMAS were integrated with results from the focus group to explain the effectiveness of the intervention in reducing mathematics anxiety.

As with the method used to analyze the data for RQ1, the qualitative mathematics anxiety data were analyzed by comparing the focus group responses to the field notes and
looking for patterns. The focus group interview questions most relevant to RQ2 were prompts 1, 2, and 10 (Appendix E). Differences between responses to focus group questions 1 and 2 were interpreted as an event that either contributed to a change or no change in anxiety. As with the method used for RQ1, a transcript of the focus group interview and field observation notes were compared to identify potential themes between the participants’ responses and what I observed during the intervention. The resulting data were used to identify themes and draw conclusions. Themes that were related to changes in psychological state, such as calmness, relaxation, and being at ease after completing module 1, were interpreted as a reduction in mathematics anxiety. As described by Ramirez, Gundersen, Levine, & Beilock (2013), the use of words such as worry, nervousness, and fidgeting, reflected negative feelings about mathematics during modules 1 through 3; therefore, these responses were interpreted as the presence of mathematics anxiety. Results from the qualitative data were blended with mAMAS results to provide more insight into the effectiveness of the intervention on mathematics anxiety.

Data from RQ3 were also analyzed by comparing the quantitative to the qualitative data and interpreting the results. SEMS questionnaire results were analyzed at the same time as results from the mAMAS. The preintervention and postintervention SEMS results for mathematics engagement were compared using a Wilcoxon Signed Ranked Test. Deciding whether the null hypothesis could be rejected was determined by comparing the test statistic to the critical value. Results from the SEMS were combined with results from the focus group to help explain the effectiveness of the intervention on mathematics engagement.
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The qualitative technique used to analyze mathematics engagement, as with mathematics anxiety, was to identify themes in the responses, compare the focus group responses to field notes, then interpret the results. For focus group questions related to Khan Academy, responses that indicated attentiveness to videos and exercises were interpreted as affirmative engagement. Also, focus group interview responses that described a desire to play Tivitz beyond the prescribed time were interpreted as changes in mathematics engagement. Responses that reflected how participants felt about playing Tivitz were also used to determine changes in engagement. Responses from the focus group and my field notes were compared to identify themes and draw conclusions about the questionnaire results. After I reviewed responses from the focus group interview, results were compared to field notes, then transferred to the master spreadsheet to organize them.

After the analysis of both quantitative and qualitative datasets was completed, the results were summarized and interpreted to determine the effectiveness of the Navigating Numbers intervention.

Summary matrix. The following matrix in Table 4.3 depicts the research questions, their associated data, and the timing during the intervention.

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Construct</th>
<th>Instruments/ Measures</th>
<th># of Data Sets</th>
<th>Analysis Type</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1: To what extent was the intervention implemented?</td>
<td>Fidelity of Implementation</td>
<td>Student Participation Log &amp; Platform Metadata</td>
<td>6</td>
<td>Tally</td>
<td>Weeks 1-6</td>
</tr>
</tbody>
</table>

Table 4.3

*Detailed matrix illustrating research questions, constructs, measures, and schedule*
INVESTIGATING MATHEMATICS ANXIETY AND ENGAGEMENT

<table>
<thead>
<tr>
<th>RQ2: Is completion of the intervention associated with a decrease in mathematics anxiety?</th>
<th>Mathematics Anxiety</th>
<th>Focus Group Interview &amp; Field Notes</th>
<th>1</th>
<th>Narrative Analysis</th>
<th>Weeks 1-6 &amp; the week after the intervention</th>
<th>mAMAS Questionnaire Pretest &amp; Post</th>
<th>2</th>
<th>Wilcoxon Signed Ranked Test</th>
<th>The week before &amp; after the intervention</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>RQ3: Is completion of the intervention associated with an increase in mathematics engagement?</th>
<th>Mathematics Engagement</th>
<th>Focus Group Interview &amp; Field Notes</th>
<th>1</th>
<th>Narrative Analysis</th>
<th>Weeks 1-6 &amp; the week after the intervention</th>
<th>SEM Questionnaire Pretest &amp; Post</th>
<th>2</th>
<th>Wilcoxon Signed Ranked Test</th>
<th>The week before &amp; after the intervention</th>
</tr>
</thead>
</table>

3-4-5 grade Focus Group Interview & Field Notes | 1 | Narrative Analysis | Weeks 1-6 & the week after the intervention

In conclusion, the Navigating Numbers intervention took place on Mondays through Thursdays for a period of six weeks at a youth center located in Baltimore City. Third, fourth, and fifth grade participants participated in mindfulness exercises to decrease their mathematics anxiety. Participants used Khan Academy to provide supplemental mathematics instruction and played Tivitz in a combined approach to increase mathematics engagement. All quantitative and qualitative data were analyzed and used to answer the research questions to determine the effectiveness of the intervention.
Chapter 5 – Intervention Findings and Discussion

The Navigating Numbers intervention was implemented at a youth center in Baltimore City during the summer of 2021 from July 6th through August 12th. The intervention took place in the same room each day; the room had its own Wi-Fi router, which decreased the likelihood of internet disruptions while participants were completing the modules. Participant seating was arranged as shown in Figure 5.1, and students kept their assigned seats throughout the intervention. The Navigating Numbers intervention was the first activity that participants engaged in each day.

\[\text{Figure 5.1. Diagram Representing Room Layout During the Intervention.}\]

Each day of the six-week intervention began with me arranging the room according to the layout shown in figure 5.1, loading each participant’s profile to their respective laptops, and connecting to the 72-inch monitor in the front of the room with my laptop to
queue up the mindfulness exercise for the week. At nine o’clock each morning, participants were brought into the room after eating breakfast. Participants were instructed to take their seats and prepare to start the intervention. Each day I briefly explained the mindfulness exercise before starting. Once everyone was seated, I started module 1. All participants completed the exercises together and remained in their assigned seats until module 1 was completed. Since each exercise varied in duration, I repeated the video demonstration until the minimum dosage was reached. I also participated in the exercises to help demonstrate and to encourage participation. After module 1 ended, participants were instructed to use their assigned laptops to access module 2 (Khan Academy instructional videos). Each day, participants picked up where they left off the previous day. When they began module 2, I started a stopwatch for 10 minutes. After 10 minutes elapsed, an audible alarm sounded, and all participants were instructed to stop. Participants then opened a tab in their browser with module 3 (Tivitz video game-based mathematics practice) and waited for the timer to begin. When all participants were ready to begin their game, I started a new timer for 10 minutes. After 10 minutes elapsed and the alarm sounded, participants were told to stop and line up to rejoin children who were not participating in the intervention.

Four modifications were made to the initial intervention procedure. The first modification was that participants stayed in the room 20 to 25 minutes after the intervention ended. After week one, participants stayed to play non-mathematics computer games or play tabletop shuffleboard. The youth center director approved this change because it made the transition smoother when participants rejoined the children who did not participate in the intervention. The second modification was the use of a reward system initiated by the youth center. Children were given tickets from youth center staff to
encourage good behavior. The tickets could be redeemed for extra food during snack time. More about how the reward system was administered will be described in the qualitative results section for RQ1. The third modification was the use of a leaderboard during module 3. After week one, I noticed that participants were comparing their results after each game. Some participants wanted to be recognized for getting a double jump, beating the computer, or getting a new high score. Since there were multiple levels of difficulty, participants did not have the correct context during many of their comparisons. That led me to use a whiteboard to list each level and write down their names and respective scores. The scores would remain on the board until the beginning of module 3 the next day. The final modification was the use of an incentive to celebrate the end of the intervention. Participants were given the opportunity to vote for either a pizza party or slime-making activity on day four of week three. They all voted to make slime. Starting the first day of week 4, I used the whiteboard to countdown the number of days until the slime-making activity, which corresponded with the day the postquestionnaires and focus group interviews were conducted.

Findings

The following section describes the findings of the intervention. Results are reported according to research questions 1, 2, and 3 and the results for each research question are organized according to quantitative, qualitative, and blended results.

RQ1 Quantitative Results

The scores in the bar graph labeled “Module 1” of Figure 5.2 represent the fidelity of implementation for the mindfulness exercises that were designed to decrease mathematics anxiety. The values listed represent the number of days a participant appeared
to be engaged with the mindfulness exercises.

**Figure 5.2. Implementation Fidelity Results.** Bar Graphs Depicting Implementation Fidelity Times for Modules 1 (Left) & Modules 2 & 3 (Right).

Participants 1, 8, 9, 10, and 11 were below the threshold score for moderate dosage (18); therefore, module 1 was implemented with low fidelity for them. Scores for participants 4, 5, 6, and 7 indicate that mindfulness exercises were implemented with moderate fidelity. However, participants 4 and 8 were both absent at least two days of the intervention. Participant 4 missed 29.3% of module 1, and participant 8 missed 43.1% of module 1. These absences lowered their fidelity of implementation dosage. The final group are participants whose scores were in the “high” implementation fidelity category. Participants 2 and 3 were in this category. Their scores were above the moderate fidelity range and were scored as a high-fidelity implementation. Therefore, module 1 was implemented with low fidelity for five participants (participants 1 and 8-11), moderate fidelity for four participants (participants 4-7), and high fidelity for two participants (participants 2 and 3).

Implementation fidelity for modules 2 and 3 is a measure of dosage for each participant. As with module 1, fidelity is categorized as either low, moderate, or high. The
range of dosage times for implementation fidelity were < 150 minutes (low), 150 to 413 minutes (moderate), and > 413 minutes (high) (Figure 5.2). Since the intervention was implemented less than 150 minutes for both participants 9 and 10, the intervention was implemented with low fidelity for them. The bar graph shows that modules 2 and 3 were implemented with moderate fidelity for all other participants (1 through eight and 11).

In summary, the mathematics anxiety portion of the intervention (module 1) was implemented with high fidelity for 18% of participants, moderate fidelity for 36% of participants, and low fidelity for 46% of participants. For the mathematics engagement portion of the intervention (modules 2 and 3), it was implemented with moderate fidelity for 82% of participants and low fidelity for 18% of participants. The mathematics engagement portion of the intervention was not implemented with high fidelity for any of the participants.

**RQ1 Qualitative Results**

Focus group questions 3, 6, and 9 were used to determine whether the intervention was implemented as designed and to determine engagement. At the outset, there was an expectation that participants would fully participate if they were present. However, some participants reported not liking some of the modules, which affected their participation and the fidelity of implementation. To encourage participation in module 1, I used the youth center’s reward system to incentivize participation in the mindfulness exercises starting the second day of week four. Participants were promised that they would earn one ticket at the end of module 1 if they were observed doing the mindfulness exercises. All participants had the opportunity to earn tickets, and it did help increase participation for participants 2,
3, and 6. The ticketing rewards were not used for modules 2 and 3 because of the potential to cause spillover effects in the engagement results.

Question three (*Did your mind wander during the mindfulness exercises? If so, how often?*) was asked to determine the fidelity of implementation for the mindfulness exercises (module 1). Participants 1 and 6 did not offer a response. Participant 2 said they had “no idea” whether their mind wondered or not. Participant 3 said their mind wandered “sometimes” and participant 7 said “yes” that their mind wandered during the mindfulness exercises. When each of the participants was asked to explain the frequency of mind wandering, no one would elaborate.

The responses to question six (*Did your mind wander when you watched any of the Kahn Academy videos? If so, how often?*) were similar. Participants 1, 2, 6, and 7 did not offer a response. Participant 3 said their mind “kind of” wandered when watching the Kahn Academy videos. Participant 8 said their mind did not wander, and participant 11 said their mind wandered when watching Kahn Academy videos. As with the follow-up response for question 3, none of the participants would expand upon their initial responses.

Question nine (*Did your mind wander when you played the Tivitz mathematics game? If so, how often?*) was asked to determine the implementation fidelity of module 3. All participants responded with either a “yes” or “no” response to this question. Participants 1 and 11 said “yes” their minds wandered when playing the Tivitz mathematics game. Participants 2, 3, 6, 7, and 8 said their minds did not wander when they played Tivitz.
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In summary, module 1 was implemented with low fidelity for participants 1, 4, 9, and 10. Module 1 was implemented with moderate fidelity for participants 6 and 7. And module 1 was implemented with high fidelity for participants 2, 3, 5, 8, and 11.

Module 2 was implemented with low fidelity for participants 1, 4, 7, 9, and 10. Module 2 was implemented with moderate fidelity for participants 2, 5, and 6. And module 2 was implemented with high fidelity for participants 3, 8, and 11.

Finally, module 3 was implemented with low fidelity for participants 9 and 10. Module 3 was implemented with moderate fidelity for participants 4, 6, and 7. And module 3 was implemented with high fidelity for participants 1, 2, 3, 5, 8, and 11.

RQ1 Blended Results

Examination of both quantitative and qualitative implementation fidelity results helped me determine the effectiveness of the intervention. The following results are listed by the fidelity of implementation for each module and are listed in order from low to high fidelity. Quantitative and qualitative results are blended according to the level of fidelity.

Module 1 fidelity. Quantitative results for module 1 indicated participants 1, 8, 9, 10, and 11 experienced module 1 with low fidelity. Qualitative results for module 1 indicated participants 1, 4, 9, and 10 experienced module 1 with low fidelity. Both quantitative and qualitative results indicated low implementation for participants 1, 9, and 10. Participants 8 and 11’s blended results showed them receiving module 1 with moderate fidelity.

Quantitative results for participants 4, 5, 6, and 7 indicated they received module 1 with moderate fidelity. Qualitative results for participants 6 and 7 indicate they received module 1 with moderate implementation fidelity. Both quantitative and qualitative results
for participants 6 and 7 confirm that they received module 1 with moderate fidelity. Qualitative results for participants 4 and 5 indicate low and high fidelity, respectively. Participant 4 was present to receive a moderate dosage; however, my observation notes indicated low fidelity exposure during those times. Participant 4 was physically present and could have received a moderate dosage; however, the participant was only visibly attentive enough to receive a low dosage. Therefore, my interpretation of the combined result was that module 1 was implemented with low fidelity for participant 4. Quantitatively, participant 5’s dosage was moderate due to absences during the intervention. However, the qualitative data captured in my field notes showed that participant 5 appeared to be excited about participating in module 1, but not fully attentive. My conclusion about the qualitative result was high fidelity; although, toward the lower end of the threshold. Therefore, I concluded that the blended quantitative and qualitative results for participant 5 resulted in moderate implementation fidelity. Regarding participants 8 and 11, Participant 8 was frequently absent and participant 11 joined the research study late; therefore, they could not receive enough hours to receive a high dosage of module 1. However, observations of both participant 8 and participant 11 indicated high fidelity during implementation. Therefore, a blending of the quantitative and qualitative data resulted in participants 8 and 11 receiving module 1 with moderate fidelity.

Quantitative results for participants 2 and 3 showed that both experienced module 1 with high fidelity. Qualitative results indicated that they both fully participated in the mindfulness exercises and were considered to receive module 1 with high fidelity. Both the quantitative and qualitative results indicated that participants 2 and 3 received module 1 with high fidelity.
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Modules 2 and 3 fidelities. Qualitative results for modules 2 and 3 were blended since both were indicators of mathematics engagement. Blending quantitative and qualitative results for the implementation fidelity of modules 2 and 3 yielded the following results. Results for RQ1 modules 2 and 3 are listed in order as low, moderate, and high fidelity.

Quantitative results for participants 9 and 10 indicated that they received modules 2 and 3 with low fidelity. Qualitative results for these participants were not recorded because they stopped attending the youth center before the intervention concluded. Therefore, results for participants 9 and 10 could not be blended.

Quantitative results for participants 4, 6, 8, and 11 indicated that they experienced modules 2 and 3 of the intervention with moderate fidelity. Participant 4 was absent for the focus group; therefore, the field notes were the sole source of qualitative data. I reported in my field notes that participant 4 struggled to attend to module 2 most days of the intervention, but was more attentive to module 3. I concluded that the qualitative data for module 2 resulted in low fidelity implementation for module 2 and moderate fidelity for module 3. Participant 4’s blended fidelity of implementation for modules 2 and 3 were moderate. Participant 6’s qualitative results were consistent with the quantitative results; therefore, implementation fidelity was moderate. Finally, the qualitative results for participants 8 and 11 indicated high fidelity for both modules 2 and 3. Neither participant received the full dosage of modules 2 and 3 due to participation and joining late; therefore, they received the modules with moderate fidelity.

Quantitative results for participants 1, 2, 3, 5, and 7 indicated that they experienced modules 2 and 3 with high fidelity. Qualitative results for the same participants were
blended. Participant 1’s combined module 2 and 3 qualitative results were considered moderate. When comparing the qualitative results to the quantitative results, participant 1 received the highest dosage of all participants. Therefore, comparing and interpreting both quantitative and qualitative data resulted in high implementation fidelity for participant 1. Qualitative results for participant 2 were moderate for module 2 and high for module 3. When comparing the qualitative results to observation notes, the combined module 2 and 3 result was high fidelity. Therefore, the blended quantitative and qualitative result was high implementation fidelity for participant 2. Qualitative results for participant 3 were consistent with the quantitative results, therefore, participant 3 received modules 2 and 3 with high fidelity. The combined qualitative results for participant 5 were determined to be high implementation fidelity; therefore, blending both quantitative and qualitative data resulted in high implementation fidelity. Combined qualitative results for participant 7 resulted in moderate implementation fidelity for modules 2 and 3. When blending the quantitative and qualitative results, participant 7 received modules 2 and 3 with moderate fidelity.

In summary, the blended results for module 1 indicated that participants experienced the intervention with levels of fidelity that ranged from low to high. Approximately 36% experienced module 1 with low fidelity; 46% experienced module 1 with moderate fidelity; and 18% of participants experienced module 1 with high fidelity. For modules 2 and 3, 18% of participants experienced the modules with low fidelity; 46% of participants experienced the modules with moderate fidelity; and 36% of participants experienced modules 2 and 3 with high fidelity. Since participants who experienced modules 1, 2, and 3 with moderate and high fidelity were expected to have lower mathematics anxiety and
increased mathematics engagement at the conclusion of the intervention, the intervention was implemented with fidelity for 64% of participants for module 1 and 82% of participants for modules 2 and 3. Overall, the intervention was implemented with fidelity for 73% of participants.

RQ2 Quantitative Results

The bar graph represented in Figure 5.3 depicts the preintervention and postintervention mathematics anxiety results of each participant, and Table 5.1 depicts the mean values of the preintervention and postintervention mAMAS. Scores less than 20 were considered to be low anxiety, scores of 20 to 30 were considered to be moderate anxiety, and scores above 30 were considered to be high anxiety. Participants 1, 2, and 3 had moderate mathematics anxiety before and after the intervention. Participants 4, 5, 6, 8, and 10 had low mathematics anxiety. Of these five, only participants 6 and 8 were present for the posttest, and neither showed a change in mathematics anxiety. Participant 11 had high anxiety and did not improve to a lower state of anxiety. Participant 7 was the only child who improved from high anxiety to moderate anxiety.

![Figure 5.3. mAMAS Prequestionnaire and Postquestionnaire Results. Preintervention mAMAS results are represented by light gray bars and postintervention mAMAS results](image-url)
are represented by dark gray bars.

Table 5.1

*Mean Values for Mathematics Anxiety*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Pre</th>
<th>Post</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29</td>
<td>28</td>
<td>-1</td>
</tr>
<tr>
<td>2</td>
<td>27</td>
<td>29</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>25</td>
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<tr>
<td>6</td>
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<td>30</td>
<td>-4</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>11</td>
<td>31</td>
<td>36</td>
<td>5</td>
</tr>
</tbody>
</table>

A Wilcoxon signed rank test was performed to compare mathematics anxiety before and after the intervention. The test statistic value was 4.0 and the p-value was (0.0500); therefore, I could not reject the null hypothesis. There was not a significant difference in mathematics anxiety prior to and after the intervention. Results indicated an overall increase in mAMAS scores; however, only participant 7’s mathematics anxiety levels changed from high mathematics anxiety to moderate mathematics anxiety. None of the results from other participants indicated an increase or decrease in mathematics anxiety levels. Participants 4, 5, 9, and 10 were not available to complete the mAMAS postquestionnaire.

A closer look at each participant’s responses provided greater insight into specific areas of mathematics anxiety where there was a change in preintervention and postintervention mAMAS scores. The two types of anxiety measured by the mAMAS questionnaire are generalized mathematics anxiety and mathematics test anxiety. Questions 1 through 9 measure generalized mathematics anxiety, but questions 2 and 4 also measure test anxiety. The average change in preintervention and postintervention scores of
generalized mathematics anxiety for participant 1 was a decrease of one point. Conversely, there was an increase of one point for questions related to mathematics test anxiety. Participant 2 experienced an increase of two points for generalized mathematics anxiety. However, there was no change in scoring for test anxiety. Participant 3 had an increase of five points for generalized mathematics anxiety and a four-point increase for mathematics test anxiety. There were large point increases for both measures of mathematics anxiety; however, they were within the cut-score range for moderate mathematics anxiety. Participant 6 had a one-point increase for both generalized and test mathematics anxiety, participant 7 had a four-point decrease in generalized mathematics anxiety and a two-point decrease in test anxiety, and participant 8 experienced a five-point increase in generalized mathematics anxiety and a three-point increase in mathematics test anxiety. These results indicated that, although participant 7 was the only participant who experienced a decrease in mathematics anxiety level, all but two experienced at least a two-point change (increase or decrease) for either generalized mathematics anxiety or mathematics test anxiety before and after the intervention.

In summary, the quantitative results showed that, of the seven participants who took both the preintervention and postintervention mAMAS, 71% of participants had an increase in average generalized mathematics anxiety scores and 29% had a decrease in average generalized mathematics anxiety scores.

**RQ2 Qualitative Results**

There were two participants who responded to question one (*Describe how you felt about learning and practicing mathematics before the mindfulness exercises*), participants 8 and 11. Participant 8 said they felt “okay” about learning and practicing mathematics
before starting the mindfulness exercises and participant 11 said they felt “fine.” None of
the other respondents provided a response. When participants were asked to “describe how
they felt about learning and practicing mathematics after the mindfulness exercises”
(question 5), participants 3 and 11 both said they felt “relaxed.” Participant 8 said they felt
“calm.” Participants 1, 2, 6, and 7 did not provide a response. The last question related to
determining mathematics anxiety was question 10 (Do you think that participating in these
activities made you less nervous about mathematics?). Participants 1, 3, 8, and 11
responded “yes,” indicating that the mindfulness exercises made them less nervous about
mathematics. Participants 2 and 6 said “no,” the exercises did not make them less nervous
about mathematics. Participant 7 was not sure whether participating in the mindfulness
exercises made them less nervous. Participants 4, 5, 9, and 10 were not present for the
focus group.

**RQ2 Blended Results**

To better understand the quantitative and qualitative results for research question 2,
the results were blended. Results for RQ2 were blended according to participants who
experienced a change in mathematics anxiety based on cut-scores and participants who did
not experience a change in mathematics anxiety. Participants 4, 5, 9, and 10 were not
present for the focus group; therefore, they were not included in the blended results.

Six of the seven participants who were present for both preintervention and
postintervention mAMAS and the focus group did not experience a change in mathematics
anxiety according to the quantitative results. When these participants (1, 2, 3, 6, 8, and 11)
participated in module 1, there was no pattern of dosage level. Therefore, there was no
relationship between the dosage time of module 1 and average point differences for
mAMAS scores. When mAMAS scores were compared to focus group results, responses for participants 1, 3, 8, and 11 did not match. Qualitative responses from the focus group indicated that they all felt the mindfulness exercises helped decrease their anxiety about learning or practicing mathematics, but their quantitative scores indicated increases in mathematics anxiety. Responses for participants 2 and 6 did match the results from the mAMAS.

The only participant who experienced a decrease in mathematics anxiety was participant 7. This participant received a moderate dosage of module 1 (fourth highest). Although not a high dosage, in this one case, mindfulness exercises were accompanied by a decrease in mathematics anxiety. A comparison between focus group responses and mAMAS results indicated that participant 7 was unsure whether participating in the mindfulness exercises decreased anxiety about mathematics. Participant 7 did not provide any additional information during the focus group that indicated module 1 resulted in decreased anxiety when learning or practicing mathematics. A summary of the quantitative, qualitative, and blended results are listed in table 5.2. Results are listed as discrete conclusions; however, the responses may have been influenced by the interactions between modules 1 through 3.

Table 5.2

Summary of quantitative, qualitative, and blended results for RQ2

<table>
<thead>
<tr>
<th></th>
<th>P001</th>
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<th>P003</th>
<th>P004</th>
<th>P005</th>
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<th>P009</th>
<th>P010</th>
<th>P011</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quantitative Results</strong></td>
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<td>No Change</td>
<td>No Change</td>
<td>No Change</td>
<td>No Change</td>
<td>Decrease</td>
<td>No Change</td>
<td>N/A</td>
<td>N/A</td>
<td>No Change</td>
<td></td>
</tr>
<tr>
<td><strong>Qualitative Results</strong></td>
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<td>No Change</td>
<td>Decrease</td>
<td>No Change</td>
<td>Decrease</td>
<td>No Change</td>
<td>No Change</td>
<td>Decrease</td>
<td>N/A</td>
<td>N/A</td>
<td>Decrease</td>
</tr>
<tr>
<td><strong>Blended Results</strong></td>
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<td>No Change</td>
<td>No Change</td>
<td>No Change</td>
<td>Decrease</td>
<td>No Change</td>
<td>N/A</td>
<td>N/A</td>
<td>No Change</td>
<td></td>
</tr>
</tbody>
</table>
**RQ3 Quantitative Results**

*Figure 5.4.* Preintervention and postintervention SEMS questionnaire results for participants 1 through 11.

The bar graph in Figure 5.4 depicts the total SEMS questionnaire scores for each participant preintervention and postintervention. Cut scores were used to determine the level of each participant’s engagement preintervention and postintervention. Scores between 13.0 and 19.4 were interpreted as *disengaged*, scores between 19.5 and 32.4 were interpreted as *somewhat disengaged*, scores between 32.5 and 45.4 were interpreted as *somewhat engaged*, and scores between 45.5 and 52.0 were interpreted as *engaged* (Leis et al., 2015). These scores were used to determine whether the null hypothesis could be rejected. A Wilcoxon signed rank test was performed to compare mathematics engagement before and after the intervention. The test statistic value was 12.0 and the p-value was (0.0500), I could not reject the null hypothesis. Participants 4, 5, 9, and 10 were not available to complete the SEMS postquestionnaire.

**Table 5.3**

*Summary of SEMS quantitative results*
<table>
<thead>
<tr>
<th>Participant</th>
<th>Disengaged (13.0-19.4)</th>
<th>Somewhat Disengaged (19.5-32.4)</th>
<th>Somewhat Engaged (32.5-45.4)</th>
<th>Engaged (45.5-52.0)</th>
<th>Change in Engagement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>Decrease</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>Decrease</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>No Change</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>No Change</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>Increase</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>No Change</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>No Change</td>
</tr>
</tbody>
</table>

*Note.* Engagement level is represented by cells with an “X.” Change in engagement for each participant is indicated in the last column.

An analysis of mathematics engagement results using the cut-score values indicated that participants 1 and 2 experienced a decrease in mathematics engagement; participants 3, 6, 8, and 11 did not experience a measurable change; and participant 7 experienced an increase in mathematics engagement (Table 5.3).

**RQ3 Qualitative Results**

Focus group questions 4 through 9 and 11 were used to determine the qualitative impact of modules 2 and 3 on mathematics engagement. Appendix E has the list of focus group questions.

**Module 2 results.** Participants 1, 2, and 6 did not provide a response to question four (*Describe how you felt about learning mathematics before doing the Khan Academy exercises*). Participant 3 was “kind of happy” about learning mathematics before watching Khan Academy videos. Participant 7 felt okay about learning mathematics before watching the videos, and participant 11 was excited about learning mathematics before watching the videos. These results indicated that no conclusions could be formed about participants 1, 2, and 6 without comparing them to the field notes and results from module 3.
Participants were then asked to describe how they felt about learning mathematics after doing the Khan Academy exercises (question five). All their responses varied from not providing a response, to “excellent.” Their specific responses were no response (participant 1), “did not know” (participant 2), “felt better after watching the videos” (participant 3), “was bored” (participant 6), was “mad” (participant 7), “learned something,” and felt “excellent” (participant 11).

When participants were asked whether their minds wandered while they watched Khan Academy videos (question 6), participants 1, 2, and 6 did not provide a response. Participant 3 said “kind of,” participant 8 said “no,” and participant 11 said “yes.” None of the participants were willing to provide additional information about how often their minds did or did not wander.

Module 3 results. When participants were asked the same questions for module 3 (practicing mathematics with Tivitz), they provided the following responses.

Question 7 was asked to determine how participants felt about practicing mathematics before playing the Tivitz mathematics game. Participants 1, 2, and 8 said they were “excited.” Participant 3 was “happy,” Participant 8 was “bored” beforehand, participant 7 was “mad,” and participant 11 felt “good” before practicing mathematics with Tivitz.

When asked question 8 (Describe how you felt about practicing mathematics after playing the Tivitz mathematics game), participants 1 and 2 reported feeling sad and disappointed (respectively). Participants 3 and 11 reported similar feelings (excited, happy, and great). Participant 7 was happy to be done practicing mathematics with Tivitz.
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Participants were then asked whether their minds wandered when practicing mathematics using Tivitz (question 9). Participants 1 and 11 said “yes,” and participants 2, 3, 6, 7, and 8 said “no.” After asking participants to elaborate on their responses, no one had anything to add.

**Summary.** Since the qualitative results provided information about the change in mathematics engagement, this summary of the qualitative results focuses on the change in how participants felt about learning and practicing mathematics before and after participating in the Khan Academy and Tivitz exercises. None of the participants provided responses that indicated a decrease in mathematics engagement. There was no change in mathematics engagement responses for participants 1, 6, and 7. Furthermore, participants 2, 3, 8, and 11 provided responses that provided evidence of an increase in mathematics engagement.

**RQ3 Blended Results**

To better understand the results for research question three, changes in mathematics engagement, quantitative results from the SEMs preintervention and postintervention questionnaires were blended with the qualitative results from the focus group. It is important to note that results from RQ1 indicated that participants 1 through 3, 6 through 8, and 11 all received a high dose of modules 2 and 3. As stated earlier, participants 4, 5, 9, and 10 were not present for the focus group. Therefore, they were not included in the blended results.

The quantitative results showed a reduction in engagement levels for participants 1 and 2. The qualitative results for these two participants were mixed, indicating ambivalence towards module 2 and being disappointed when asked to end module 3. Both
INVESTIGATING MATHEMATICS ANXIETY AND ENGAGEMENT

quantitative and qualitative results indicated disengagement with mathematics overall, particularly with module 2. However, it is possible that module 1 may have affected the engagement results and also contributed to the blended results for RQ3.

Quantitative results for participants 3, 6, 8, and 11 indicated no change in mathematics engagement level between the preintervention and postintervention questionnaires. Qualitative results for participants 3, 8, and 11 indicated they were engaged with both module 2 and module 3. The qualitative results indicated positive feelings toward both module 2 and module 3; however, their positive feelings did not translate to a quantifiable increase in mathematics engagement. Participant 6 was the only person who indicated not being engaged with either module 2 or module 3 during the focus group interview. The combined quantitative and qualitative results suggested that mathematics engagement for participant 6 was unchanged due to feelings of boredom and ambivalence toward modules 2 and 3.

The quantitative results for participant 7 yielded the only measurable improvement in mathematics engagement. However, qualitative results indicated that module 2 made the participant mad and they did not enjoy participating in module 3. Since I failed to reject the null hypothesis after conducting the Wilcoxon signed rank test for RQ3, the combined quantitative and qualitative results indicated that the intervention did not increase mathematics engagement for participant 7.

Conclusions

In conclusion, the blended results for RQ1 showed that two participants experienced module 1 with high fidelity; four participants experienced module 1 with moderate fidelity; and five participants experienced module 1 with a low degree of fidelity. Participants who
experienced module 1 with moderate to high fidelity were expected to have a measurable reduction in mathematics anxiety at the conclusion of the intervention; however, this did not occur for most participants. After examining the results for modules 2 and 3, the blended results did not exhibit any discernable patterns. The blended results for modules 2 and 3 indicated that four participants experienced modules 2 and 3 with high fidelity; five participants experienced modules 2 and 3 of the intervention with moderate fidelity; and two participants experienced modules 2 and 3 with low fidelity. Blended results for RQ2 and RQ3 indicated no change in mathematics anxiety or mathematics engagement for any of the participants. Although, the blended results from RQ1 may have contributed to the results for RQ2 and RQ3.

**Discussion**

The following section is a discussion of the navigating numbers research study. The section discusses the results related to the constructs of implementation fidelity, mathematics anxiety, and mathematics engagement. The discussion concludes with a summary the constructs, descriptions of the limitations of the research study, and recommendations for future studies.

**Implementation Fidelity**

The implementation fidelity was moderate overall, but varied for each participant. Implementation fidelity was moderate for all participants because the average attendance stayed between the cut score limits for low and high fidelity. The following is a discussion about the potential reasons for the variance in fidelity related to all of the study participants who completed the intervention. The factors related to moderate implementation fidelity were low adherence and Zoom fatigue. Cassata et al. (2015) described the four elements of
adherence as content, coverage, frequency, and duration. Aspects of the intervention that appeared to be affected by adherence were content and frequency. Based on feedback noted during observations, the participants’ expressed a need for more engaging content for the mindfulness exercises, more engaging instructional content, and a wider variety of game-based content to practice mathematics.

Factors related to frequency also impacted implementation fidelity. Frequency refers to the amount of practice that is optimal for participants to receive the required dosage (Cassata et al., 2015). Because of the short duration of this intervention, participants couldn’t be absent more than two days without having their implementation fidelity score decrease. All of the participants, except participant 3 missed at least one day and the average was 19 out of 24 days. In similar interventions, one of the most important factors required to change anxiety and engagement was sufficient exposure to the intervention (Brigham, 2015; Flook et al., 2010; Gros, 2015; Khng, 2017; Supekar et al., 2015).

The final factor discussed that could have impacted the implementation fidelity results is Zoom fatigue. When the navigating numbers intervention was first designed, delivering mindfulness exercises, mathematics instruction, and mathematics practice in the youth center during OST was a novel concept. However, during the COVID-19 pandemic, all of the children who attend the youth center were forced to learn all of their school subjects using a computer. Peper et al. (2021) conducted a study to determine the effects of learning via computer or mobile device and determined that too much screen time resulted in decreased learning and desire to learn. I did not measure Zoom fatigue as part of this study, but participants did display some of the indicators mentioned by Peper et al. (2021) during the intervention.
**Mathematics Anxiety**

After analyzing the blended qualitative and quantitative mathematics anxiety data, several factors may have contributed to the results for participants 1, 2, 3, 6, 7, 8, and 11. Since the qualitative and quantitative results for participants 1, 2, 3, and 6 were congruent, this part of the discussion focuses on factors that may have contributed to the lack of change in mathematics anxiety. Those factors include treating evaluation-related mathematics anxiety instead of generalized mathematics anxiety, inability to increase executive function, and intervention duration. Bellinger et al. (2015) concluded that their mindfulness techniques were effective at mediating evaluation-related mathematics anxiety, but these results may not transfer to generalized mathematics anxiety. Similar to the Bellinger et al. (2015) study, the Khng (2017) intervention also concluded that their mindfulness exercises were effective at reducing evaluation-related mathematics anxiety. The Bellinger et al. (2015), Khng (2017) studies, and this study may provide evidence that mindfulness exercises are effective at reducing evaluation-related mathematics anxiety and not generalized mathematics anxiety. Another area that mindfulness exercises demonstrate effectiveness at reducing mathematics anxiety is through the mechanism of increasing executive functions, such as behavioral regulation and metacognition. Flook et al. (2010) demonstrated how mathematics anxiety could be reduced by using games and age-appropriate exercises to improve sensory awareness. My navigating numbers used similar games and exercises; however, they were not used during the mindfulness module. This in addition to the shorter duration of my intervention may have contributed to the lack of change in mathematics anxiety results.
The second half of the discussion focuses on factors that may have contributed to the incongruent results for participants 7, 8, and 11. It is possible that participant 7 was positively impacted by the mindfulness exercises despite their expressed dislike for the exercises. It is also possible that participating in the exercises for modules 2 and 3 helped to increase participant 7’s confidence in mathematics and resulted in a reduction in mathematics anxiety. Cognitive modeling and my theory of change provide evidence that an increase in mathematics proficiency could result in a decrease in mathematics anxiety (Schunk, 2021; Supekar et al., 2015). The incongruence between the quantitative and qualitative results for participants 8 and 11 may be attributed to module 1 not being focused on addressing the specific areas of mathematics anxiety that the mAMAS measures. For example, the mindfulness exercises were designed to make children aware of their physical and emotional state-of-mind. A comparison to the study conducted by Khng (2017) suggested that spending more time performing body scanning exercises instead of short breathing exercises could possibly have done more to help mediate generalized mathematics anxiety. It is also possible that the anticipation of completing modules 2 and 3 could have induced anxiety. I attempted to isolate module 1 from the other modules; however, I did not ask about the potential interactions that could have contributed to the results during the focus group. Similar to the potential causes of the results for participants 1, 2, 3, and 6, the difference between the results from the navigating numbers intervention and those listed in chapter three could also be attributed to mindfulness exercises being more effective at mitigating the effects of evaluation-related mathematics anxiety instead of generalized mathematics anxiety.
Mathematics Engagement

The blended quantitative and qualitative results for modules 2 and 3 showed no indication of a change in mathematics engagement for participants 1 through 3, 6 through 8, and 11. However, the quantitative and qualitative results were incongruent. Engagement as measured with a quantitative questionnaire, did not result in a statistically significant difference in engagement, but the statements provided by four of the seven participants during the focus group interview indicated increased mathematics engagement. After comparing the mathematics engagement results from my navigating numbers intervention to those reviewed in chapter three, several factors may have contributed to the incongruent results. Those factors include opportunities to respond, immediate feedback, badges, and points systems, and role-play. Gros (2015) identified six characteristics that should be included in mathematics games to improve mathematics engagement. From the six characteristics, the mathematics instruction module that used Khan Academy videos were missing opportunities to respond, immediate feedback, badges, a points system, and role play. Khan Academy does provide most of these characteristics in many of their units, but those features were not used for this intervention. Brigham (2015) also emphasized the importance of including the game design elements in a non-game context to increase engagement when using CAI platforms. I decided to supplement those elements with Tivitz because anecdotal feedback from children at the youth center indicated it was more engaging than the gamified elements of Khan Academy. The participants did indicate that practicing mathematics with Tivitz was more engaging than watching instructional videos on Khan Academy. Therefore, the incongruent responses may be attributed to the differences in engagement potential between Khan Academy and Tivitz.
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Other factors not mentioned in chapter three are social desirability bias, SEMS question phrasing, and intervention locale. Social desirability bias and interactions with module 1, could have also influenced participants’ responses during the focus group interview. Social desirability bias is the underreporting of socially undesirable attitudes or behaviors and over-reporting of more desirable attributes by interviewed participants (Fisher, 1993). Participants’ responses during the focus group interview appeared to be influenced by the tone and cadence of other respondents. However, I cannot definitively attribute their behavior to social desirability bias. Mathematics engagement results could have also been influenced by the mindfulness exercises in module 1. The mindfulness exercises were designed to reduce anxiety but could have had the opposite effect. Further research would have to be conducted without module 1 to isolate changes and attribute them to the mathematics engagement exercises in modules 2 and 3.

There was also a difference between how the SEMS and focus group questions were phrased and the locale of the intervention. The SEMS is designed to be given in the classroom, and the intervention was given outside of the classroom during the summer. Participants may have been referring to thinking about their mathematics class during school instead of thinking about the intervention when responding. I instructed participants to think of the intervention setting when taking the SEMS and during the focus group, but there may have been some confusion about which locale to reference when participants read the SEMS and had to respond on their own.

Summary

There were several factors that influenced the outcomes of each construct examined by this research study. Factors, such as adherence, Zoom fatigue, treating evaluation-
related mathematics instead of generalized mathematics anxiety, interactions between modules, and module exercises. All of these factors appeared to have interactions within and between the three intervention modules. Out of the factors explored, adherence, specifically content and frequency, and the types of module exercises appeared to have had direct and indirect impacts on implementation fidelity, mathematics anxiety, and mathematics engagement.

**Limitations of the Study**

Several factors were limitations of the navigating numbers research study. The most notable factors were the effects of COVID-19, the types of exercises selected to treat mathematics anxiety and mathematics engagement, and the duration of the intervention.

The COVID-19 pandemic presented a number of challenges that potentially had significant effects on the outcomes of the intervention. Those affects included introducing potential spillover from Zoom fatigue, interpreting the quantitative results because of the small sample size, and the increased difficulty of implementing the intervention due to the COVID-19 policies implemented by the youth center.

Another limitation of the study was the types of mindfulness and mathematics instruction exercises that participants used for modules 1 and 2. The mindfulness exercises were developed to treat general anxiety and were used because there was evidence of them being effective at decreasing evaluation-related mathematics anxiety (Bellinger et al., 2015; Flook et al., 2010; Khng, 2017). However, those specific exercises may have limited the participants’ ability to reduce generalized mathematics anxiety and also affected the mathematics engagement results. In addition to the mindfulness exercises, using videos from Khan Academy that did not require any interaction also appeared to limit mathematics
engagement. Furthermore, Tivitz, was limited in the variety of mathematics games that the participants could use for practice. Since both the mathematics instruction and practice platforms were used to increase engagement, it was unclear how much the interaction between the two modules may have affected the mathematics engagement outcomes.

The last limitation discussed here was the duration of the intervention. The amount of time allotted to implement the intervention was limited by the youth center schedule and the uncertainty caused by the COVID-19 pandemic. These two constraints were the primary reasons that the intervention was limited to six weeks.

**Recommendations**

There were several lessons learned from the Navigating Mathematics research study. The following four recommendations have the potential to improve the outcomes related to implementation fidelity, mathematics anxiety, and mathematics engagement. The recommendations are not listed in order of priority and implementing one, some, or all of them has the potential to improve the outcomes of similar studies.

The first recommendation is to use or develop exercises that are developed specifically to decrease generalized mathematics anxiety. Prior interventions demonstrated that mindfulness exercises designed to reduce general anxiety could be used to reduce evaluation-related mathematics anxiety (Bellinger et al., 2015; Flook et al., 2010; Khng, 2017). It would be informative to determine if other mindfulness techniques that were designed to treat generalized mathematics anxiety would be effective.

The second recommendation is to provide more interactive mathematics videos and a wider variety of mathematics games to increase mathematics engagement. Children in grades 3 through 5 might find an instructional mathematics platform that includes more
interactive videos more engaging. Another recommendation related to improving the outcomes for mathematics engagement would be to select a platform with a variety of games to practice mathematics concepts. Most participants enjoyed playing Tivitz to practice mathematics, but were bored if they did not advance quickly enough. Mathematics games that are similar to Tivitz and include role-play and leaderboards could provide better outcomes (Brigham, 2015; Gros, 2015).

Recommendation three is to increase adherence, by increasing the frequency or duration of the intervention. Increasing the duration of the intervention would provide more time to expose participants to the modules and potentially improve the outcomes for mathematics anxiety and mathematics engagement. Räsänen et al. (2009) and Slavin and Lake (2007) provided evidence that a broad range of intervention durations could be effective; however, outcomes were better for studies with longer durations.

The final recommendation, is to limit the interaction between modules to reduce potential spillover effects. Measuring spillover was not included in this experimental design, but there was a potential for implementation fidelity, mathematics anxiety, and mathematics engagement to be affected by modules 1, 2, and 3.
Appendix A – Modified Abbreviated Mathematics Anxiety Scale (mAMAS)

Questionnaire

Please give each sentence a score in terms of how anxious you would feel during each situation. Use the scale at the right side and circle the number which you think best describes how you feel.

<table>
<thead>
<tr>
<th></th>
<th>Low Anxiety</th>
<th>Some Anxiety</th>
<th>Moderate Anxiety</th>
<th>Quite a bit of Anxiety</th>
<th>High Anxiety</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Having to complete a worksheet by yourself.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Thinking about a math test the day before you take it.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Watching the teacher work out a math problem on the board.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Taking a math test.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Being given math homework with lots of difficult questions that you have to hand in the next day.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Listening to the teacher talk for a long time in math.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>Listening to another child in your class explain a math problem.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>Finding out you are going to have a surprise math quiz when you start your math lesson.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>Starting a new topic in math.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
### Appendix B – eSEI-5ps Needs Assessment Study Questionnaire

<table>
<thead>
<tr>
<th>#</th>
<th>Question</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>My family/guardian(s) are there for me when I need them.</td>
<td></td>
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<tr>
<td>2</td>
<td>If I don’t do well in school it’s because I’m not smart.</td>
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<tr>
<td>3</td>
<td>My teachers are there for me when I need them.</td>
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<tr>
<td>4</td>
<td>Other students here like me the way I am.</td>
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<tr>
<td>5</td>
<td>Adults at my school listen to the students.</td>
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</tr>
<tr>
<td>6</td>
<td>Other students care about me.</td>
<td></td>
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<tr>
<td>7</td>
<td>Students at my school are there for me when I need them.</td>
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<tr>
<td>8</td>
<td>My education will create many chances for me to reach my future goals.</td>
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<tr>
<td>9</td>
<td>I don’t pay attention during class.</td>
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<tr>
<td>10</td>
<td>The rules at my school are fair.</td>
<td></td>
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<tr>
<td>11</td>
<td>Continuing to learn after high school is important.</td>
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<tr>
<td>12</td>
<td>My family/guardian(s) want to know when something good happens at school.</td>
<td></td>
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<tr>
<td>13</td>
<td>Most teachers care about me as a person, not just a student.</td>
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<tr>
<td>14</td>
<td>Students here respect what I have to say.</td>
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<tr>
<td>15</td>
<td>I don’t like school.</td>
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<tr>
<td>16</td>
<td>My teachers are honest with me.</td>
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<tr>
<td>17</td>
<td>I plan to go to college after I graduate from high school.</td>
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<tr>
<td>18</td>
<td>I will learn only if teachers give me a reward.</td>
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<tr>
<td>19</td>
<td>School is important for reaching my future goals.</td>
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<tr>
<td>20</td>
<td>When I have problems at my school, my family/guardian(s) are ready to help me.</td>
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<tr>
<td>21</td>
<td>Adults at my school are fair towards students most of the time.</td>
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</tr>
<tr>
<td>22</td>
<td>I like talking to the teachers here.</td>
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<tr>
<td>23</td>
<td>I enjoy talking to the students here.</td>
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</tr>
<tr>
<td>24</td>
<td>I have friends at school.</td>
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<tr>
<td>25</td>
<td>I feel nervous when I’m at school.</td>
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<tr>
<td>26</td>
<td>I don’t understand why I get the grades I do.</td>
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<tr>
<td>27</td>
<td>I feel safe at school.</td>
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<tr>
<td>28</td>
<td>I feel upset when I don’t do well in school.</td>
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</tr>
<tr>
<td>29</td>
<td>My family/guardian(s) want me to keep trying when things are tough at school.</td>
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<tr>
<td>30</td>
<td>I am hopeful about my future.</td>
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</tr>
<tr>
<td>31</td>
<td>Teachers at my school care about the students.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>32</td>
<td>I will learn only if my parent/guardian(s) give me a reward.</td>
<td></td>
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</tr>
<tr>
<td>33</td>
<td>My grades show how hard I work.</td>
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</tr>
<tr>
<td>34</td>
<td>I am responsible for the grades I get.</td>
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<tr>
<td></td>
<td>Question</td>
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<td>-------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>35</td>
<td>I am easily distracted in class.</td>
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<td></td>
</tr>
<tr>
<td>36</td>
<td>How often do you feel bored at school?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>How often did you come to class and find yourself:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Without what you need to do classwork</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Without reading materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Without your homework done</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix C – Modified Self-Efficacy Youth Questionnaire (MSYQ)

Thank you for taking the time to answer these questions. This is NOT A TEST. There are no right or wrong answers. Please be honest when answering the questions. Your honest answers will help your school or program do a better job to help you learn!

These questions are about different ways students may behave in school. Please mark the box that best describes you.

<table>
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<tr>
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<th>Somewhat like me</th>
<th>A lot like me</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>I can wait in line patiently.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>2</td>
<td>I sit still when I'm supposed to.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>3</td>
<td>I can wait for my turn to talk in class.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>4</td>
<td>I can easily calm down when excited.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>5</td>
<td>I calm down quickly when I get upset.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

These next questions are about how well you feel you can do your schoolwork. Mark the box that best describes you.

<table>
<thead>
<tr>
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<th>A little like me</th>
<th>Somewhat like me</th>
<th>A lot like me</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>I can do even the hardest homework if I try.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>7</td>
<td>I can learn the things taught in school.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>8</td>
<td>I can figure out difficult homework.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

Please turn to the next page so you can finish the next questions.
These next questions are about how you get your schoolwork done. Mark the box that best describes you.

<table>
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<tr>
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<th>Somewhat like me</th>
<th>A lot like me</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>If I solve a problem wrong the first time, I just keep trying until I get it right.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>10</td>
<td>When I do badly on a test, I work harder the next time.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>11</td>
<td>I always work hard to complete my school work.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

These last set of questions will ask you how you feel about school. Please mark the box that best describes you.

<table>
<thead>
<tr>
<th></th>
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<th>Somewhat like me</th>
<th>A lot like me</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>I do my schoolwork because I like to learn new things.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>13</td>
<td>I do my schoolwork because I'm interested in it.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>14</td>
<td>I do my schoolwork because I enjoy it.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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</table>

Thank you! You're done!
# Appendix D – Student Participation Log

<table>
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<th>Participant ID</th>
<th>Module</th>
<th>Amount Completed</th>
<th>Notes</th>
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<td>1</td>
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<tr>
<td></td>
<td>2</td>
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<td>3</td>
<td></td>
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<tr>
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<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
<td></td>
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<td></td>
<td>3</td>
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<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**General Notes**

**Date:**
Appendix E – Focus Group Interview Questions

Your participation in this study is entirely voluntary: If you choose to participate it will help me determine if using relaxation techniques and using computers to explain and practice math are a good way to help kids your age in your community do better in math. If you decide not to participate, there are no penalties and you will not lose any benefits that you would be entitled to at the youth center.

If you are participating in the focus group, you must keep the discussion confidential which also means private.

If you want to stop participating in the study, tell me or one of the youth leaders that you don’t want to continue. A confirmation email or phone call will be sent to your mom, dad, or guardian confirming your removal from the study.

Question 1. Describe how you felt about learning and practicing math before the mindfulness exercises.

Question 2. Describe how you felt about learning and practicing math after the mindfulness exercises.

Question 3. Did your mind wander during the mindfulness exercises? If so, how often?

Question 4. Describe how you felt about learning math before doing the Khan Academy exercises.

Question 5. Describe how you felt about learning math after doing the Khan Academy exercises.

Question 6. Did your mind wander when you watched any of the Khan Academy videos? If so, how often?

Question 7. Describe how you felt about practicing math before playing the Tivitz math game.

Question 8. Describe how you felt about practicing math after playing the Tivitz math game.

Question 9. Did your mind wander when you played the Tivitz mathematics game? If so, how often?

Question 10. Do you think that participating in these activities made you less nervous about math?

Question 11. Were you able to focus more when learning and practicing math using these activities?
Appendix F – Student Engagement in Mathematics Scale (SEMS)

We are interested in your thoughts about math class today. Please read each statement, and circle the number that fits.

<table>
<thead>
<tr>
<th>#</th>
<th>Statement</th>
<th>No, not at all true</th>
<th>A little true</th>
<th>Often true</th>
<th>Yes, very true</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Today in math class I worked as hard as I could.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Today I talked about math to other kids in class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Today I helped other kids with math when they didn’t know what to do.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Today I shared ideas and materials with other kids in math class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Students in my math class helped each other learn today.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Math class was fun today.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>Today I felt bored in math class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>I enjoyed thinking about math today.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>Today it was important to me that I understood the math really well.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>I tried to learn as much as I could in math class today.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>Learning math was interesting to me today.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12</td>
<td>I liked the feeling of solving problems in math today.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13</td>
<td>I did a lot of thinking in math class today.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

If there is anything else you would like to write about how you felt in math class today please write it below:

Note. Item 7 will be reverse scored. Emotional engagement items: 6, 7, 8, 11, 12. Social engagement items: 2, 3, 4, 5. Cognitive engagement items: 1, 9, 10, 13.
# Appendix G – iReady Cut Point Scale

## Fall Smarter Balanced

<table>
<thead>
<tr>
<th>Grade 3</th>
<th>Grade 4</th>
<th>Grade 5</th>
<th>Grade 6</th>
<th>Grade 7</th>
<th>Grade 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>407</td>
<td>426</td>
<td>444</td>
<td>458</td>
<td>465</td>
<td>474</td>
</tr>
</tbody>
</table>

## Winter Smarter Balanced

<table>
<thead>
<tr>
<th>Grade 3</th>
<th>Grade 4</th>
<th>Grade 5</th>
<th>Grade 6</th>
<th>Grade 7</th>
<th>Grade 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>420</td>
<td>439</td>
<td>453</td>
<td>465</td>
<td>472</td>
<td>481</td>
</tr>
</tbody>
</table>

## Spring Smarter Balanced

<table>
<thead>
<tr>
<th>Grade 3</th>
<th>Grade 4</th>
<th>Grade 5</th>
<th>Grade 6</th>
<th>Grade 7</th>
<th>Grade 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>430</td>
<td>446</td>
<td>459</td>
<td>470</td>
<td>474</td>
<td>482</td>
</tr>
</tbody>
</table>

## Fall NY State Testing Program

<table>
<thead>
<tr>
<th>Grade 3</th>
<th>Grade 4</th>
<th>Grade 5</th>
<th>Grade 6</th>
<th>Grade 7</th>
<th>Grade 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>407</td>
<td>426</td>
<td>444</td>
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<td>474</td>
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## Winter NY State Testing Program

<table>
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<tr>
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<th>Grade 6</th>
<th>Grade 7</th>
<th>Grade 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>420</td>
<td>439</td>
<td>453</td>
<td>465</td>
<td>472</td>
<td>481</td>
</tr>
</tbody>
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## Spring NY State Testing Program

<table>
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<th>Grade 6</th>
<th>Grade 7</th>
<th>Grade 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>430</td>
<td>446</td>
<td>459</td>
<td>470</td>
<td>474</td>
<td>482</td>
</tr>
</tbody>
</table>
Bibliography


INVESTIGATING MATHEMATICS ANXIETY AND ENGAGEMENT


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https://doi.org/10.1207/s15326985ep2802_3


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https://doi.org/10.1177/0042085903038004006

https://doi.org/10.1086/209351

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INVESTIGATING MATHEMATICS ANXIETY AND ENGAGEMENT


INVESTIGATING MATHEMATICS ANXIETY AND ENGAGEMENT


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https://doi.org/10.1016/j.jsp.2013.05.001


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https://doi.org/10.15540/nr.8.1.47

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https://doi.org/10.4324/9780429499821-33


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