Development of the STEM Attitudes of Educators Tool: A Measurement Tool to Assess the STEM Self-efficacy and Motivation of Afterschool Educators

by

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Abstract

The purpose of this study was to understand how a science, technology, engineering, and math (STEM) professional development workshop improved teachers' self-efficacy and motivation to implement STEM in their afterschool programs as well as develop a tool that measures STEM motivation and self-efficacy. Educators' self-efficacy and motivation were measured using the proposed instrument before and after they attended a professional development workshop centered around an engineering design activity.

Quantitative data were collected and analyzed over four phases. A proposed instrument measuring two constructs, self-efficacy and motivation, was implemented, analyzed by factor analyses, and refined until a final instrument version was created.

Findings indicated that there is sufficient evidence to support the validity of the proposed instrument. While there is sufficient evidence of validity, future research should be conducted to improve the validity as well as better conceptualize educator self-efficacy and motivation regarding STEM implementation.

Implications from this study have the ability to improve professional development design and practice as well as encourage educators to implement STEM focused curricula in afterschool by increasing their confidence and motivation to do so. This research also adds to the existing literature by providing information about educators' needs and attitudes around STEM education. Lastly, this research has the ability to inform practitioners, stakeholders, researchers,

and policymakers about how to motivate afterschool program staff to effectively provide integrated STEM learning with confidence.

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CHAPTER 1: THE PROBLEM

Introduction

Although the acronym, STEM, has been used in the past 25 years, the discussion about improving education in the disciplines of science, technology, engineering, and mathematics has been around much longer. In the late 1950s, after the launch of Sputnik I, the *Race to Space* sparked an emphasis on advancing American technology as well as reforming science and math education (Burkhart, 1959; Koehler, Binns, & Bloom, 2016). Under the Reagan administration, the Secretary of Education, Terrel H. Bell, formed The National Commission on Excellence in Education (NCEE), which published a report, *A Nation at Risk*, that addressed the concerns regarding the education system in the United States (NCEE, 1983). This committee had several tasks including assessing the quality of teaching and learning in the United States, comparing U.S. schools with schools in other advanced nations, as well as identifying problems to overcome and solutions to put in place if “we are to successfully pursue the course of excellence in education” (NCEE, 1983, p.10). The committee found that academic achievement based on 19 academic tests during the time of the study (1981-1983) was lower than it was when Sputnik was launched in 1957, enrollment in remedial math courses in college had increased significantly by 72 percent and science achievement was declining (NCEE, 1983). Additionally, compared to other nations, the United States was last seven times in achievement (NCEE, 1983). Paul Hurd, a nationally prominent science educator, stated his concern that new generations of Americans were both scientifically and technologically illiterate (NCEE, 1983). The report concluded that academic achievement as a nation, was due to many aspects of the educational process such as content, expectations regarding college readiness, time students spent in school, and teacher retention and recruitment.

In 1989, the American Association for the Advancement of Science (AAAS) published *Project 2061: Science for All Americans* which discussed a framework with the intention of getting all Americans to be literate in science, mathematics, and technology (AAAS, 1989). The recommendations also included standards for engineering. It was this report that set the tone for STEM education reform by painting a clear picture of K-12 science curriculum, helping teachers fill in the gaps of their own knowledge regarding science, math, and technology, and also clearly defining science literacy (AAAS, 1989). Although the acronym STEM was not yet conceived, the improvement in science, technology, engineering, and mathematics education was being discussed.

Origin of the Acronym "STEM" and Defining STEM

It was not until the 1990s when the acronym STEM was coined, originally called SMET, and the credit for the acronym was given to the National Science Foundation (NSF) (Sanders, 2009). Although an emphasis on the separate components of STEM and STEM education had been around for some time, the ambiguity of the acronym left many to wonder "What exactly does STEM mean?" When the term was first being used, many thought it pertained to stem cell research or had to do with botany (Breiner, Harkness, Johnson, & Koehler, 2012; Sanders, 2009). Still today, there is no consensus on the precise definition of STEM, and one can find many vague definitions depending on the perspective, whether it is a political perspective, economic perspective, or educational perspective. The educational perspective of STEM refers to the traditional coursework in the four disciplines, lacking an integrated approach, while the political and societal perspectives of STEM focus on 21st century skills needed in the workforce of the STEM fields (Breiner et al., 2012). According to one report by the Congressional Research Service (CRS), "STEM education" refers to "teaching and learning in the fields of science, technology, engineering, and mathematics," (Gonzalez & Kuenzi, 2012). The National Science Foundation uses a broader definition that includes psychology and the social sciences as well as the core sciences and engineering (Gonzalez & Kuenzi, 2012). However, the Department of Homeland Security and U.S. Immigration and Customs Enforcement have adopted a definition that disregards the social sciences and focuses on math, chemistry, physics, computer and information sciences, and engineering (Gonzalez & Kuenzi, 2012). Others define STEM education as a "meta-discipline" and an interdisciplinary approach to learning where academics are connected with real-world applications (Tsupros, Kohler, & Hallinen, 2009). Another definition refers to STEM education as the following:

> a standards-based, meta-discipline residing at the school level where all teachers, especially science, technology, engineering, and mathematics (STEM) teachers, teach an integrated approach to teaching and learning, where discipline-specific content is not divided, but addressed and treated as one lively, fluid study (Brown, Brown, Reardon, & Merrill, 2011, p.6)

One area of concern, pointed out by Sanders (2009), is that when people say "STEM", what they really should be saying is "STEM education." He argues that STEM without education is merely a reference to segregated disciplines in which scientists, engineers, and mathematicians work. This idea of segregated disciplines is aligned with the results of a study by researchers at the University of Cincinnati which concluded that a large proportion of faculty members defined STEM by the four content areas (Breiner et al., 2012). Other educational experts indicated that

STEM as an educational concept is problematic. One such educational expert and Honorary Visiting Fellow at the University of York stated the following:

> There is little consensus as to what it is, how it can be taught in schools, whether it needs be taught as a discrete subject or whether it should be an approach to teaching the component subjects, what progression in STEM education is, and how STEM learning can be assessed (Pitt, 2009, p.41).

One of the most modern definitions of STEM education is the intentional integration of the four disciplines together to solve real-world problems, termed "integrated STEM." Integrated STEM can be defined as "the teaching and learning of the content and practices of disciplinary knowledge which include science and/or mathematics through the integration of the practices of engineering and engineering design of relevant technologies," which may be enhanced through further integration with other school subjects such as art or history (Sanders & Wells, 2010; Bryan, Moore, Johnson & Roehrig, 2016, pp. 23-24). Many educators know what STEM is in their distinct content areas but they do not know how to integrate the four disciplines together to achieve a learning goal. When students participate in truly integrated STEM, they should be able to demonstrate STEM knowledge and practices such as designing, making, and evaluating solutions to authentic problems, and engaging in the engineering design process while emphasizing 21st-century skills (Sanders, 2012; Bryan et al., 2016). The report *Benchmarks for Science Literacy* also parallels this notion of integrative STEM education by asserting "The ideas and practice of science, mathematics, and technology are so closely intertwined that we do not see how education in any one of them can be undertaken well in isolation from the others" (AAAS, 1993).

Importance of STEM Education

Although there is no consensus on the definition of STEM education, one point of agreement is on the importance of integrative STEM in K-12 and postsecondary education. It is not only important for learners to understand science and math concepts, but also how to apply knowledge to solve problems. According to the U.S. Department of Commerce, STEM jobs are growing at 17%, more than any other field (Langdon, McKittrick, Beede, Khan, & Doms, 2011). However, the issue is that the United States is not producing enough qualified potential STEM employees to fill these positions (Langdon et al., 2011). The workforce in science, technology, engineering, and math fields is essential to sustained growth and stability of the economy as well as for the advancement and progress of our society and our global competitiveness. The STEM workforce will need to tackle challenges of the 21st century such as medical advancements in cures for diseases as well as developing clean sources of energy that not only reduce our reliance on foreign oil but also reduce carbon emissions so the effects of climate change will likely lessen (The White House, 2009). Recognizing the importance of STEM education and the need for STEM education improvement, President Barack Obama launched the "Educate to Innovate" campaign declaring that "reaffirming and strengthening America's role as the world's engine of scientific discovery and technological innovation… is essential to meeting the challenges of this century," and making STEM education a national priority (The White House, 2009, para. 3). The implementation of STEM education will contribute to increased global competitiveness, improve our nation's economic position and develop a well-prepared and abundant STEM workforce.

STEM education is not only beneficial for the U.S. economy and at the global level, but there are also many benefits at the micro level. STEM students benefit by becoming better problem solvers, innovators, and logical thinkers, and become more self-reliant and literate in technology and science. STEM education also has a positive impact on student attitudes, motivation, achievement, and interest in school (Stohlmann, Moore, & Roehrig, 2012). Implementing integrated STEM in an informal learning environment such as afterschool programs has the capability of enhancing STEM attitudes and potentially bridging the gender and ethnic gap often seen in the STEM workforce (Flowers, 2008; Levine, Seiro, Radaram, Chaudhuri, & Talbert, 2015).

Additionally, schools benefit from implementing a STEM-focused curriculum. Schools increase teacher recruitment and retention, see improved scores, students have increased motivation, and there is potentially an "enhanced profile in the community" and increased partnerships with stakeholders and local businesses (Pitt, 2009, p.42). As Pitt (2009, p.42) argues, "it goes beyond just policy to address skills shortages."

Knowing the importance of STEM education and the rapid growth in STEM jobs, why is the United States unable to produce enough potential employees to fill these positions? Some would argue that there are enough employees. Rather than a shortage of potential STEM workforce, some believe there is a shortage of STEM jobs. According to an article published in the *Chronicle of Higher Education* "unemployment rates within STEM fields…are often higher than they've been in years" (Anft, 2013, p.2). Mirroring this statement, the Bureau of Labor Statistics believes there are STEM "surpluses" and "crises" depending on the STEM field and the circumstances at the time data are being collected (Xue & Larson, 2015). Regardless of the debate, there is no argument that some STEM fields have a deficit of employees. The cause of this dilemma is rooted in K-12 STEM education- the pipeline to the future STEM workforce. Issues center around lack of access, high-stakes testing, teacher lack of knowledge, and students' fear of failure.

The first issue of creating a STEM pipeline is access. According to the U.S. Department of Education (n.d.), a student's race, zip code, and socioeconomic status can determine their "STEM fluency" by diminishing their access to a full range of science and math subjects. This hinders a student's ability to be college-ready and therefore, they are unlikely to pursue a STEM major.

A second cause is pressure placed on faculty to have high achievement on state standardized tests. With the pressure of high-stakes testing, teachers spend much of the time teaching rote memorization which leaves little time for students to have opportunities to engage in authentic STEM practices such as asking questions, collaborating with peers, and utilizing the engineering design process to solve problems. In this era of high-stakes testing, educators feel unprepared to effectively implement integrated STEM into their already limited class time. This lack of preparedness may be due to preservice teacher programs not focusing on STEM as well as ineffective STEM professional development for existing educators.

A final issue is students' unwillingness to fail and try again. Not only do teachers feel pressure, but students do as well. Entry to top tier colleges and attainment of scholarship offerings are more competitive now than ever, and high achievement on standardized tests such as the ACT and SAT (along with GPA) play an important role in achieving this, which leaves little room for failure-or so students think. Failure has long had a negative connotation. However, failure is instructive and can teach students valuable lessons both in academics and in life. Failure can teach students where they went wrong to begin with and how to problem-solve. Failure is a pivotal component of the engineering design process and is essential to STEM education. Nonetheless, students are uncomfortable with this notion which is likely due to educators not offering opportunities to do so. Some research introduces the concept of *scaffolding for failure*, the idea of helping students feel comfortable with failure by creating a supportive environment where they can learn from their design failures and mistakes (Lottero-Perdue & Perry, 2017). Creating a safe and supportive environment for students experiencing failure is essential to not discourage future attempts. However, creating opportunities for failure with integrated STEM as well as creating this safe environment for design failure can be hindered by normal school day requirements. If teachers feel they are unable to implement integrated STEM during the school day, where can students have authentic STEM opportunities and the freedom to fail?

Importance of STEM in Afterschool

One setting where truly integrated STEM can be implemented successfully without the pressure of grades or time is the out-of-school space. Studies have shown the impact that afterschool programs have on students' lives including improvement in self-perception and increase in positive social behaviors (Everage et al., 2014; Gibson & Chase, 2002; Krishnamurthi, Ballard, & Noam, 2014; Sahin, 2013; Sahin et al., 2014). The overall approach to afterschool is similar to the approach of STEM education. Successful afterschool programs create a student-centered environment where youth have the freedom to be creative and make choices regarding their learning without the pressure of penalties such as grades (Afterschool Alliance, 2011; Holstead, Hightower, & Miller, 2015). Therefore, they have the freedom to fail and try again- an essential component to STEM education. Recognizing the parallels between afterschool and STEM education objectives, many programs are beginning to focus on implementing STEM in the out-of-school space (Afterschool Alliance, 2013). Acknowledging the importance of STEM education in afterschool, federal agencies have budgeted money to help with STEM initiatives. Recently, President Donald Trump signed into law the FY2017 budget which appropriates approximately $3.9 billion across several federal science agencies with a large portion targeting afterschool programs, an increase from the $3 billion appropriation in FY2016 (Krishnamurthi, 2016; AIP, 2017). This budget does not include philanthropic funding such as that from The Noyce Foundation or corporate funding from companies such as Verizon which also support STEM education in afterschool. Reports indicate that approximately 8.4 million youth attend informal learning programs in out-of-school time each year (Krishnamurthi et al., 2014). This astounding number exhibits the potential impact that STEM in afterschool could have on students and our society.

Findings from a study by the National Research Council suggested that students in informal learning environments experience increased motivation, interest, and excitement regarding science phenomena, as well as receive a positive impact on STEM identity development (Krishnamurthi et al., 2014). A STEM identity is being able to identify with STEM culture or STEM professionals (NSF, 2015). Previous research suggests that a lack of STEM identity is a reason that students, especially those underrepresented in STEM, choose not to pursue STEM fields (ASPIRES Project, 2014). With an underrepresentation of African-Americans, Hispanics, Native Americans and females in STEM fields, development of STEM identities fostered by afterschool programs can help bridge this gap. A second study revealed that the achievement gap in math between low- and high-income students narrowed when low-income students participated in afterschool programs that implemented engaging activities that excited youth and motivated students to participate consistently (Vandell, 2013). Students who are exposed to STEM opportunities, especially in informal spaces, show increased achievement in science during the school day as well as improved skills, critical thinking, and interest in science (Ganesh & Schnittka, 2014; Krishnamurthi et al., 2014). Providing STEM opportunities for youth also helps them connect their learning to real-world relevance. These studies demonstrate that STEM in afterschool not only impacts science and math achievement but also affects youth's personal development such as skills essential for the 21st century. If research validates the importance of STEM education in afterschool, why does every afterschool program not implement more opportunities?

Challenges with Implementing STEM in Afterschool

Although many agree on the importance of implementing STEM in the out-of-school time, programs continue to face many challenges. There are two predominant challenges that programs confront when attempting to integrate STEM education into their afterschool program: funding and staff.

The lack of funding continues to be a hindrance when beginning to initiate a STEM-focused afterschool program. Although there are many avenues for funding, whether it is federal, state or local funding, private organizations, or public companies, many programs do not have access to these grants unless they have staff members with the time or ability to write grant proposals. This can limit the funding significantly for many programs. In this STEM-focused revolution our society is facing, everything online or in stores seems to be labeled "STEM." Companies are profiting significantly by marketing almost anything and everything as STEM, charging a few dollars to several thousand dollars per kit. Many program staff believe they must have an expensive STEM kit, and therefore, are discouraged by the amount of money they must spend to sustain STEM all year long.

Also, regarding funding, when programs do receive a grant, they are often asked to provide documentation or data to policymakers and funders that validates their money and showcases the impact of STEM. This can be a challenge in the afterschool space where formal assessment does not exist. It can be difficult for afterschool staff to document the impact STEM has on personal growth and development.

A second challenge facing programs is issues surrounding staff. With limited funding or none at all, many afterschool programs must rely on the support of volunteers to engage students in STEM activities. Some educators feel overworked by the demands that the in-school-time places on them so that they are unable to volunteer or work at the end of the day. Therefore, many programs must look for volunteers or workers in the community, many of whom may not be trained in education or STEM. This leaves staff feeling uncomfortable and uncertain when implementing STEM, mainly because they do not know what truly integrated STEM entails. Educators and non-educators believe they do not have the ability to initiate STEM in their programs because they either do not have a science or math background or they believe they are not engineers or know what it means to be an engineer. This is further perpetuated by the lack of quality STEM professional development. One survey conducted by Alabama Afterschool Community Network indicated that 87% of afterschool programs in Alabama claimed they were implementing STEM (Truman Pierce Institute, 2016). However, from the same survey, 66% of educators working for these programs stated they had never heard of the engineering design process or did not know how to apply it (TPI, 2016). These contradictory results further demonstrate that afterschool staff do not know what integrated STEM is and, therefore, must not be truly implementing quality STEM. When asked what challenges their Alabama program faced, 60% surveyed claimed “knowledge, confidence or ability to employ STEM activities” was a challenge while 45% agreed “STEM training and professional development” was an issue they faced (TPI, 2016).

Although programs face challenges regarding funding and staff, both challenges can be overcome by quality STEM professional development. Professional development has the ability to train staff to write grants to obtain funding, increase knowledge of integrated STEM, and increase knowledge concerning the engineering design process. In return, staff confidence will likely increase and students will reap the benefits of a quality STEM afterschool program.

Problem Statement

While much of the current research focuses on new curricula and strategies to engage students in STEM, there is little research on what motivates both in-school and out-of-school educators to implement STEM and increases their confidence in their ability to do so. Due to the lack of consensus on the definition of STEM education or how to implement truly integrated STEM, teachers are left feeling confused and lack motivation and confidence to implement STEM in their afterschool programs. Along with the disagreement on what STEM education entails, teachers also are less willing to implement STEM due to limited resources, time, and their lack of knowledge of the Engineering Design Process (EDP).

Understanding the EDP is essential to planning and implementing truly integrated STEM in both in-school and out-of-school time. However, many educators report not understanding what the EDP is or how to implement it correctly. Implementing design-based learning activities (STEM activities) without the knowledge of the EDP can lead teachers to unintentionally "model inefficient design behaviors and habits…or reinforce students' design misconceptions" (Crismond & Adams, 2012, p.740). Therefore, quality STEM professional development is an essential first step in helping teachers become knowledgeable, comfortable, and confident in the EDP and implementing design-based activities.

The purpose of this study is to understand how a STEM professional development workshop improves teachers' self-efficacy and motivation to implement STEM in their afterschool programs as well as develop a tool that measures STEM motivation and self-efficacy.

Specifically, the research questions guiding this study are the following:

1) Does a STEM professional development workshop improve teachers' self-efficacy and motivation?
   a) How do teachers rate their motivation to implement STEM before and after a STEM workshop?
   b) How do teachers rate their self-efficacy regarding STEM implementation before and after a STEM workshop?
2) What evidence of reliability and validity supports the proposed *STEM Attitudes of Educators* instrument in evaluating educator motivation and self-efficacy regarding STEM implementation?

Some afterschool teachers and staff do not have STEM backgrounds and, therefore, do not feel confident or motivated to implement integrated STEM activities into their programs. Through a professional development opportunity, teachers will become familiar with dimensions of quality STEM, become confident, and become motivated to implement activities into their own program.

Significance of the Study

Informing and supporting educators in how to implement integrated STEM correctly and confidently is an essential first step to engaging students in STEM. Until educators become comfortable with guiding their students through the engineering design process, they will be less motivated to plan and implement quality STEM activities. Therefore, investigating motivation and self-efficacy of afterschool staff can inform future professional development design and implementation. While current research focuses on engaging students in STEM, there is little knowledge regarding how to motivate educators to implement STEM effectively, and there are few to measure educator STEM self-efficacy and motivation.

Integrated STEM education has the potential to impact two key areas: student learning and achievement, and student interest and identity (National Research Council, 2014). Through participation in integrated STEM activities, previous findings indicate that students have improved conceptual learning across multiple disciplines (NRC, 2014). However, are they able to connect what they learn in the out-of-school time with the in-school time? Research suggests that although some students are able to make links in their learning, there is a lack in connecting concepts from out-of-school learning with in-school learning (Fallik, Rosenfeld & Eylon, 2013). According to Fallik et al. (2013), bridging this gap provides multiple learning opportunities for a variety of learners and can increase student motivation for learning, expand student conceptions, and provide opportunities for students to develop new skills and abilities. Cause of this gap may include lack of understanding, lack of tools, or poor communication between staff to provide opportunities for bridging in the in-school day with the out-of-school time. A design-based science curriculum aligned with state standards can be implemented in informal settings, such as afterschool, to reinforce science content and bridge this gap (Schnittka, Evans, Won, & Drape, 2015; Valentine, 2016). This would provide effective professional development for teachers regarding how to implement integrated STEM with design-based curricula and connect concepts, and is essential to bridging in-school time with out-of-school time.

With such a high emphasis on providing integrated STEM in the out-of-school time, stakeholders, policy makers, and educators should be aware of the foundation of providing maximum learning opportunities in STEM which is teacher motivation and self-efficacy. Therefore, this research is designed to inform practitioners, stakeholders, researchers, and policymakers about how to motivate afterschool program staff to effectively provide integrated STEM learning with confidence.

CHAPTER 2: REVIEW OF THE LITERATURE

Introduction

The literature reviewed in this chapter relates to both the design and subject of the proposed research study, which is to investigate how to develop a valid and reliable tool to measure teacher motivation and self-efficacy regarding STEM implementation in afterschool programs. Therefore, this chapter begins with a discussion of STEM programs in afterschool focusing on support for STEM initiatives, the impact of STEM in afterschool, and various STEM program models. It follows with a discussion of professional development best practices as well different professional development models. It concludes by discussing the lack of research regarding phenomenological studies to understand teacher motivation as well as the lack of research on a valid and reliable tool to measure STEM motivation and self-efficacy of educators.

STEM in Afterschool

Support.

Nationally, more than 10.2 million students participate in afterschool programs, and in Alabama alone there are approximately 105,000 K-12 students enrolled in afterschool programs while another 275,000 are waiting for program availability according to the Afterschool Alliance (2014; 2017). It is clear that afterschool programs reach many students, but there is a demand for more programs. With limited resources, programs and program staff are continually being reduced or eliminated. In addition, there is significant interest in including science in afterschool programs but, due to the lack of resources and funding, not all youth are exposed to science and integrated STEM afterschool (Chi, Freeman, & Lee, 2008). In Chi et al.'s (2008) market-research study, a survey was created that focused on general information about the afterschool program, information on implementation of science activities (types, frequency, reasons), specific details about activity origins (purchased or self-created), and descriptions of program needs, challenges, etc. Chi et al. were interested in learning about the existing emerging markets for science in afterschool and painting a picture of what afterschool programs were doing across the nation. They found there was a significant interest in including science in afterschool but students were also offered limited access to quality science-learning opportunities (Chi et al., 2008). According to this same study, there is also demand for support to increase the quality and quantity of science in afterschool programs. Support, however, does not only include financial support but also time and quality training for staff. Although beneficial for painting a holistic picture of afterschool in America, the study fails to capture accurately the number of youths served and also provides vague information regarding activity descriptions and curricula used.

Impact.

Research has suggested that STEM in afterschool has many positive benefits for students. Programs not only have a positive impact on youth perceptions related to STEM and STEM jobs, but also an impact on female perceptions related to engineering (Everage, Feldhuas, Tlabert-Hatch, & Fernandez, 2014). Everage et al. (2014) aimed to determine the efficacy of an engineering camp in improving student perceptions regarding the desire to pursue an engineering career as well as perceived success in engineering by administering the POWER Camp Perception Survey. Using test-retest reliability, Pearson’s r was evaluated for each statement in the survey. Questions were found have a correlation coefficient between 0.70 and 1.00, suggesting that each statement was reliable (Everage et al., 2014). See Figure 1 for sample survey items. Pre- and post-surveys were conducted on a sample of sixteen high school females.

Although the sample size was limited, results indicated that the camp had a positive impact on girls' perceptions related to engineering and how women fit into these roles (Everage et al., 2014).

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. It would be pretty fun to work in an engineering related job.	5	4	3	2	1
2. It is difficult for women to have successful engineering careers.	5	4	3	2	1
3. I might be willing to try a job related to engineering, but I don't think I would like it.	5	4	3	2	1

Figure 1. Sample questions from POWER Camp Perception Survey

In a study by Koch, Georges, Gorges & Fujii (2010), researchers suggest that through quality exposure to STEM jobs and STEM professionals, girls' attitudes and interests regarding STEM make a positive change. In this study, researchers reported on how a youth development program targeting girls impacted attitudes toward, and interest in, information technology (IT) careers. Using a mixed-method, pre-posttest approach to achieve a deeper understanding of factors influencing attitudes, they collected survey data from 439 participants and interviewed 170 girls using the IT Attitudes Survey. An example survey question from this study is: "What do you think about computer-related jobs like web-designers, software developers, or computer engineers?" (Koch et al., 2010). Three composite scores were generated and reliability coefficients were calculated. The first composite score captured attitudes about computer/technology related jobs and the reliability coefficient was calculated to be .75. The second composite score captured attitudes regarding computers and computer work and the reliability coefficient was calculated to be .76. Lastly, the third composite score captured girls' views of women in IT careers, and the reliability coefficient was .72. These reliability coefficients ranging from .72 to .76, suggest that the survey items are sufficient but a reliability coefficient of .95 or higher is desirable (Thorndike, 1995). Although the study had limitations regarding logistics of arranging fieldtrips and recruiting IT professionals, results add to the existing literature about the importance of exposing young girls to STEM professionals. When exposed, they begin to realize the possibility of seeing themselves in those roles (Koch et al., 2010).

In a two-year study by Gibson and Chase (2002), researchers suggest that attitudes developed early in a child's education are difficult to change once they reach middle school age, and increasing and sustaining interest in science can be accomplished through afterschool programs focusing on science and STEM. This claim was based on a two-year study that consisted of survey data and interviews from 79 middle school-age students who applied for the Summer Science Exploratorium Program (SSEP) summer camp. Two surveys were administered (The Science Opinion Survey and the Career Decision Making System- Revised) to all participants and 22 were selected for interviews. The Science Opinion Survey, produced by the National Association of Educational Progress (NAEP), is a 30-item questionnaire which assesses interest and attitudes about science activities on a 5-point scale (*Strongly agree, Agree, Not Sure, Disagree*, *Strongly Disagree*) (O'Sullivan & Weiss, 1999). Sample questions include statements such as "Science lessons are fun" and "I look forward to science lessons." The Career Decision Making System-Revised survey developed by Harrington and O'Shea (1992) is a 96-question career interest survey using a 3-point rating scale (*Like*, *Not sure*, *Dislike*). Sample items include "Perform scientific studies" and "Do research work." Cronbach's alpha coefficients ranged from .88 to .93 suggesting the instrument is reliable (Harrington & O'Shea, 1992). The combined surveys totaled 126 questions, which could potentially be daunting for participants and may not accurately portray the attitudes or interests of the participants. Also, post interviews were conducted two years after the camp ended and, therefore, students may not remember their feelings or excitement (or lack thereof) of their experience with SSEP. Results from pre-survey data suggest that students who attended camp initially had more positive attitudes and interests compared to those who did not attend. This is not a surprising finding considering that students who applied to the program and attended would naturally have a higher interest in science compared to those who did not apply. Interviews from the participants shed light on the informal camp experience regarding interest in science. Most students stated they enjoyed the camp and that they were interested in science. However, these statements contradict post-survey data that show a decrease interest in science. The authors suggest that this contradiction may be due to the traditional approach teachers use to teach in high-school compared to middle school science. To gain a deeper understanding of these data, researchers interviewed students and confirmed that they enjoyed science less in high school because the teacher focused heavily on lecturing and note taking as opposed to an inquiry-based approach (Gibson & Chase, 2002). Teachers approaching science from a traditional method can negatively impact students' interest and attitudes in science (Gibson & Chase, 2002).

However, several studies by Alpaslan Sahin and his colleagues indicate that the more students are exposed to STEM, and given opportunities to engage in STEM clubs, the higher the matriculation rate in STEM majors (Sahin, 2013; Sahin, Ayar, & Adiguzel, 2014). This claim is based on data collected by Sahin (2013) on 379 high school seniors from a charter school who attended one of seven afterschool STEM-related clubs. An online survey was developed to collect data about student demographics, college acceptance status, majors they selected, and how many years they participated in science fairs and STEM clubs. Furthermore, Sahin believed that, based on results, schools should provide a variety of flexible clubs and that engaging students early in their secondary education promotes interest in STEM which could potentially impact students' choice in a STEM major. A second study by Sahin et al. (2014) claimed that because activities in afterschool are not grade-oriented, students feel more comfortable and enjoy the tasks at hand and, therefore, feel motivated to accomplish STEM goals. This is based on a case study of 10 students attending STEM afterschool clubs at a charter school. From interviews, observations, and field notes, the authors suggest that afterschool programs implementing STEM-focused activities contribute to the development of 21st century skills that impact students' abilities to solve social, political, and cultural problems. Students acquire complex communication and collaboration skills applicable to real-world contexts, which are essential for being prepared for the 21st century workforce (Sahin et al., 2014). STEM in afterschool not only impacts students but also has a positive impact on the school, the community, and globally.

Models.

What should STEM in afterschool look like? Simply participating in STEM afterschool programs is not sufficient. STEM focused programs must be of high quality for students to reap the benefits. One way to assess the quality of a STEM afterschool program is through the use of the Dimensions of Success (DoS) observation tool which measures quality along 12 indicators in four domains so educators can pinpoint strengths and weaknesses of afterschool STEM learning opportunities (Papazian, Noam, Shah, & Rufo-McCormic, 2013). Not only can the tool show growth of quality STEM in a program, but it has the potential to shed light on areas where professional development may be needed in terms of quality STEM activities (Papazian et al., 2013). This observation tool assesses the learning environment, activity engagement, STEM knowledge and practices, and youth development in STEM- all key factors that provide students with a quality STEM experience in afterschool.

The development of this tool by Papazian et al. (2013) initially began in 2007 by observing 1,700 students in K-12 settings. A few years later, in 2011, Shah et al. (2018) conducted studies to establish the psychometric properties of the observation tool. Two studies were conducted. The first study focused on establishing validity and reliability evidence while study two focused on further reliability evidence and tool refinement. Study one consisted of 284 observations that took place in out-of-school time settings and summer programs. Observers were recruited and interviewed. After the selection process, observers were required to complete a two-day training (online or in-person) that was led by the tool developers. After training, a pair of observers went to the field to conduct observations. A pair of observers were used to establish a rater reliability. The observers watched the activity simultaneously in fifteen-minute blocks and spent ten minutes scoring each dimension. Observers would discuss start and end times of activity, but not ratings or evidence, until all data had been submitted to researchers. To establish evidence for reliability and validity, researchers examined the quality of the scores given by calculating percent exact agreement, percent exact or adjacent agreement, the quadratic weighted Kappa, and the correlation of each dimension across observations. *Percent Exact or Adjacent Agreement* is defined as two observers rating the same score or a score differing by one point on the same dimension. The quadratic weighted Kappa is a measure of inter-observer agreement that takes into account agreement happening by chance. Finally, correlations between pairs of scores were calculated. Additionally, researchers conducted an exploratory factor analysis. Study 1 results based on Kappa value interpretations suggest that four dimensions showed moderate agreement (Kappa value of .41 to .60), six showed fair agreement (Kappa value of .21 to .40), and two showed slight agreement (Kappa value of 0 and .20). *Percent Exact Agreement* ranged from 40.2 to 50.4 across the dimensions while *Percent Exact or Adjacent Agreement* ranged from 83.8 to 92.3 across the dimensions. The Exploratory Factor Analysis (EFA) indicated that dimensions loaded into two groups: a learning environment factor and a STEM meaning-making factor, providing evidence for validity.

Study two, focusing on supporting reliability evidence and tool refinement, contained 56 observations. Procedures were very similar to study one. However, this study implemented a longer and more rigorous training and certification process for becoming an observer (Shah, Wylie, Gitomer, & Noam, 2018). Kappa value interpretations indicated eight dimensions had perfect or substantial agreement (Kappa value of 0.81 to 1.00) while the remaining dimensions had substantial agreement (Kappa value of 0.60 to 0.80). Therefore, agreement improved after further training. Based on results from both studies, Shah et al. lay out reliability and validity evidence that supports the tool's use in evaluating STEM in afterschool settings.

Not only is it important to assess the quality of STEM taking place but it is important to find out if learning is taking place as well. There are several ways to document conceptualization of science content in afterschool settings including storyboards, videotapes, social networking, interviews, and pre- and posttests (Schnittka, Evans, Won, & Drape, 2015). In this study, Schnittka and her team sought to understand how middle school youth learned and expressed science and engineering content knowledge as they participated in an engineering design-based curriculum. This study is relevant due to a lack of research on determining what youth might learn in after-school settings in regards to science and engineering. The authors explain how afterschool settings provide educational benefits and personal growth of youth. However, measuring outcomes between a formal school setting and afterschool settings differ and, therefore, may fail to capture the range of ways youth demonstrate learning in informal settings. The curriculum, *Save the Penguins* (Schnittka, 2009), was implemented in this afterschool setting and focused on building structures to shelter penguins to keep them cool and to have a safe place to lay their eggs. The main concepts featured in this curriculum kit focus on heat transfer including conduction, convection, and radiation with ties to reducing carbon emissions. This article also describes an afterschool program, named Studio STEM, which aims to increase understanding of science, technology, and engineering through challenges related to energy and sustainability for students in middle school. The authors explain that Studio STEM centers around design-based science- a pedagogical practice which aims to create artifacts by applying science knowledge. The participants were middle-school-aged youth scattered among three middle schools in a rural region of the United States. These students were led by three educators with a science or math background as well as undergraduate students who were in STEM fields. All educators and undergraduate facilitators were trained on the *Save the Penguins* curriculum kit prior to teaching it.

Triangulating data sources to address construct validity, the researchers answered their research questions using multiple instruments including videotaped observations, pre- and posttests, Edmodo chat logs, storyboards, and transcripts of interviews. To address conceptions about heat transfer, students took a 12-item multiple choice test called *Heat Transfer Evaluation* created by Schnittka and Bell (2011). This evaluation was tested for reliability using test-retest method. Linear regression was used to determine that the correlation coefficient was $r=.71$ which is considered acceptable (Hinkle, Wiersma, & Jurs, 1982; Schnittka, 2009).

Results indicated there were many useful ways to track changes in participants' understanding of science concepts. Storyboards, videotapes, social networking, interviews, and pre- and posttests all demonstrated learning took place during Studio STEM. Overall, the curriculum implemented in Studio STEM had an impact on youth's understanding of heat transfer concepts. Studio STEM had a well-defined goal and appeared to have a positive effect on knowledge and interest in science for participating youth. There were gains in science content knowledge between pre- and posttests in majority of participating youth. Analyzing all data sources, results suggest that actions of the educators and facilitators were key in impacting learning. Results further indicated that social networking resulted in positive outcomes for youth to express themselves with each other and the facilitators.

Research also suggests that afterschool STEM programs should work in tandem with schools to provide information on STEM career paths (Everage et al., 2014). STEM programs should emphasize equality in STEM fields to change existing perceptions by exposing students, especially those that are underrepresented, to STEM professionals to change perceptions and develop STEM identities as well as emphasize that STEM jobs are fun and exciting (Everage et al., 2014; Koch et al., 2010). It is not enough just to have STEM professionals visit and describe their careers. The professionals should share their job experiences, duties, salient life, and education decisions that enabled them to achieve their jobs as well as be interactive with youth and engage them with tools, technology, and activities to increase their excitement (Koch et al., 2010). Therefore, professionals should explain connections between their careers and the school curriculum. Afterschool program staff can accomplish this task by reaching out to their local STEM professionals within their community and begin building relationships with them.

Allowing opportunities for collaboration is also key in STEM programs. Working in groups allows greater opportunities for students to design, build, test, and rebuild models, and also allows students to become aware of their strengths and weaknesses as well as their peers' strengths and weaknesses (Sahin et al., 2014). Sahin et al. (2014) also suggests that collaboration contributes to student learning and understanding of different aspects of the task at hand. Sahin et al. (2014) concludes that designing STEM related afterschool program activities aligned with 21st century skills is key to developing a generation of lifelong learners.

Another approach to integrating STEM in the afterschool setting is through the Studio STEM model. This model engages youth, increases satisfaction and motivation of students, and promotes students' beliefs, intrinsic and extrinsic value, and identification with engineering, science, and computer science (Schnittka, Brandt, Jones, & Evans, 2012). One study concluded that the Studio STEM model created an environment where youth felt empowered and encouraged students to enroll and participate in STEM subjects (Schnittka et al., 2012). In this study, researchers created a Studio STEM environment at a Boys and Girls Club working with middle school youth implementing an engineering curriculum, *Save the Penguins*, to measure students' motivation, beliefs, and identification with engineering, science, and computer science. The authors point out that there is little research regarding how youth learn engineering in informal settings and how informal engineering education affects beliefs and identification with engineering. Participants included eight middle school youth enrolled in a local afterschool Boys and Girls Club. The group consisted of all Caucasian students. Although it is ideal for all youth of any race to have positive associations regarding engineering and science, this study could have benefited from having participants of underrepresented groups, bolstering claims of afterschool impact on underrepresented groups in STEM fields. Questionnaires about beliefs, interests, and values were administered before and after the study. Two scales from the Intrinsic *Motivation Inventory* were modified and given to measure interest in the Studio STEM project. The two scales used included the Interest/Enjoyment scale with seven items to assess the students' interest in participating in Studio STEM (e.g., "I enjoyed participating in Studio STEM very much." and "Studio STEM was fun to do.") as well as the 5-item Effort/importance scale to measure the amount of effort students put into Studio STEM (e.g., "I tried very hard in Studio STEM." and "I put a lot of effort into Studio STEM.") All items were scaled on a 5-point Likert-type scale. This questionnaire has previously produced valid and reliable results in multiple studies (Deci, Eghrari, Patrick, & Leone, 1994; Ryan, 1982; Ryan, Mims & Koestner, 1983; Plant & Ryan, 1985). Additionally, two scales from the *Classroom Life Instrument* (Teacher Academic Support and Student Academic Support) (Johnson, Johnson, & Anderson, 1983) were modified and administered to measure caring (academic support) by the instructors (e.g., "The Studio STEM teacher cares about how much I learn." and "Other students in Studio STEM want me to do my best on this project.").

The authors argue that Studio STEM helped students feel empowered, successful, and interested in engineering, science, and computer science. Also, the authors concluded that Studio STEM provided the caring needed by students to increase their identification. Because of increase in beliefs, this led to students putting forth more effort. Studio STEM also has the potential to promote enrollment in STEM subject areas. Overall, the Studio STEM model is ideal for the afterschool space by fostering positive outcomes regarding beliefs and motivation regarding STEM. Furthermore, this study provides a framework for analyzing the impact of informal learning regarding science and engineering.

The structure of Studio STEM also provides an atmosphere for students to engage in free choice, tinkering, and self-directed learning (Schnittka et al., 2015). Free choice learning is a concept used to describe the ability to choose what, where, and how a student learns. Transforming a learning environment from teacher-centered to learner-led has the potential to increase and sustain motivation throughout a STEM experience (Newbill, Drape, Schnittka, Baum, & Evans, 2015). In one study by Newbill and her team, researchers transformed a school-based curriculum to a problem-based curriculum designed specifically for a summer day camp. To accomplish this task, they identified seven design strategies including: [configuring] the space instead of the time, [issuing] the challenge at the beginning of the experience, [including] a public presentation, [converting] scaffolding material to badge requirements, [strengthening] learning goals for process and reflection, [using] technology to make information available, and [training] facilitators (Newbill et al., 2015, p.7). Using these seven strategies to modify a curriculum for summer camp, the researchers assessed how well the redesign worked by collecting data in multiple ways including interviews, badging notebooks, observations, and artifacts (curriculum materials, schedules, and maps). Participants included 15 middle school students who attended a summer camp over a four-day period. By transforming a temporally organized activity into a spatially organized activity, students were able to take control of their learning by deciding which badges to complete to accomplish the STEM learning goal. The authors concluded their redesign was successful. Afterschool program educators can redesign a curriculum using the seven strategies outlined in this study to transform a curriculum to a learner-led experience that will stimulate students' interest in STEM learning (Newbill et al., 2015). The afterschool space is an ideal environment for free choice learning to take place.

Professional Development

Providing quality STEM professional development (PD) opportunities for educators is an essential first step in helping them become confident and motivated to implement integrated STEM into their afterschool programs. When designing and implementing PD workshops, research suggests several elements that facilitators (those conducting workshops) should consider so that educators (those working in the in-school space and out-of-school space) reap the maximum benefits. These elements include the purpose, the environment, modeling, duration, active learning, and coherence, and may differ depending on the PD model (face-to-face, online, or hybrid) (Avery & Reeve, 2013; Banilower & Shimkus, 2004; Desimone, 2009; Garet, Porter, Desimone, Birman, & Yoon, 2001; Goodnough, Pelech, & Stordy, 2014).

There are three platforms from which PD can be implemented: face-to-face, online, and hybrid. Face-to-face models consist of participants meeting in a common location with a facilitator leading instruction in person and available in real-time to answer participant questions. Online PD can take form through a learning management system where teachers enroll in courses or modules, or could be completed through an online meeting space. Online PD gives educators the flexibility to learn at their convenience at a lower cost to school districts and also provides other benefits including more resources and more variety in course offerings (Thomas, 2009). Hybrid PD is a combination of participants meeting both face-to-face and online and is believed to be the best method for achieving interaction and ongoing education (Harwell, 2003). The idea of hybrid learning has evolved from traditional one-size-fits-all workshops into a more "teacher-centered, self-directed model of teacher learning" (Web-Based Education Commission, 2000, p.60).

The best PD approach (e.g. study groups/coaching/mentoring vs. workshops) depends on the intended purpose (e.g. promoting effective instruction vs. leadership strategies) (Banilower & Shimkus, 2004). In one study by Banilower & Shimkus (2004), evaluators conducted a quantitative observational study using the PD Observation Protocol (PDOP) to rate features and quality of the sessions they observed. The researchers investigated whether certain features were important predictors of the quality of the PD using hierarchical linear modeling. Observations were conducted at over 2100 PD sites by multiple evaluators using the PDOP tool.

The authors discussed several key findings. First, as PD projects matured, session quality ratings improved. This is likely due to increased preparation and experiences of the PD providers. Also, engaging educators in problem solving or investigation activities was effective in creating a vision of instruction, learning to use materials, building professional networks, learning pedagogical strategies, and in understanding student thinking. These findings confirm that active learning is key to high quality PD (Banilower & Shimkus, 2004). Findings also suggest that the best approach to PD (study groups/coaching/mentoring vs. workshops) depends on the intended purpose (Banilower & Shimkus, 2004). For example, providing PD with the intent of promoting effective instruction should be approached in a workshop style, as opposed to a mentoring approach, which may be more effective for promoting strategies of leadership. Finally, PD providers may be an important predictor of PD quality (Banilower & Shimkus, 2004). For purposes in promoting effective instruction, reflective practices, or understanding student thinking, facilitators should be science/mathematics education faculty.

There are two criticisms to offer with this study. First, what is the difference between high quality and low quality according to this report? These variables are not clearly defined. Second, there is no interrater reliability discussed. Some researchers could score a PD as high quality while others score it as middle to low quality.

In the case of developing a STEM PD training program, the best approach would be a workshop with the intended purpose of promoting effective instruction with a focus on STEM content knowledge that is appropriate for each grade level (Desimone, 2009). Additionally, a train-the-trainer model for PD can be conducted to have a larger impact across the state (Schnittka et al., 2014).

In a study by Goodnough et al. (2014), researchers gained perceptions of primary and elementary teachers on effective STEM PD. This article was part of a larger five-year study, *Teachers in Action*, focused on enhancing STEM teaching and learning. The authors explained how effective STEM PD is especially important for elementary teachers because they lack degrees in STEM disciplines. They describe different definitions of PD as well as the distinction between PD and professional learning. For example, some argue that PD is something done to teachers while professional learning is about how teachers construct their knowledge and develop new skills or improve existing ones (Goodnough et al., 2014). Through this action research study, the authors aimed to better understand the perceptions of educators regarding effective STEM PD. The participants in this study were twenty-two primary and elementary teachers across five school districts in Canada who gathered for a week to learn about STEM topics as well as how to conduct action research. Once back at their schools, teachers worked in pairs and collaborated with the researchers via an online platform. Although the authors of this paper note this is part of a larger five-year study, they failed to mention the timeframe from which the data for the article were gathered.

Instruments used to collect qualitative data came from various resources so researchers could achieve triangulation. Participants completed an open-ended questionnaire which focused on characteristics they deemed essential for effective PD and asked how they could best be supported in teaching STEM (e.g., "Describe what you believe are the characteristics of effect PD in science.") (Goodnough et al., 2014). Participants journaled and participated in online discussions. Video was recorded and analyzed from planning meetings and online communications. The data were analyzed using the software, MAXQDA, to look for themes. Researchers recorded analytic memos and coded to generate subcategories and generate broader themes.

Several themes emerged from the results. The key characteristics that the educators found essential to effective PD were that: 1) PD needs to be directly connected to student learning, have strategies for diverse learners, 2) there should be opportunities for collaboration and sharing so they can learn about good teaching practices to improve their own teaching, and finally, 3) the activities in PD need to be relevant (Goodnough et al., 2014). Additionally, teachers noted that opportunities to engage in hands-on activities were important to them.

Another theme that emerged from the data was support systems as a key element to effective PD. Support needed to implement effective STEM included time, opportunities to collaborate, provision of resources, access to technology, and support and guidance from administration and researchers (Goodnough et al., 2014).

The participants also shared their views on action research. The most prevalent theme that emerged was a focus on student learning. The educators declared there is a link between improving their own practices and enhancing student learning and that teacher reflection plays a role in this (Goodnough et al., 2014).

Effective PD should not only focus on STEM concepts but also teaching and assessment methods to improve learning for all students (Goodnough et al., 2014). Effective PD should provide support for teachers such as time, opportunities to collaborate, provision of resources, access to technology, and support and guidance from administration (Goodnough et al., 2014). Professional learning communities (PLCs) are another approach for PD. These communities consist of educators coming together on a regular basis to discuss expertise and discuss ways to improve teaching skills to increase achievement of students (Hord, 2009). These learning communities are designed to foster collaboration among educators as well as to provide insight into effective instructional strategies. Professional learning communities are constructivist in nature. PLCs model a constructivist environment by creating a setting for working relationships indicative of constructivism based on the following dimensions: shared beliefs, supportive leadership, supportive structural conditions, trust, collective learning, and peer sharing (Hord, 2009). Hord (2009) suggests that, to be most effective, PLCs must consider community membership, learning time, learning space, data use support, and sharing leadership.

Environment is another key element that needs to be considered when planning and implementing a PD workshop. It is important to provide a supportive environment for educators (Avery & Reeve, 2013). Avery & Reeve (2013) believed there was a need to examine factors that can contribute to successful PD in STEM areas, especially in regard to integrating the engineering design process. The authors set out to solve this problem by conducting a qualitative case study to examine the effects of PD on infusing engineering design and problem solving into STEM curricula areas and the overall effects that STEM PD had on teaching practices. The authors gathered data from three sources including teacher interviews, teacher documents, and classroom observations. Participants were four in-service high school teachers with science backgrounds who participated in the NCETE PD (National Center for Engineering and Technology Education) workshops that were conducted in 2006 (2-3 years prior to the study). Teacher documents consisted of course outlines, lesson plans, and design briefs. Interviews were approximately one hour in length, in person, and consisted of seven open-ended questions. Classroom observations were conducted in 2009 to verify statements from the interviews.

The researchers discuss three major themes that emerged from the data: incorporation of PD content, challenges with incorporating PD content, and benefits of incorporating PD content (Avery & Reeve, 2013). Data from teachers showed that the PD provided a model for how they should incorporate STEM into their own classrooms as well as helping them connect STEM educational theories to their teaching practices. This provided their students with more enriching learning experiences. Results also pointed out several challenges among these teachers regarding STEM implementation. These challenges included the following: evaluating group projects, standards-based pressures, availability of authentic engineering design challenges, and developing STEM lessons (Avery & Reeve, 2013). Finally, themes around benefits were described. Teachers believed that the STEM PD benefitted their classroom because it: facilitated teaching, increased student motivation for STEM learning, prolonged student engagement, increased student appreciation for science and math, improved student thinking and problem-solving skills, and improved student learning (Avery & Reeve, 2013).

The authors believe the findings from their case study revealed key issues/areas that are relevant to effective STEM PD development and implementation, and concluded with six recommendations for developing effective PD. First, when conducting STEM PD, the facilitator must provide a supportive environment which may involve serving good and healthy meals, providing teacher stipends, having a willingness to listen to teacher ideas and recommendations for PD improvement, showing respect for what teachers do teach, and providing necessary support to sustain what they learned through STEM PD (Avery & Reeve, 2013). Second, it is important to provide an exemplar engineering design challenge for teachers to reference as a model (Avery & Reeve, 2013). STEM PD developers should also incorporate ways to assess group projects since peer collaboration is paralleled in real-world contexts (Avery & Reeve, 2013). Also, PD developers should consider standards-based pressures that impact STEM learning and provide suggestions to remediate this (Avery & Reeve, 2013). Additionally, when planning PD, facilitators should train teachers on how to develop their own standards-based, engineering design challenges and lesson plans (Avery & Reeve, 2013). Finally, STEM PD should train teachers how to integrate STEM concepts into their instructional materials by reviewing appropriate content standards (Avery & Reeve, 2013).

When considering online PD, teacher presence plays a large role in participant satisfaction and learning and should have instructors that are present and engaged with participants (Holmes, Signer, & MacLeod, 2010). In a study by Holmes et al. (2010), researchers examined factors that promoted interaction and satisfaction within an online PD course for K-12 educators. The authors used a within-stage mixed-method approach that consisted of 95 in-service K-12 private school teachers who were enrolled across seven online PD courses. Researchers used a Likert-scale instrument with two open-ended questions as well as a focus group. The instrument centered around themes of feedback, course resources, interactions, requirements, impact on teaching, sense of community, lack of visual images, and learner satisfaction. The open-ended questions focused on participants' teaching and suggestions to improve the online PD experience. Surveys were distributed to participants before and after taking the online course.

Results suggested that even with the same instructional model, teacher interactions, implementation, and interpretations varied among the seven courses (Holmes et al., 2010). Also, results suggested that previous online course experience played a role in overall satisfaction and preference for online PD (Holmes et al., 2010). Open-ended responses were independently coded and compared. These results suggested that the online PD provided new ideas for classroom instruction (Holmes et al., 2010). Participants stated that the course had direct applications for classroom instruction. Features that had the most impact were course resources/tools and ability to integrate these tools into teaching practice (Holmes et al., 2010). Participants also stated that the PD heightened their awareness of their own teaching style.

Other results suggested that teacher presence within the course impacted their teaching (Holmes et al., 2010). The instructor seemed to be a valuable feature in satisfaction and enhancing teaching methods among individuals. Finally, results suggested that exposing participants to new information and concepts had the greatest impact on learning among participants (Holmes et al., 2010). Although not frequently mentioned, surveys also suggested that the online PD should address faster feedback, more teacher presence (for courses that lacked it), more variety, richer discussions, and a synchronous chat option. These may be features that can be studied in future research. It is also important for facilitators to provide tools to help build relationships among educators, as well as between course facilitator and participants, and develop a climate of respect (Holmes et al., 2010; King, 2002).

Face-to-face models should use a constructivist-based approach. Desimone (2009) believes that PD is constructivist in nature, as teachers attend workshops with other teachers and engage in discourse about their practice as they consider new strategies and grow their understanding of content. Constructivist-based workshop models for PD have a positive impact on participant learning (Donahue, Schnittka, & Richards, 2010). This claim is based on a 2010 study by Susan Donahue and her colleagues. In the study, the researchers assessed whether a workshop model based on constructivist principles would provide a statistically significant increase in learning. The authors explain that the Engineering Teaching Kits (ETK) used were grounded on the principles of constructivism using strategies of guided inquiry and inductive learning. The authors describe the history and creation of the ETKs as well as the philosophy behind it. The authors explain that the ETKs center around the use of active learning strategies. Specifically, the "learners actively and inductively [build and rebuild] their understanding of reality based on their experiences" (Donahue et al., 2010, p.15).

In this workshop model, the researchers concentrated on inquiry and inductive learning strategies (project-based learning). They approached their study using a quantitative survey methodology. Pre-assessment and post-assessments that focused on self-perceived competencies of the concepts addressed in the design challenges of the ETKs were administered. However, the authors do not elaborate further on questions that were included. Participants included 71 educators, faculty members, and university students across three training sites. Each training site was doing a different challenge.

Results suggest that there was a statistically significant amount of learning. Therefore, there was a positive response to the research question and, therefore, constructivist-based workshop models do provide an environment that supports a statistically significant increase in learning (Donahue et al., 2010). The authors also state that they found three factors that had the most impact on increases in competencies and knowledge: a focus on content knowledge, active learning-based activities, and relevance to the participants' instructional responsibilities (Donahue et al., 2010). The authors conclude by affirming the positive outcome of using constructivist-based workshop models and how they will continue to do so in the future.

Research suggests that active learning is key to high quality PD. Collaboration, an element of active learning, is critical for fostering professional learning and teachers feel collaboration allows them to learn best practices from others and improve their own teaching (Goodnough et al., 2014). Facilitators play an important role in effective PD. Backgrounds of facilitators play an important role in the quality of PD, and quality will likely improve as facilitators implement more sessions and gain more experience (Banilower & Shimkus, 2004).

Modeling, another key element, is imperative in STEM PD workshops to allow educators to visualize the proper techniques to implement STEM in their afterschool programs. Specifically, facilitators should model an exemplar engineering design challenge that teachers can reference. This can be beneficial for teacher retention and motivation (Avery & Reeve, 2013). Research suggests that engineering focused PD increases teacher self-efficacy, attitudes, motivation, and science content knowledge (Schnittka et al., 2014). Desimone (2009) believes that integrated STEM requires teachers to experience the curriculum they will deliver and acquire new content and skills and, therefore, they should experience the same problems or challenges that students may face. Additionally, they should reflect on how activities may look in their own classroom or program and should practice delivery of their new instructional models, skills, and curriculum (Desimone, 2009).

Duration is also key to providing effective PD. Duration includes time span as well as contact hours of the workshop, and research suggests that teacher skills and knowledge are positively impacted by duration of higher quality PD if the PD is sustained over time and involves a significant number of hours (Garet, Porter, Desimone, Birman, & Yoon, 2001). As noted by these authors, student success is dependent on teacher qualifications and effectiveness, thus making teacher PD a major focus of education reform initiatives. According to these authors, although there is a large body of literature on PD, there is little systemic research on the effect of PD on improvements in teaching or student outcomes as well as comparing the effects of different characteristics of PD (Garet et al., 2001). Thus, the authors believe there is a definite need for systematic research on the effectiveness of alternative strategies for PD.

In this large-scale empirical comparison of effects of different characteristics of PD on teachers' learning, a national probability sample of 1,027 science and math educators was taken. The authors examined the relationship between features of PD that have been identified in the literature and self-reported change in teachers' knowledge, skills, and classroom teaching practices. The authors used data collected from a Teacher Activity Survey that was part of the Eisenhower PD Program. Teachers were surveyed about PD activities during one year. Analysis focused on two features: structural features and core features. Structural features were defined as characteristics of the structure or design of the PD activities while core features were defined as dimensions of the substance or core of the PD experiences (Garet et al., 2001). Structural features included form of the activity, duration of the activity, and the degree to which the activity emphasized collective participation (Garet et al., 2001). Core features included content focus, active learning, and coherence (Garet et al., 2001). To assess teacher outcomes, participants took a Likert-type survey that focused on teacher knowledge and skills as well as changes in classroom teaching practice.

The results indicated that activity type has an important influence on duration. For example, reform activities spanned a longer period and involved a greater number of contact hours than did traditional activities (Garet et al., 2001). Also, reform activities had more positive outcomes when all design features and quality characteristics were included (Garet et al., 2001). All three measures of core features had a positive influence on enhanced knowledge and skills. Activities that were more focused on content without increasing teachers' knowledge or skills had a negative impact on teacher practice. Lastly, results indicated that enhanced knowledge and skills had a significant positive influence on changes in teacher practice.

Different models of PD may have differing lengths of duration but Garet et al. (2001).

suggests that reform-type PDs tend to be longer in duration and, therefore, have more positive outcomes when compared to traditional PD models. Desimone (2009) believes that the most effective PD opportunities are approximately 80 hours in length and should be spread over the academic year, which could include a 5-10 day workshop over the summer and an additional workshop each month thereafter (Desimone, 2009).

Research suggests that coherence is key in planning and implementing effective PD. When developing STEM PD, goals of the workshop should be aligned with policies at the school, district, and state levels, which can be a challenge if STEM is not a priority at all of these levels (Desimone, 2009). This is also mirrored by Avery & Reeve's (2013) research that states that facilitators should incorporate ways to teach educators how to plan their own engineering design challenges and lesson plans based on standards. Facilitators should also develop workshops that are relevant in terms of activities, needs of teachers, and needs of students (Goodnough et al., 2014). Providing relevant resources that directly relate to teacher instruction is also important when developing online PD opportunities (Holmes et al., 2010).

Implementing these key elements into a PD workshop has many positive outcomes. Teachers believe effective STEM PD increases student motivation for STEM learning, prolongs student engagement, increases student appreciation for science and math, improves student thinking and problem-solving skills, and improves student learning (Avery & Reeve, 2013). Increasing teacher self-efficacy, attitudes, motivation, and science content knowledge regarding engineering has a positive impact on student engagement and motivation (Schnittka et al., 2014). Content-focused activities that do not increase teachers' knowledge and skills have a negative impact on teacher practices but enhancing teacher knowledge and skills through PD has a positive influence on teaching practice (Garet et al., 2001). Although using online PD may be new to some users, research suggests that satisfaction with online PD improves as participants have more experience with online courses. Holmes et al. (2010) aimed to examine factors that promoted interaction and satisfaction within an online PD course for K-12 educators. In a mixed-method approach, 95 in-service K-12 teachers were surveyed and interviewed before and after completing one of seven online PD courses. Researchers used a Likert-scale instrument with two open-ended questions as well as a focus group. The instrument centered around themes of feedback, course resources, interactions, requirements, impact on teaching, sense of community, lack of visual images, and learner satisfaction. The open-ended questions focused on participants' teaching and suggestions to improve the online PD experience. Results suggest online PD also has a positive impact on classroom instruction (Holmes et al., 2010). Features that had the most impact were course resources/tools and the ability to integrate these tools into teaching practice (Holmes et al., 2010). This study, however, had many limitations including topics and assignments that varied across the seven courses and the variation may have played a role in the results. Also, because there were different facilitators of each course, teacher presence varied among the seven courses.

Another option is creating hybrid courses. Although research is lacking on hybrid courses, King (2002), using a qualitative approach, aimed to capture the dynamic relationships among facilitator, learners, and the teaching and learning process. Participants consisted of preservice and in-service teachers and data sources included online discussion board postings, journal postings, and self-reflection summaries and observations. King (2002) concluded that implementing a hybrid model of face-to-face PD and online PD helps educators build learning communities as well as provide a format that is flexible, personalized, and rich in content.

Measuring STEM Motivation and Self-efficacy

Self-efficacy is believed to affect an individual's choice of activities, effort and persistence (Bandura, 1977). According to Schunk (1991), individuals who have a low sense of self-efficacy may avoid an activity and those who feel efficacious are believed to participate readily, work harder, and persist longer. In the case of educators, those who feel comfortable with STEM may have a higher sense of self-efficacy and will therefore feel motivated to implement STEM in their afterschool programs as opposed to those who doubt their capabilities. Measuring educators' sense of self-efficacy and motivation is crucial to understanding how to create and conduct effective STEM PD. Over the years, research has focused on measuring motivation and self-efficacy in educators as well as students. While tools have been developed that focus on measuring motivation and self-efficacy regarding science and engineering, an online search using key terms: *self-efficacy, self-efficacy scales, motivation measures of self-efficacy and/or motivation in science, technology, engineering, and mathematics*, revealed there has been a lack of research on tool development in regard to measuring STEM motivation and self-efficacy in educators.

One tool that was developed, named the Self-Efficacy for Technology and Science (SETS), is a context-specific measure of self-efficacy in science developed by Diane Ketelhut (2010). In this study, Ketelhut (2010) piloted the original SETS instrument in two middle schools with a sample of 98 students. In a second phase of the study, a modified subscale with 71 questions was implemented in middle schools located in four larger districts across the United States and included a sample of over 2000 students. The initial SETS instrument had four sub-contexts: *Computer Use, Videogaming, Synchronous Chat Use, and Inquiry Science*. The initial instrument was analyzed for content validity by a panel of experts in gaming, curriculum design, and scientific inquiry, and a modified version of the instrument was created based on feedback. The survey was then administered to students online and the instrument was analyzed for reliability. For all subscales, reliability estimates ranged between .79 and .94 suggesting the subscales are reliable (Ketelhut, 2010). Another study building on Ketelhut's SETS survey proposed a shortened version to prevent survey fatigue and to help identify students in need of intervention. This survey was named the Self-Efficacy in Technology and Science Short Form survey (SETS-SF) (Lamb, Vallett, & Annetta, 2014). The SETS-SF is a 16-item survey that measures three component subscales (science reasoning, computer use, and video gaming) using a 5-point Likert scale (Lamb et al., 2014). Although two major topics, science and technology, were the focus of these surveys, they were aimed at measuring student self-efficacy rather than the educator's.

Another tool, the STEBI (Science Teaching Efficacy Belief Instrument), was developed by combining two previous scales- the Personal Science Teaching Efficacy Belief scale and the Science Teaching Outcome Expectancy scale (Riggs & Enochs, 1990). This tool was designed and modified based on the previously mentioned instruments to include an elementary science classroom setting and items reflected both self-efficacy and outcome expectancy. This survey initially consisted of fifty Likert-type items that was administered in a pilot study consisting of 71 elementary teachers. Results from this study allowed for tool refinement which resulted in a final survey that consisted of 25 Likert-type items that was administered to a larger sample size of 331 teachers. Through testing, STEBI was determined to be a valid and reliable tool for studying elementary teachers' beliefs toward science teaching and learning. However, again, this tool focuses on the science content area as a whole rather than the four integrated disciplines of STEM.

Another study attempted to measure the teaching self-efficacy of STEM GTAs (Graduate Teaching Assistants) at Oregon State University. The tool was adapted from a previous teaching self-efficacy instrument used specifically for counseling psychology educators named College Teaching Self-Efficacy Survey (CTSES) (DeChenne & Enochs, 2010). The original CTSES contained 44 items but was modified by researchers to remove questions regarding course design and planning. The final version contained 28 items measured on a five-point scale (DeChenne & Enochs, 2010). Although the proposed tool was geared toward STEM GTA self-efficacy, items did not focus on STEM concepts specifically and rather, focused on teaching practices.

The Teaching Engineering Self-efficacy Scale (TESS) was developed with the intent of adequately addressing the needs of teachers as well as evaluate the success of K-12 engineering PD (Yoon Yoon, Evans, & Strobel, 2014). One hundred and twenty-eight items were among the following five factors: engineering content knowledge self-efficacy, instructional self-efficacy, engagement self-efficacy, disciplinary self-efficacy, and outcome expectancy (Yoon Yoon et al., 2014). Through rigorous testing, the tool was found to be both valid and reliable (Cronbach's alpha=.98, n=153) (Yoon Yoon et al., 2014). Further validation of the tool resulted in 128 items being refined and reduced to 23 items across four factors (engineering pedagogical content knowledge, engineering engagement, engineering disciplinary self-efficacy, and outcome expectancy) (Yoon Yoon et al., 2014). The TESS has been used in multiple studies including a recent study aimed at understanding the influence of an engineering focused methods course in a science education program. Using the TESS, researchers were able to report on the positive outcomes of improving teacher self-efficacy for teaching engineering (Smetana, 2017). However, the tool only focuses on engineering and not STEM as a whole.

Multiple searches through the literature revealed one survey instrument aimed at measuring self-efficacy of teachers regarding STEM as a whole. The Friday Institute for Educational Innovation (2012) developed the Teacher Efficacy and Attitudes toward STEM (T-STEM) survey that aims to measure five constructs including personal teaching efficacy and beliefs, teaching outcome expectancy beliefs, student technology use, STEM instruction, 21st century learning attitudes, teacher leadership attitudes, and STEM career awareness. Questions measuring two of the constructs (Personal Teaching Efficacy and Beliefs, Teaching Outcome Expectancy Beliefs) were derived from STEBI while other questions were derived from the Student Technology Needs Assessment (STNA) and Friday Institute's Student Learning Conditions Survey (Friday Institute for Educational Innovation, 2012). This tool was initially developed and distributed to educators in the state of North Carolina. The tool was modified through pilot testing and found to be statistically reliable and valid after being administered to over 100 science, 100 math, 200 elementary, and 60 technology or engineering teachers (Friday Institute for Educational Innovation, 2012). Specifically, for all constructs, Cronbach's alpha was above 0.80 when the test was taken by those teaching science and math, whether at the secondary or elementary level (Friday Institute for Educational Innovation, 2012). The three constructs: 21st C, Teacher leader, and STEM career, were highly reliable for technology and engineering teachers with a Cronbach's alpha above 0.87 when they were the only portion of the test given (Friday Institute for Educational Innovation, 2012). Although this valid and reliable tool focuses on STEM self-efficacy, literature regarding the tool and its questions is lacking.

Measuring educators' sense of self-efficacy and motivation is crucial to understanding how to create and conduct effective PD. Although research regarding STEM, motivation, and self-efficacy is abundant, research regarding valid and reliable tools to measure educators' self-efficacy and motivation regarding STEM is lacking. Several tools such as the SETS and SETS-SF were developed but focus on student self-efficacy rather than the educator's. The STEBI measures teacher beliefs but focuses on the science content as a whole rather than on STEM. Another tool, the CTSES, focuses on STEM self-efficacy in teaching assistants but questions are geared towards teaching practices rather than STEM concepts. In an attempt to get a step closer, the TESS was developed to measure self-efficacy of educators, but this tool only focused on the Engineering content area of STEM and not STEM as a whole. Finally, one tool found to be valid and reliable to measure teacher self-efficacy regarding STEM is the T-STEM survey but there is little information published regarding its questions and data.

Searching for valid and reliable instruments to measure STEM self-efficacy and motivation has suggested a lack of research regarding the topic. This study will build upon previous literature and instruments to create and test a valid and reliable instrument to measure STEM self-efficacy and motivation of educators.

Motivation Phenomenology Studies

Qualitative research is a method of inquiry aimed at gaining a deeper understanding of the perspectives of individuals or events and is used to describe or explain the social world around us (Creswell & Poth, 2017; Morse & Field, 1996). In qualitative studies, researchers can address their research questions through five approaches: narrative research, phenomenology, grounded theory, ethnography, and case study. With a variety of approaches to choose from, how do researchers decide their approach? Deciding the appropriate approach to address the questions of the study depends on the researcher's aim, focus, and purpose of the study. For the proposed study, a phenomenological approach will be used.

In a phenomenology, the aim is to understand the essence of an experience which is best used to describe a phenomenon such as teacher motivation and self-efficacy (Creswell, 2013). In these types of studies, data can be collected from a range of five to twenty-five individuals who have experienced the phenomenon. Data in this type of approach are primarily in the form of interviews, but can also include documents or observations (Creswell, 2013). Finally, in phenomenological studies, the researcher analyzes data for meaningful statements, textual and structural description, and description of the "essence" (Creswell, 2013).

Although there is extensive literature regarding teacher motivation, there is limited research using the phenomenological approach to address this topic. A study by Pihie and Elias (2004) aimed to understand the self-motivation of preservice teachers and what drove them to entering the teaching profession. The study consisted of 221 preservice teachers in primary schools located in Malaysia. A questionnaire was given to pre-service teachers enrolled in an "Educational Management" course. The survey asked participants to write reasons why they enjoyed teaching and why they did not enjoy teaching. They were also asked to give suggestions on how their motivation could be improved. Data were analyzed inductively to study the phenomenon of motivation and look for emergent themes. Results indicated six themes from pre-service teacher responses on what motivated them to like teaching: 1) fulfill self-interest and satisfaction, 2) contribute to students' advancement, 3) noble profession, 4) self-improvement/challenging career, 5) security, and 6) ambition. There were also five additional emergent themes on why participants did not like teaching which could affect their motivation: 1) teaching load, 2) low salary/lack of promotion opportunities, 3) students' discipline problems, 4) unsatisfactory leader behavior, and 5) pressure from various quarters.

The authors conclude that their study paralleled a previous study on motivation which identified several factors to improve teacher motivation such as freedom to try new ideas and being able to contribute to achievement of students. Motivation of teachers is important because teacher motivation is related to student achievement (Bishay, 1996).

A study by Gozzoli, Frascaroli, and D'Angelo (2015) aimed to investigate the phenomenon of professional malaise in teachers by examining how different resources and efforts influence their wellbeing or malaise. Specifically, at the individual level, the researchers explored teachers' professional history and motivations. Previous research focused on teacher burnout using a quantitative approach. Therefore, to address their aims, the researchers conducted a phenomenological approach by leading semi-structured interviews as well as using the *Professional Life-Space Drawing* test to explore teachers' lived experiences and gain further understanding of teachers' motivation (Mowstin, 1980; Gozzoli & Tamanza, 2008).

Participants included a purposeful sampling of 50 Italian high school teachers. Semi-structured interviews centered around topics of motivation, professional role, and professional relationships. Interviews were transcribed and analyzed. The *Professional Life-Space Drawing* test is a tool modified from the *Family Life Space* tool. Two versions were given to participants: actual professional life-space and future professional life-space. Drawings were analyzed at the "descriptive-phenomenological level," (Gozzoli et al., 2015, p. 2243).

Results suggested that there were three types of past and current motivations at work: crystalized motivation, mortified motivation, and renewed motivation. According to the authors, crystalized, or idealized, motivation supports the teacher but is detached from professional life. Mortified, or absent, motivation was defined as motivation being low or absent early in the teachers' career. Finally, renewed motivation was described as being able to sustain motivation over time because the teacher renewed meaning to her/his work, especially regarding relationships with students.

The authors conclude by discussing scenarios in which each of these three types of motivation were evaluated that contributed to teachers' wellbeing or malaise. By understanding these motivational scenarios, the researchers conclude that their study provides insight into interventions to support professionals such as "training courses or career counselling programs for groups of teachers in specific contexts" (Gozzoli et al., 2015, p. 2244).

One last study by Shishigu (2015) aimed to identify which factors discourage, or demotivate, teachers to stay at their jobs. To address the research questions, the researcher conducted a phenomenological study to gain a rich description of teachers' motivation and professionalism. The author states that the goal of the study was to "understand the culture, setting, or social phenomenon of teachers" (p. 141). The researcher used non-participant observation as well as semi-structured interviews that center around topics such as factors affecting teacher motivation and unaddressed issues teachers face.

Participants were selected via convenience sampling. Data collection consisted of 15 teacher interviews as well as 32 teachers completing a questionnaire. The questionnaire contained both open-ended and closed-ended questions. Although the author describes this study as a phenomenology, the data collection process employed is geared towards a mixed methods study. Interview data were recorded and transcribed as well as member-checked. Transcriptions were then coded to look for emergent themes. Closed-ended questions were analyzed and reported by tables and percentages.

Results generated four themes regarding motivation and professionalism as teachers: salary/benefits, administration, discipline, and societal views of teaching. Teachers reported that the biggest discouragement they face that hinders motivation is the inadequate salary they receive. They also report that inadequate communication between administration and teaching staff hinders their motivation to continue to work. Thirdly, teachers reported that dealing with students' misbehavior affects student achievement as well as their motivation to continue. Lastly, lack of respect for their profession by society lessens their motivation.

The author concludes by stating that the participants were de-motivated due to extrinsic factors but were generally satisfied with the responsibilities of teaching. By understanding these extrinsic factors, policy makers and practitioners will be able to target areas to motivate new teachers as well as retain veteran teachers.

The previous three studies all aimed to gain a deeper understanding of teacher motivation using a phenomenological approach. In the study by Pihie and Elias (2004), the researchers aimed to understand what motivated educators to enter the teaching profession. They identified several factors that improved teacher motivation including the freedom to try new ideas and being able to contribute to the achievement of students. In the study by Gozzolie et al. (2015), the researchers aimed to understand professional malaise and motivation in teachers. Three themes emerged to describe scenarios that contributed to teachers' wellbeing: crystalized, mortified, and renewed motivation. This study provides insight into factors that keep teachers motivated. Finally, the study conducted by Shishigu (2015) aimed to identify factors that discourage teachers to stay at their job. Four themes emerged in this study including salary/benefits, administration, discipline, and societal views. In general, the authors of these studies conclude that factors discouraging educators are mostly extrinsic. Although these three studies aimed at understanding teacher motivation using a phenomenological approach, they all differ in the methods used to accomplish their goals. These studies used a variety of methods to collect data such as conducting interviews, using questionnaires and surveys with both open and closed-ended questions, and one study employed a drawing test to further understand teacher motivation.

Due to the lack of research aimed at studying motivation using a phenomenological approach, this study will add to the body of existing research and possibly provide new insight into teacher motivation and self-efficacy. The phenomenological approach to this study could be beneficial to practitioners, researchers, and stakeholders by providing in-depth knowledge about the shared experiences of educators in regard to STEM implementation.

Summary of the Literature

The following section includes a summary of the studies that addressed STEM programs in afterschool settings, best practices for PD, tools to measure STEM self-efficacy of educators, and phenomenological studies aimed at understanding teacher motivation.

Summary of STEM Afterschool Programs

Multiple studies have aimed at painting a holistic picture of learning that takes place in the out-of-school space. Previous research has focused on the impact of programs, the lack of support, and different models of afterschool programs. Chi et al. (2008) concluded that there is an increase in the demand for more programs, however, there is a lack of support and limited funding to do so. This study also concluded there is increased interest to include more quality science in the out-of-school time, but this is hindered by limited financial support and quality training of afterschool program staff.

Multiple studies focus on the role that afterschool plays in students' lives, especially those student groups that are considered underrepresented in STEM fields. STEM focused camps as well as exposure to STEM professionals have a positive impact on girls' perceptions related to engineering and increasing their attitudes towards STEM fields (Gibson & Chase, 2002; Koch et al., 2010; Everage et al., 2014). Although afterschool programs can positively impact attitudes and sustain interest in science, one study found that approaching science from a traditional method can have a negative impact on student achievement (Gibson & Chase, 2002). This is why the afterschool space has the potential to be so important. Because STEM in out-of-school is not grade oriented, students experienced increased enjoyment and more motivation to accomplish STEM related goals, according to Sahin et al. (2014). Additionally, the more students were exposed to science and STEM related activities, the higher the matriculation rate into STEM majors (Sahin, 2013; Sahin et al., 2014).

Other studies focus on different models of afterschool programs to illustrate what STEM should look like in the out-of-school space. One study suggests a framework, called the Dimensions of Success, that focuses on 12 indicators that impact the student's STEM learning experience (Papazian et al., 2013). These indicators span four categories that center around the student's environment, their engagement, STEM practices they experience, and youth development (Papazian et al., 2013; Shah et al., 2018). Everage et al. (2014) and Koch et al. (2010) both suggest creating opportunities to expose students, especially those underrepresented, to STEM professionals to change perceptions and foster STEM identities. Additionally, a studio STEM model creates an environment that empowers students and creates an atmosphere for free choice and self-directed learning (Schnittka et al., 2012). Although students feel empowered and motivated because the out-of-school time is not grade oriented, it is important to assess if learning is taking place. Several ways to capture conceptualization of STEM knowledge are by storyboards, videotapes, social media posts, interviews, and pre- and posttests (Schnittka et al., 2015).

Though previous research has focused on support, impact, and models for afterschool programs, there continues to be a lack of research on increasing self-efficacy and motivating staff to implement STEM in afterschool programs.

Summary of Best Practices in Professional Development

Effective professional PD development is a crucial step in helping to support afterschool staff implement STEM into their programs. There are three platforms to provide PD to educators: face-to-face, online, or hybrid. Regardless of the platform implemented, several factors need to be considered when creating a quality PD opportunity. Research suggests that facilitators should consider the approach, the environment, modeling, duration, and coherence (Garet et al., 2001; Banilower & Shimkus, 2004; Desimone, 2009; Avery & Reeve, 2013; Goodnough et al., 2014).

The approach the facilitator uses will depend upon the purpose of the PD. Banilower & Shimkus (2004) suggests that approaching a PD opportunity through study groups, mentoring/coaching, or workshops will depend on whether the goal is to promote effective instruction or to focus on leadership strategies. For the purpose of promoting effective instruction regarding STEM implementation, a workshop is the best approach. The workshop should focus on STEM concepts, teaching methods, and assessment methods (Goodnough et al., 2014). Goodnough et al. (2014) also suggests providing support such as time, opportunities to collaborate, and administrative guidance, to teachers to make PD most effective.

Research also suggests creating a supportive environment is key to quality and effective PD. Facilitators should be present and engaged with participants and provide tools to foster positive relationships (Holmes et al., 2010; Avery & Reeve, 2013). Research also suggests that workshops that are constructivist-based are most effective (Holmes et al., 2010; King, 2012).

Modeling proper techniques in constructivist-based workshops is imperative to creating quality STEM PD. Modeling engineering-focused activities, for example, increases teacher self-efficacy, motivation, attitudes, and science content knowledge (Schnittka et al., 2014). Desimone (2009) also states that modeling is important because teachers need to practice delivery of the curriculum, experience the same challenges students may face, and reflect how these activities may look in their own classroom or afterschool programs.

Facilitators should also consider duration when creating effective PD opportunities. Research states that both timespan and contact hours should be considered (Garet et al., 2001). Garet et al. (2001) states that PD has a higher impact when sustained over time and involves a significant number of hours. Desimone (2009) mirrors this statement and states that the most effective PD opportunities average approximately 80 hours over an academic year.

Finally, research suggests that coherence is important to quality professional development. STEM workshops should be aligned with the goals and policies at the school, district, and state levels (Desimone, 2009). Facilitators should also help teachers plan their own STEM challenges and provide relevant resources that directly relate to teacher instruction (Holmes et al., 2010; Avery & Reeves, 2013).

Effectiveness of PD opportunities is maximized when considering approach, environment, modeling, duration and coherence. Effective PD increases teacher self-efficacy, motivation, attitudes, and science content knowledge which has a positive impact on student engagement and motivation (Garet et al., 2001; Schnittka et al., 2014).

Summary of Tools to Measure STEM Self-Efficacy and Motivation

Measuring educators’ sense of self-efficacy and motivation is crucial to creating and conducting effective PD opportunities. However, there is a lack of research regarding a valid and reliable tool to measure these constructs specifically in regard to STEM implementation. Several tools have been developed to measure self-efficacy and motivation of teachers regarding science and engineering but not STEM as a whole. SETS and SETS-SF measure student self-efficacy, but not that of educators. STEBI measures educator efficacy in the science content area but not STEM. CTSES measures STEM self-efficacy but focuses on teaching practices rather than STEM concepts. The TESS measures self-efficacy of educators but focuses only on engineering. Finally, one tool, T-STEM, measures self-efficacy of educators regarding STEM but little has been published about the survey or its data. Based on previous research, there is a clear need for valid and reliable tools to measure teacher self-efficacy and motivation regarding STEM implementation.

Summary of Motivation Phenomenological Studies

Quantitative research measuring teacher motivation is abundant, but there is a lack of phenomenological studies to gain a deeper understanding behind what motivates teachers to implement integrated STEM. A phenomenology attempts to gain a deeper understanding of the essence of a shared experience, such as teacher motivation and self-efficacy. An initial search showed that phenomenological studies focused on teacher motivation were lacking. Three previous studies, by Pihie & Elias (2004), Gozzoli et al. (2015), and Bishay (1996), all used a phenomenological approach to understand teacher motivation. However, they all employed different data collection methods to accomplish their research goals. The variety of methods to collect data consisted of interviews, questionnaires, surveys, and a drawing test. All three studies looked for emerging themes to understand motivation of educators. This study will draw from previous phenomenologies to understand the shared experiences of afterschool program staff and what motivates them to implement integrated STEM.

Conclusion

This chapter began with a review of literature related to afterschool programs including a need for more support, both training and financial. It followed with a review of literature of current tools to measure motivation and a discussion of the need for reliable and valid tools to measure teacher motivation regarding STEM. It concluded with a discussion of current phenomenological studies focused on motivation and the need for more qualitative studies to understand what motivates teachers to implement STEM.

Supporting educators to implement STEM correctly and confidently is imperative in engaging students in integrated STEM. This study aims to investigate motivation and self-efficacy of afterschool staff to inform future PD design and implementation. This study also aims to create a valid and reliable tool that measures teacher motivation and self-efficacy specifically regarding integrated STEM implementation. With the out-of-school space being an ideal environment to implement integrated STEM, this research has the potential to inform practitioners, stakeholders, researchers, and policymakers on how to effectively support afterschool programs and their staff. The details of this study, as well as the theoretical framework on which this study is based, will be discussed in the methodology in Chapter 3.

CHAPTER 3: METHODOLOGY

Purpose

STEM is an acronym that has become a buzzword among policy makers, stakeholders, and educators. However, there is no consensus on how STEM should be defined (Breiner et al., 2012). One definition highlights the integration of the four disciplines that make up STEM. Integrated STEM is defined as "an effort to combine some or all of the four disciplines of science, technology, engineering, and mathematics into one class, unit, or lesson that is based on the connections between the subjects and real-world problems" (Moore, Stohlmann, Wang, Tank, Glancy, & Roehrig, 2014, p.38). Integrated STEM is one of many definitions of what "STEM education" is as a construct. This lack of consensus about definitions has left some educators confused and uncertain when implementing truly integrated STEM, potentially leaving students negatively impacted by not presenting the best of what STEM education has to offer. The afterschool setting is a perfect time and place to help students explore topics embedded in engaging and compelling engineering contexts because it gives students the ability to fail without repercussions. Allowing students to engage in the engineering design process (EDP) is a key component of truly integrated STEM and is important for bringing the four disciplines to an equal platform as well as for building connections between the four STEM disciplines (Kelley & Knowles, 2016). However, according to a recent survey, 66% of afterschool educators across Alabama who were polled said they did not know what the engineering design process was or how to use it (TPI, 2016). Afterschool directors and staff are in search of opportunities to link the regular school day curriculum to the activities conducted during afterschool time.

Afterschool instructors need PD that will aid in the implementation of truly integrated STEM and the understanding of the engineering design process. But, can PD improve afterschool teachers' knowledge about integrated STEM and the EDP, and can it improve their motivation to teach integrated STEM and their self-efficacy to do so?

Teachers' self-efficacy can be defined as their "judgements of their capabilities to organize and execute courses of action required to attain designated types of performances," and can be impacted by their content knowledge and pedagogical knowledge (Bandura, 1986, p.391; Stohlmann, Moore, & Roehrig, 2012). Motivation, being moved to act toward an end goal, can vary in the *level* of motivation as well as the *orientation* of that motivation (Ryan & Deci, 2000). According to Ryan and Deci (2000), *level* of motivation describes how much motivation one has while *orientation* of motivation describes the type of motivation (extrinsic vs intrinsic). However, the question remains as to whether STEM PD can influence teachers' self-efficacy and motivation in implementing STEM in their afterschool programs. This question leads to the impetus for this research, which is to design an instrument to determine whether specific PD programs directed towards afterschool teachers actually influence their self-efficacy and motivation to bring STEM into their afterschool classroom.

The purpose of this study was to build a validity argument for a proposed instrument to measure how a STEM PD workshop improves teachers' self-efficacy and motivation to implement STEM in their afterschool programs. To examine self-efficacy and motivation of STEM implementation meaningfully, it must be explicitly conceptualized and then translated into an instrument that appropriately operationalizes and measures this conceptualization.

Research Question

Specifically, the research question guiding this study is:

1) What evidence of reliability and validity supports the proposed *STEM Attitudes of Educators* instrument in evaluating educator motivation and self-efficacy regarding STEM implementation?

To address the research question, validity and reliability must be defined. Validity of an instrument refers to the "strength of evidence that the scale score accurately represents the level an individual possesses of the construct of interest" (Carney, Brendefur, Hughes, & Thiede, 2015). Reliability of an instrument refers to "the degree to which scores obtained with an instrument are consistent measures of whatever the instrument measures" (Fraenkel, Wallen, & Hyun, 2011)

Some afterschool teachers and staff do not have STEM backgrounds and, therefore, do not feel confident or motivated to implement integrated STEM activities into their program (Stohlmann et al., 2012). Quality PD opportunities give teachers the potential to become familiar with the dimensions of quality STEM education, become confident, and become motivated to implement activities into their own program. However, there is a need to quantify this potential.

Method

A quantitative study was conducted to address this research question. Permission was granted form the Office of Research Integrity at Auburn University to conduct this study. See Appendix I. In this study, data were collected over multiple phases which will be described in greater detail in the following sections.

The Pilot Study

The purpose of the pilot study.

The purpose of the pilot study was to understand how a STEM PD workshop improved teachers' self-efficacy and motivation to implement STEM in their afterschool programs as well as develop an instrument that measured STEM motivation and self-efficacy. The pilot study was conducted at Auburn University, a large (30,000 student) southern university located in Auburn, Alabama. Participants consisted of 38 afterschool educators from schools across Alabama. Participants were recruited based on their affiliation with 21st Century Community Learning Centers. The first PD workshop consisted of 38 participants-educators across the state of Alabama. The 38 participants were 97% female and 3% male. Participants identified themselves in many potentially overlapping roles including 53% as in-school time teachers, 45% as afterschool program coordinators, 58% as afterschool program staff, and 5% identified as "Other."

Pilot Study Research Questions.

The research questions guiding the pilot study were:

1) Does a STEM professional development workshop improve teachers' self-efficacy and motivation?
    a. How do teachers rate their motivation to implement STEM before and after a STEM workshop?
    b. How do teachers rate their self-efficacy regarding STEM implementation before and after a STEM workshop?

Methods of the pilot study.

Treatment.

The treatment in the pilot study was a STEM-focused PD workshop hosted for eight hours over the course of one day. This workshop focused on two major topics: Dimensions of Success and an engineering design-based curriculum kit about bridges designed by the Boston Museum of Science (Papazian, Noam, Shah, & Rufo-McCormic, 2013).

Dimensions of Success (DoS) is an observation instrument used by afterschool programs to assess the quality of STEM implemented during out-of-school time. This tool consists of 12 indicators of a quality STEM activity. Together, these indicators measure how often quality STEM is being implemented in the afterschool program. A higher rating on each of the dimensions indicates that students are receiving greater benefit of quality STEM education in their out-of-school space. In the treatment, the facilitator discussed the 12 indicators in depth and provided examples for each. The facilitator discussed examples of low ratings versus high ratings for each of the 12 dimensions. By understanding the 12 dimensions, afterschool staff are better able to design and implement quality STEM activities to maximize student learning in the out-of-school space. Participants who attended this workshop learned about these 12 dimensions.

The second focus of the STEM PD workshop was the modeling of an engineering design-based curriculum kit developed by Boston Museum of Science's Engineering is Elementary (EIE) group called *To Get to the Other Side: Designing Bridges*, in which participants were challenged to design and construct a bridge that will withstand different forces. Participants learned about the connection between science topics such as force, balance, and stability, and the real-world application to the field of civil engineering. The facilitator modeled best practices as indicated by the Dimensions of Success tool while teaching the five lessons in the curriculum kit. After each lesson, participants had a chance to discuss and plan how they will incorporate the lesson into their afterschool program.

Instruments.

Dimensions of Success observation tool.

The Dimensions of Success (DoS) observation tool is used to pinpoint strengths and weaknesses in informal science learning in the afterschool space to gauge quality STEM implementation (Papazian et al., 2013). This instrument consists of 12 indicators, or dimensions, in four domains which are rated on a scale from one to four. The four domains are features of the learning environment, activity engagement, STEM knowledge and practice, and youth development in STEM (Papazian et al., 2013). See Figure 2 for an illustration of the four domains. To establish evidence for inter-rater reliability, researchers examined the quality of the scores given by calculating percent exact agreement, percent exact or adjacent agreement, the quadratic weighted Kappa, and the correlation of each dimension across observations. *Percent Exact Agreement* is defined as the degree to which both observers rate the exact score on a particular dimension during the same observation period. *Percent Exact or Adjacent Agreement* is defined as two observers rating the same score or a score differing by one point on the same dimension. The quadratic weighted for Kappa is a measure of inter-observer agreement that takes into account agreement happening by chance. Finally, correlations between the pairs of scores were calculated. Additionally, researchers conducted an Exploratory Factor Analysis (EFA). Results indicated that dimensions loaded into two groups. Study 1 results based on Kappa value interpretations suggest that four dimensions showed moderate agreement (Kappa value of .41 to .60), six showed fair agreement (Kappa value of .21 to .40), and two showed slight agreement (Kappa value of 0 and .20). *Percent Exact Agreement* ranged from 40.2 to 50.4% across the dimensions while *Percent Exact or Adjacent Agreement* ranged from 83.8 to 92.3% across the dimensions.

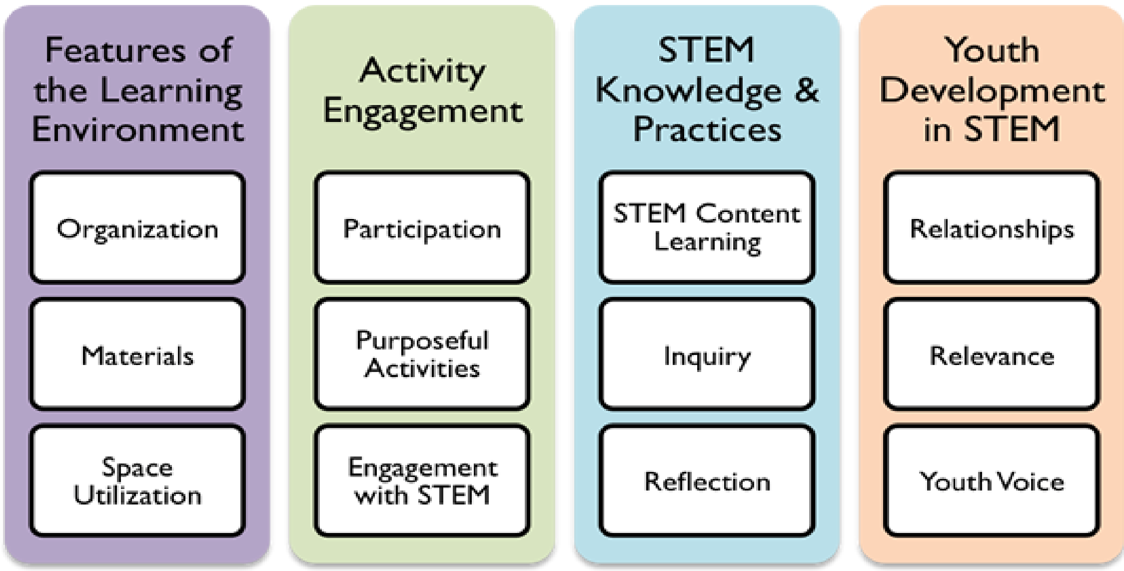


Figure 2. Domains of Dimensions of Success. Adapted from Dimensions of Success: An Observation Tool for STEM Programming for Out-of-School Time" by The PEAR Institute, 2016, p.3. Copyright 2016 by The PEAR Institute. Reprinted with permission.

Features of the Learning Environment, the first domain of DoS, consists of the following three dimensions: organization, materials, and space utilization. This domain focuses on planning. The first dimension, organization, emphasizes the importance of preparing materials in advance so time is not lost. Organization also focuses on planning enough time for the activity or planning a backup plan in case an unexpected situation arises. The second dimension, materials, focuses on two key elements: appropriateness and appeal. Are the materials appropriate for the age group? Are materials appealing to the age group? Finally, the third dimension under this domain is space utilization. This dimension emphasizes the importance of creating an informal learning environment appropriate for the activity as well creating an environment free of distractions. Scoring high in these three dimensions indicates the facilitator has effectively planned a quality STEM activity.

The *Activity Engagement* domain consists of the following three dimensions: participation, purposeful activities, and engagement with STEM. This domain centers around the execution of the lesson plan. The first dimension of this domain, participation, centers on whether all students have access to the materials. If students are placed in groups, for example, all students in the group must have equal access to all materials and be actively participating. The evaluator also assesses if the facilitator prompts disengaged students to participate. The second dimension of this domain is purposeful activities. This dimension is based on aligning the activities with the STEM learning goals. Does each activity intentionally lead to the learning goal at hand, or do students spend time doing extraneous work such as coloring worksheets? The last dimension in this domain is engagement with STEM. This dimension emphasizes the importance on implementing activities that are both hands on and minds on. The evaluator must use student quotes as evidence that learning is taking place. Scoring high in these dimensions indicates that the facilitator has executed a quality STEM lesson.

The *STEM Knowledge and Practice* domain consists of the following three dimensions: STEM content learning, inquiry, and reflection. This domain focuses on the approach to STEM. The dimension STEM content learning emphasizes the importance of integration among the STEM disciplines in the activity. The evaluator assesses if misconceptions are being corrected or perpetuated. Lastly, for true STEM content learning, students should show evidence of learning as opposed to rote memorization. The next dimension in this domain focuses on inquiry. Inquiry emphasizes the importance of providing opportunities for students to engage in STEM practices such as asking questions, making observations, analyzing data, etc. In the inquiry dimension, students should be engaged in an authentic approach to STEM and mimicking STEM professionals as opposed to following cookbook style directions. The last dimension emphasizes the importance of providing time for student reflection throughout the activity. Deep reflection supports student learning and helps students demonstrate sense making. Scoring high in each of the dimensions in this domain indicates the facilitator has demonstrated a quality approach to STEM.

The *Youth development in STEM* domain consists of the following three dimensions: relationships, relevance, and youth voice. This domain focuses on STEM impact on students and the community. The first dimension, relationships, emphasizes the importance of fostering a positive learning environment and creating positive relationships between students and facilitators. The second dimension of this domain, relevance, focuses on making connections between the STEM activity and the real world. Not only should facilitators illustrate connections to the real world but students should be able to make the connections themselves. The last dimension focuses on youth voice. Students should take ownership of their activity and disseminate what they have learned to their community. Scoring high in this domain indicates that youth have been impacted by the STEM activity.

When scoring the dimensions on this observation tool, the evaluator can rate each dimension on a scale of one to four. One, the lowest category, suggests that evidence is absent that the teacher met the indicators in the dimension. A two would suggest inconsistent evidence. Scoring a three on a dimension would indicate reasonable evidence and a four would suggest compelling evidence that the teacher met the criteria of the dimension. Together, when implemented, these indicators maximize learning opportunities for youth and enhance the students' STEM experience. See Figure 3 for an example of the DoS rubric.

Level 1 Evidence absent	Level 2 Inconsistent evidence	Level 3 Reasonable evidence	Level 4 Compelling evidence
There is minimal evidence that the youth are engaged in hands-on activities in which they can explore STEM content.	There is weak evidence that the youth are engaged in hands-on activities in which they can explore STEM content.	There is clear evidence that the youth are engaged in hands-on activities in which they can explore STEM content.	There is consistent and meaningful evidence that youth are engaged in hands-on activities in which they can explore STEM content.
The activities mostly leave youth in a passive role, where they are observing a demonstration or listening to the facilitator talk (minimal hands-on opportunities).	Youth engage in hands-on activities; however, there is limited evidence that the hands-on activities encourage youth to engage with STEM content in meaningful ways ("hands-on, minds-off").	There are some opportunities for youth to engage in hands-on activities that allow them to actively explore STEM content. Some parts of the activities still leave youth as passive observers while the facilitator does all the cognitive work. OR Activities are hands-on and minds-on (at level 4) for less than half of the youth.	There are consistent opportunities for youth to actively explore STEM content by engaging in hands-on activities, where youth do the cognitive work themselves and the facilitator maintains the role of facilitator versus teller.

Figure 3. Rubric for determining level of STEM engagement taking place during an activity. Adapted from "Improving STEM program quality in out-of-school-time: Tool development and validation" by Shah, A., Wylie, C., Gitomer, D., & Noam, G., 2018, p.6. Copyright 2018 by Wiley Periodicals. Reprinted with permission.

STEM Attitudes of Educators instrument.

The STEM Attitudes of Educators instrument, which was developed for this study, is used to gauge teachers' conceptions about self-efficacy and motivation regarding STEM implementation. The instrument contains five demographic questions centered on gender, ethnicity, education, job title, and program location. The inventory contains 27 total questions which fall under two constructs: self-efficacy and motivation. Ten four-point Likert scale items ranging from "Not Confident at all" to "Very Confident" assess how teachers perceive their self-efficacy about implementing STEM-focused activities in their afterschool program. Seventeen four-point Likert scale items ranging from "Strongly Disagree" to "Strongly Agree" assess educators' motivation to implement STEM activities in their afterschool program. The scores from each of the 10 items on self-efficacy are summed to compute a composite score of self-efficacy, and the scores from each of the 17 items on motivation are summed to compute a composite score of motivation. A minimum score of 10 on the survey instrument measuring self-efficacy would indicate a teacher's lack of confidence in their ability to implement STEM in their afterschool program whereas a maximum score of 40 would indicate a high level of confidence in their ability. In addition, a minimum score of 17 on the survey instrument measuring motivation would indicate a lack of motivation to implement STEM whereas a maximum score of 68 would indicate an educator who is highly motivated to implement STEM. See Figure 4 for examples of self-efficacy statements. See Figure 5 for examples of motivation statements. See Appendix A for a complete list of survey items for the first draft of the STEM Attitudes of Educators instrument.

Question	Not Confident at all	Somewhat Confident	Confident	Very Confident
1. Implementing STEM activities that challenge students	1	2	3	4
2. Creating opportunities for students to engage in STEM practices (e.g. making observations, collecting data, sharing findings with peers, using engineering design process, asking questions, planning/carrying out investigations)	1	2	3	4
3. Guiding students' reflections about STEM activities	1	2	3	4

Figure 4. Statements gauging teachers' self-efficacy.

Question	Strongly Disagree	Disagree	Agree	Strongly Agree
1. I have the resources I need to implement STEM activities.	1	2	3	4
2. I give my students opportunities to engage in STEM activities.	1	2	3	4
3. I have staff to help me implement STEM activities	1	2	3	4

Figure 5. Statements gauging teachers' motivation.

With a sample of 38 teachers taking the survey, the measure of internal consistency, Cronbach's alpha, for the 10 self-efficacy items was .85 and for the 17 motivation items was .81. These are acceptable values for educational surveys (Tavakol & Dennick, 2011).

Data analysis consisted of conducting a paired-samples *t*-test ($p < 0.05$) on the means of participants' pre- and post-surveys in order to evaluate validity.

Results of the pilot study.

Did the PD workshop increase the educators' self-efficacy and motivation to implement STEM? A paired-samples *t*-test was conducted to compare teacher motivation and self-efficacy before and after the PD workshop. There was a significant, positive change in teacher self-efficacy from before the workshop (M= 2.45, SD = 0.32) to after the workshop (M=2.97, SD = 0.13); $t(9)$= 2.26, p<.001. These results suggest that the PD workshop had a positive effect on teacher self-efficacy. Specifically, these results suggest that when teachers attend a STEM focused PD workshop implementing best practices, their self-efficacy to implement STEM increases. The pre-workshop mean of motivation was (M= 2.52, SD = 0.59,) and the post-workshop mean was (M= 2.54, SD = 0.49); $t(16)$= 2.12, p=0.15. These results suggest that the PD workshop did not significantly change teacher motivation.

Increasing motivation and self-efficacy regarding STEM implementation is important. Although results from the pilot study indicated that educator confidence increased, their motivation remained the same. This could be due to the fact that the instrument used to measure motivation focused on how teachers implemented STEM in the past. To see a change in motivation, participants' motivation should be measured in the future, after they have had an opportunity to practice what they have gained from the PD workshop.

Procedure

The purpose of this study was to refine the proposed instrument from the pilot study and build a validity argument. This study was conducted in four phases. See Figure 6 for an overview.

The first phase of this study, also called the pilot study, involved the development of the STEM Attitudes of Educators instrument. The two constructs that were measured were motivation and self-efficacy. The survey was reviewed by a panel of experts for content validity. This panel consisted of an Associate Professor of engineering education with at least thirteen years of experience, an Associate Professor of science education with at least fifteen years of experience, a state STEM Lead with three years of experience, and an Associate Director of a STEM education center with at least twenty-four years of experience. Based on feedback,

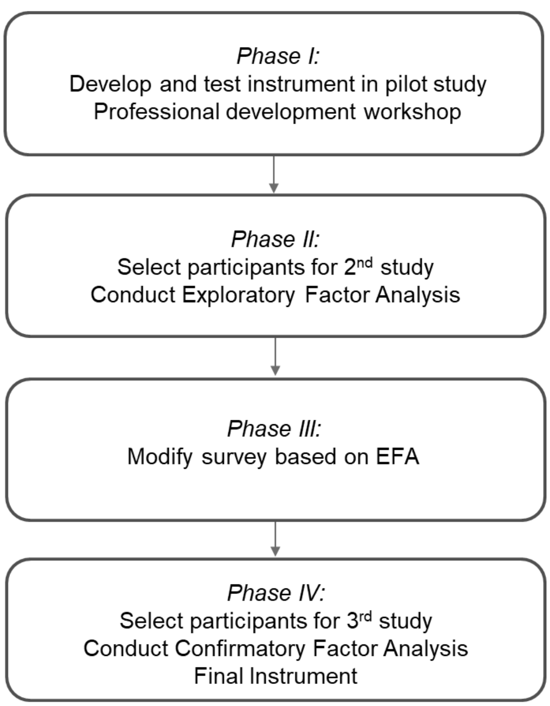


Figure 6. Stages of the study.

questions were added, deleted, or modified.

The second phase involved selecting participants for Study 2. An email was sent to two cohorts of 21st Century Community Learning Centers (21st CCLC) grantees. The cohorts consisted of grantees (afterschool programs) who were awarded a 21st CCLC grant in the same award year. This email asked grantees to participate in a survey with a link provided via Qualtrics. Additional participants were recruited at the annual Alabama Community Education Association conference in Orange Beach, Alabama. These participants were attending a session entitled “Infusing STEM in Your Afterschool Program.” The data collected from Study 2 were analyzed by conducting an exploratory factor analysis. The purpose of the Exploratory Factor Analysis was to explore the underlining dimensions of a given construct.

In phase three, the survey was modified based on the exploratory factor analysis in Study 2. One self-efficacy item was deleted and three motivation items were deleted. The modified survey was further analyzed in the next phase.

Phase four focused on the creation of the final survey instrument. In this phase, also known as Study 3, participants were selected by their affiliation with afterschool education. In an attempt to create a large sample size, new participants were recruited from a pool of 21st Century Community Learning Center grantees that consisted of two cohorts. These two cohorts are made up of 126 site locations. Additional participants were selected through the Afterschool Alliance, an organization that works with afterschool programs and policy makers across the United States. Lastly, participants were recruited via the National Science Teacher Association (NSTA) and National Association for Research in Science Teaching (NARST) listservs. The modified survey was distributed via email which contained a link to the Qualtrics survey. Data were collected and then analyzed by conducting a confirmatory factor analysis. The purpose of a confirmatory factor analysis is to examine how well a measured variable represents the number of constructs (Meyers, Gamst, and Guarino, 2016). The final phase of this study provided stronger validity evidence for the proposed survey instrument.

Data Analysis

Quantitative data consisted of Likert scale data from the STEM Attitudes of Educators instrument collected throughout Study 1, Study 2, and Study 3.

In Study 1, the pilot study, the dependent variables were motivation and self-efficacy while the independent variable was the STEM PD workshop. Statistical analysis using paired samples *t*-tests was conducted using Statistical Package of the Social Sciences (SPSS) to reveal differences in teachers' motivation scores as well as self-efficacy scores before attending the workshop and after the workshop using a significant level of .05. Paired samples *t* tests, also known as dependent *t* tests, are most appropriate to compare the means of the pre- and post-surveys to determine whether there is evidence that the differences between the scores before and after a treatment are significantly different from zero (Field, 2009). Seven questions measuring motivation on the STEM Attitudes of Educators instrument were rephrased from positive to negative statements to check for consistency among participant answers and, therefore, were reverse coded before conducting statistical analysis. In Study 2, data were analyzed by conducting an Exploratory Factor Analysis using SPSS. The purpose of the Exploratory Factor Analysis was to explore the underlining dimensions of a given construct. In Study 3, data were analyzed by conducting a Confirmatory Factor Analysis using AMOS (Analysis of a Moment Structures) and SPSS. The purpose of a Confirmatory Factor Analysis was to test how well a measured variable represents the number of constructs to build evidence of construct validity.

Summary

The purpose of this study was to design, refine, and build a validity argument for the proposed instrument to measure STEM self-efficacy and motivation of afterschool educators. Literature regarding a valid and reliable instrument to measure STEM attitudes of educators is limited. Through multiple phases of this study, the researcher aimed to provide validity evidence of the proposed *STEM Attitudes of Educators* instrument. Study 1, the pilot study, used the initial instrument to measure changes in self-efficacy and motivation. Study 2 built upon previous evidence to build a stronger case for validation of the instrument by conducting an Exploratory Factor Analysis on a larger sample. Finally, in Study 3, a Confirmatory Factor Analysis was conducted. Evidence collected through multiple studies builds a stronger argument for the use of this instrument as a valid tool for measuring educators' STEM attitudes.

CHAPTER 4: RESULTS

Introduction

The purpose of this investigation was to design, refine, and build a validity argument for the proposed instrument to measure how a STEM PD workshop improves teachers' self-efficacy and motivation to implement STEM in their afterschool programs. To examine self-efficacy and motivation of STEM implementation meaningfully, it must be explicitly conceptualized and then translated into an instrument that appropriately operationalizes and measures this conceptualization. This investigation was conducted through a series of phases to collect evidence of validity. Phase one consisted of building and testing the initial instrument at a PD workshop. Phase two consisted of conducting an Exploratory Factor Analysis (EFA). Phase three focused on modifying the survey instrument based on the EFA results. Finally, phase four consisted of sending out the survey nationwide to gather data to conduct a confirmatory factor analysis to create the final instrument. The research question asked in this study was: What evidence of validity supports the proposed *STEM Attitudes of Educators* instrument in evaluating educator motivation and self-efficacy regarding STEM implementation?

This chapter is organized into two sections. The first section provides an overview of the proposed instrument. The second section will discuss implementation and modification of the instrument throughout the four phases and describes specifically how evidence of validity was built to support the final instrument.

The Instrument

The initial STEM Attitudes of Educators inventory, which was developed for this study, was designed to gauge teachers' conceptions about self-efficacy and motivation regarding STEM implementation. The initial instrument contained five demographic questions centered on gender, ethnicity, education, job title, and program location. It also contained 27 questions which fell under two constructs: motivation and self-efficacy. Ten four-point Likert scale items ranging from "Not Confident at all" to "Very Confident" assessed how teachers perceived their self-efficacy about implementing STEM focused activities in their afterschool program. Seventeen four-point Likert scale items ranging from "Strongly Disagree" to "Strongly Agree" assessed educators' motivation to implement STEM activities in their afterschool program. A minimum score of 10 on the survey instrument measuring self-efficacy would indicate a teacher's lack of confidence in their ability to implement STEM in their afterschool program whereas a maximum score of 40 would indicate a high level of confidence in their ability. In addition, a minimum score of 17 on the survey instrument measuring motivation would indicate a lack of motivation to implement STEM whereas a maximum score of 68 would indicate an educator who is highly motivated to implement STEM.

Instrument Modification and Evidence of Validity

Phase I

The first phase consisted of the initial development of the STEM Attitudes of Educators inventory. The first version of the instrument consisted of 27 questions: 10 measuring self-efficacy and 17 measuring motivation. A panel of five STEM experts and professors analyzed the items. Any items regarded as inaccurately measuring the constructs were revised or removed. For example, several negative statements (The engineering-design process is unfamiliar to me) were added to parallel positive statements (I feel comfortable explaining the engineering-design process).

The next step in *Phase I*, called the pilot study, was the implementation of the initial instrument before and after a STEM PD workshop. The purpose of the pilot study was to understand how a STEM PD workshop improved teachers' self-efficacy and motivation to implement STEM in their afterschool programs as well as further develop the proposed instrument that measured STEM motivation and self-efficacy. To establish content validity of the STEM Attitudes of Educators inventory, a panel of five STEM experts analyzed the items. Any items regarded as inaccurately measuring the constructs were revised or removed. Furthermore, the panel suggested additional questions and formatting suggestions for the instrument. Once initial development of the tool was completed, refinement continued until the initial 27 items were reduced to a final set of 22 items that centered around the two constructs being measured: self-efficacy and motivation of educators.

The first PD workshop consisted of 38 participants-educators across the state of Alabama. The 38 participants were composed of 37 females and one male. Participants identified themselves in many overlapping roles including 53% as in-school time teachers, 45% as afterschool program coordinators, 58% as afterschool program staff, and 5% identified as "Other." Data were collected and reliability was calculated. Incomplete survey data were not analyzed, creating a sample size of 34 participants. Cronbach's alphas for the 10 self-efficacy and 17 motivation items were .85 and .81, respectively (N=34). These are acceptable values for educational surveys (Tavakol & Dennick, 2011). To continue building stronger evidence of content validity, additional workshops were implemented to create a larger sample size which will be discussed in *Phase II*.

Phase II

Phase II of the study focused on building a stronger validity argument by collecting data to form a larger sample size. A series of PD workshops were conducted at Alabama Community Education Association, an afterschool conference for the state of Alabama. Data were collected from 116 participants who identified themselves in many roles including afterschool staff, educators, and school system administration staff. The 116 participants were 92% female and 8% males. Cronbach's alphas for the 10 self-efficacy and 17 motivation items were .90 and .85 (N=116) respectively, an increase from the previous sample in *Phase I*. These are good values for educational surveys (Tavakol & Dennick, 2011).

Next, an Exploratory Factor Analysis (EFA) was conducted to further investigate the number of constructs and to structure this instrument to build a stronger argument for validity. In the EFA, principal-axis factor extraction with direct Oblimin oblique rotation was used to determine the factor structure of both constructs (self-efficacy and motivation).

Results of the EFA exhibited factor loadings for self-efficacy ranging from .34 to .89 (n=116) into a two-factor solution (Table 1). A total of two factors had eigenvalues great than 1.00, cumulatively accounting for 70.87% of the total variance. Nine of the survey items loaded in *Factor 1* while one item loaded in *Factor 2*. Because the goal was to have all items load onto one factor, one question (Question 9) for self-efficacy was deleted and an EFA was conducted a second time. The final EFA for the self-efficacy items all loaded onto one factor having an eigenvalue greater than 1.00, cumulatively accounting for 59.79% of the total variance (Table 2). Therefore, question 9 (Fostering positive relationships with students) was deleted for the draft of the second instrument.

Table 1

Exploratory Factor Analysis Structure Matrix for Ten Self-Efficacy Items

	Factor Loading	
Item	**1**	**2**
1	**.87**	.34
2	**.89**	.36
3	**.83**	**.40**
4	**.78**	
5	**.89**	
6	**.75**	**.56**
7	**.63**	**.70**
8	**.61**	**.74**
9		**.87**
10	**.41**	**.88**

Note. Factor loadings > .40 are in boldface. Cronbach's alpha= .90 (N=116)

Table 2

Exploratory Factor Analysis Structure Matrix for Nine Self-Efficacy Items

	Factor Loading
Item	**1**
1	**.87**
2	**.90**
3	**.85**
4	**.79**
5	**.89**
6	**.69**
7	**.54**
8	**.52**
10	**.40**

Note. Factor loadings > .40 are in boldface. Cronbach's alpha= .91 (N=116).

Results for the EFA exhibited factor loadings for motivation ranging from .19 to .86 into a two-factor solution (n=116) (Table 3). Three of the items for motivation loaded onto factor one, four loaded onto factor two, and ten items cross-loaded onto both factors. Although all items loaded into two factors, three items had low factors loadings (<.3) and therefore, were removed for the draft of the second instrument (MacCallum, 2001). After conducting and analyzing the exploratory factor analysis, modification of the survey took place which will be discussed in the following phase.

Table 3

Exploratory Factor Analysis Structure Matrix for 17 Motivation Items

	Factor Loading	
Item	**1**	**2**
16	**.75**	
7	**.58**	.22
MR13	.16	**.86**
MR15		**.86**
8		**.72**
MR14	.37	**.72**
6	**.55**	**.63**
MR12	.21	.35
MR5	.15	
MR9	-.19	.38
MR17		.16
4	.33	
1	.21	.34
10		.27
3	.32	.35
2	**.48**	**.55**
11	**.59**	**.55**

Note. Factor loadings > .40 are in boldface. Cronbach's alpha= .85 (N=116).

Phase III

Phase III of the study focused on modifying the survey based on EFA results as well as a second review by a panel of experts. Three changes were made: format of the survey, deletion of items for self-efficacy, and deletion of items for motivation.

The panel of experts suggested moving demographic questions to the end of the survey. Therefore, gender, ethnicity, education, program location, and role were moved to the end (after survey items) for the second draft.

Next, based on EFA results, one self-efficacy item "Question 9: Fostering positive relationships with students," was removed after being the only item not loading onto factor one. Removal of this item resulted in an increase in internal consistency from .90 to .91 (N=116) and all remaining items loading onto one factor.

Finally, based on EFA results for motivation, the following three items were removed due to low factor loadings (<.3):

Question 5: I think implementing STEM activities takes too much time.

Question 10: I have the materials I need to implement STEM activities.

Question 17: There is not enough space at my site location to implement STEM activities.

Internal consistency was recalculated after the removal of these three items and found to be .85 (N=116) indicating good reliability.

Once the initial development of the tool was completed and an exploratory factor analysis was conducted, the refinement process resulted in 27 items being reduced to a final set of 22 items that centered around the two constructs being measured: self-efficacy and motivation of educators (Appendix B). This 22 item STEM Educator Attitudes instrument was used in the final phase of the study to build evidence for construct validity.

Phase IV

Phase IV of this study focused on selecting participants for the third participant group to conduct a confirmatory factor analysis (CFA), conduct and analyze the CFA, and create the final draft of the STEM Attitudes of Educators instrument.

A CFA is conducted to determine whether the sample data reasonably matches the hypothesized model. A CFA can be simple (where the measured variables are associated with a single factor) to more complex (where the structure of multiple factors are examined within a single model with a single goal of obtaining a good fit) (Meyers et al., 2016). Confirmatory factor analysis models are presented in the form of diagrams and contain the following five elements: measured variables, latent factors, error terms, paths, and parameter constraints (Meyers et al., 2016).

Measured variables are represented by rectangles/squares in the model while latent factors, also known as constructs that are not directly measured but are defined by the measured variables, are represented as ovals/circles. Error terms, also known as unique variables, also exist within the model and are associated with a residual variable. Uniqueness refers to variance that cannot be attributed to a specific cause (Meyers et al., 2016). In the model, unique variables have a directional arrow pointed to them from the latent variable and, therefore, are influenced by that variable (Meyers et al., 2016). Paths are depicted in the model by directional arrows which represent influence or causality. There are two types of arrows: unidirectional and bidirectional. Unidirectional arrows (also known as directional arrows for simplicity) have one arrowhead while bidirectional arrows have arrowheads at both ends and represent correlations between variables (Meyers et al., 2016). The last element to be depicted on the model is parameter constraints. Latent variables are not in the data file and have not been directly assessed. Therefore, they must be linked to the scale of measurement of an associated indicator variable which is done by placing a constraint with a value of 1.0 on the path from the latent variable to an indicator (Meyers et al., 2016). Using these five elements, a theoretical structure model can be created and analyzed to determine if the sample data reasonably match the hypothesized model.

Additionally, CFA models are theory based. In this particular study, an EFA was conducted previously as a theory-generating technique to hypothesize the underlying structure of the model.

Finally, the major objective in CFA is to determine if the relationships between the variables in the hypothesized model resemble relationship between the variables in the observed data (Meyers et al., 2016). This process undergoes five steps: model specification, model identification, selection of the model estimation technique, model evaluation, and model specification. These steps are described in the following paragraphs.

Conducting a CFA requires a larger sample size and, therefore, participants were pulled from multiple sources. The second draft of the survey was sent out to 21st Century Community Learning Centers grantees, members of the Afterschool Alliance in multiple states, subscribers to the National Science Teacher Association (NSTA) listserv, and the National Association for Research in Science Teaching (NARST) listserv. This resulted in 233 participants. From this group, there was a complete data set from 207 participants. Of these participants, 87% were female while 13% were male. Participants identified themselves in many overlapping roles including 29% as in-school time teachers, 59% as afterschool program coordinators, 27% as afterschool program staff, 3% as principals or vice principals and 23% identified as "Other."

Those participants that identified themselves as “other” listed student, researcher, director, museum educator, etc. Cronbach's alphas for the 9 self-efficacy and 14 motivation items were .91 and .88, respectively (n=207). These are good values for educational surveys (Tavakol & Dennick, 2011).

The purpose of conducting a CFA is to determine the goodness of fit between a hypothesized model and the sample data. For this study the two hypothesized models were a one factor model (self-efficacy) and a two factor model (motivation). The initial models proposed in the CFA for self-efficacy and motivation, shown in Figure 7a and 7b respectively, were evaluated without including any correlations between error variables.

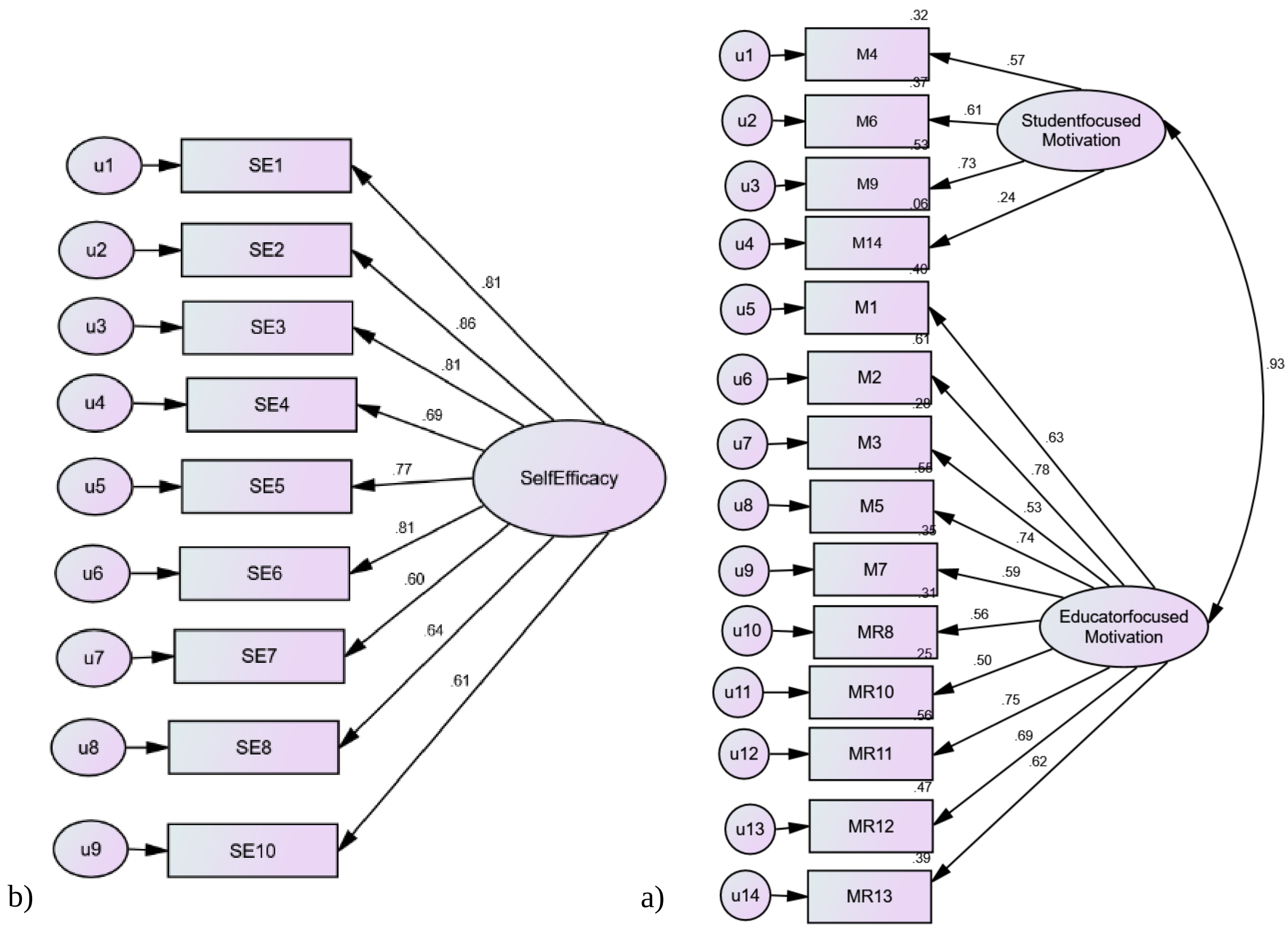


Figure 7. Hypothesized confirmatory factor analysis model for a) one-factor structure for self-efficacy, and b) two-factor structure for motivation.

Assessing the hypothesized model begins with generating and evaluating the estimates of the parameters in the model. The Exploratory Factor Analysis was used a theory-generating tool to configure the hypothesize model. If the observed data and the hypothesized model resonate with each other, the model is said to fit the data and, therefore, needs an index that quantifies the degree of fit between the data and model (Meyers et al., 2016). Chi square is used to assess the fit of the model and test the difference between the predicted and the observed relationships and, therefore, has been used for this study (Meyers et al., 2016).

Results from the initial model evaluation of self-efficacy yielded pattern coefficients relating the factors with the items that were reasonably robust, ranging from .60 to .86. Fit indices for the original model revealed a statistically significant chi-square test with a value of 200.76 (df=27, N=207), p<.001. The GFI (.785), CFI (.852), and RMSEA (.177) showed values that, taken together, suggest that the model was on the border of adequate to good fit.

Examination of the modification indices suggested that addition of some correlations between pairs of errors would improve model fit. The respecified model with its standardized coefficients is presented in Figure 8a. Fit was noticeably improved. Fit indices for the respecified model revealed a statistically significant chi-square test with a value of 60.19 (df=21, N=207), p<.001. However, the GFI (.937), CFI (.967), and RMSEA (.095) showed values that when considered together represented a very good model fit for the proposed self-efficacy model structure. For sample sizes larger than 100, a RMSEA of <.10 is considered acceptable (Kenny, Kaniskan, and McCoach, 2015). Results from the respecified model of self-efficacy yielded pattern coefficients relating the factors with the items ranging from .52 to .87, and all were statistically significant (p<.001).

These results, summarized in Table 4, suggest that the proposed one-factor structure for self-efficacy of the STEM Educator Attitudes was supported using data from this sample.

Table 4

Fit Statistics for Confirmatory Factor Analysis of Self-efficacy Items for the Proposed Model and Respecified Model

Model	***N***	**X^2**	***df***	**GFI**	**CFI**	**RMSEA**
Prior	207	200.76*	27	.785	.852	.177
After	207	60.19*	21	.937	.967	.095

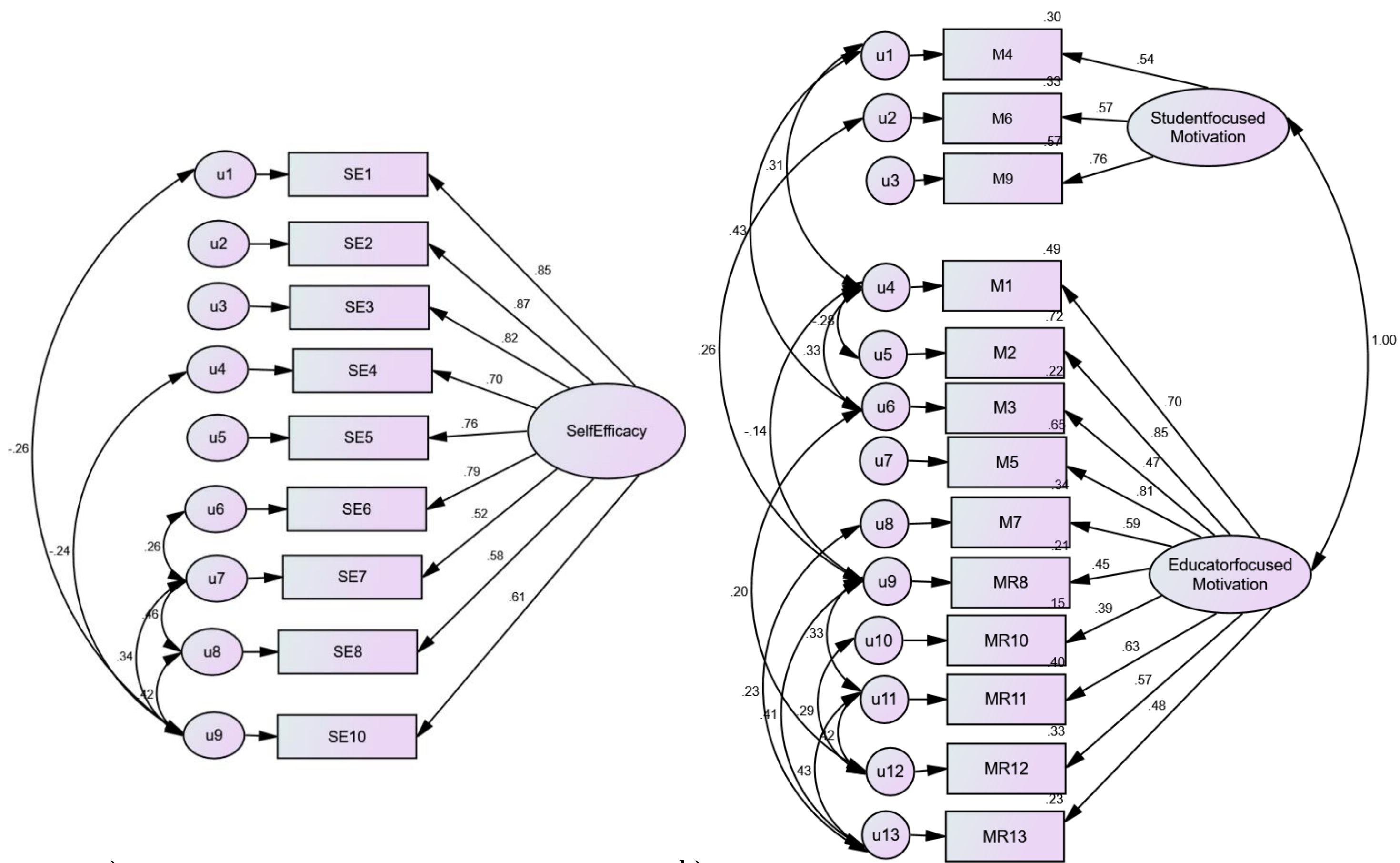
Note: GFI= goodness of fit index; CFI= comparative fit index; RMSEA= root mean square error of approximation.
*p<.01

Results from the initial model evaluation of motivation yielded pattern coefficients relating the factors with the items ranging from .24 to .78. Fit indices for the original model revealed a statistically significant chi-square test with a value of 539.792 (*df*=76, N=207), p<.001. The GFI (.685), CFI (.671), and RMSEA (.172) showed values that, taken together, suggest that the model was on the border of adequate to good fit.

An examination of the modification indices suggested that the addition of some correlations between pairs of errors would improve model fit. Additionally, one item with a low factor loading (<.3) was removed for the respecified model (MacCallum, 2001).

The respecified model with its standardized coefficients is presented in Figure 8b. Fit was noticeably improved. Fit indexes for the respecified model revealed a statistically significant chi-square test with a value of 152.362 (*df*=51, N=207), p<.001. However, the GFI (.905), CFI (.925), and RMSEA (.098) showed values that when considered together represented a good model fit for the proposed self-efficacy model structure. Results from the respecified model of self-efficacy yielded pattern coefficients relating the factors with the items ranging from .41 to

.83, and all were statistically significant ($p<.001$). These results, summarized in Table 5, suggest that the proposed two-factor structure for motivation of the STEM Educator Attitudes was supported using the data from this sample.



a) b)

Figure 8. Respecified CFA model for a) one-factor structure for self-efficacy, and b) two-factor structure for motivation.

Table 5

Fit Statistics for Confirmatory Factor Analysis of Motivation Items for the Proposed Model and Respecified Model

Model	***N***	***X*²**	***df***	**GFI**	**CFI**	**RMSEA**
Prior	207	539.79*	76	.685	.671	.172
After	207	152.36*	51	.905	.925	.098

Note: GFI= goodness of fit index; CFI= comparative fit index; RMSEA= root mean square error of approximation.
*$p<.01$

Summary

To examine self-efficacy and motivation of STEM implementation meaningfully, it must be explicitly conceptualized and then translated into an instrument that appropriately operationalizes and measures this conceptualization. This investigation was conducted through a series of phases to collect evidence of validity. The initial instrument consisted of 27 total items: 10 self-efficacy and 17 motivation items. To establish content validity, the questions were reviewed by a panel of experts.

Questions were modified, added, or deleted based on feedback. The first implementation of the instrument was distributed to a group of participants at a STEM PD workshop. Reliability tests were conducted to build further evidence of content validity. Cronbach's alphas for the 10 self-efficacy and 17 motivation items were .85 and .81, respectively (N=34). A second distribution of the instrument at a subsequent STEM PD workshop was implemented to continue to build a stronger case for validity. Cronbach's alphas were recalculated for the 10 self-efficacy and 17 motivation items and were .90 and .85 (N=116) respectively, an increase from the previous sample in instrument one.

After an EFA was conducted, nine self-efficacy items loaded onto factor one while one remaining item loaded into factor two. Therefore, one item (item 9) of self-efficacy was deleted for the second proposed instrument. Reliability tests were recalculated and Cronbach's alpha for nine self-efficacy items was .91 (N=116) which is considered excellent reliability.

All motivation items loaded into a two-factor structure as expected. However, three motivation items received low factor loadings (<.3) and, therefore, were deleted for the second proposed instrument. Reliability tests were recalculated and Cronbach's alpha for 14 motivations items was .85 (N=116) which is considered acceptable reliability.

A second draft of the survey was created consisting of nine self-efficacy items and 14 motivation items. This second draft was distributed through multiple listservs to gather participants over the United States. This final group of participants consisted of 233 individuals, 207 of which had complete data sets for analysis. After responses were gathered, a CFA was conducted with a proposed and final model. The purpose of conducting a CFA is to determine the goodness of fit between a hypothesized model and the sample data to build an argument for construct validity. Results indicating a final model for both a one-factor structure for self-efficacy and a two-factor structure for motivation provided evidence for construct validity for the proposed instrument. The initial instruments were refined to a final instrument consisting of nine self-efficacy items and thirteen motivation items. Results suggest that the proposed instrument appropriately operationalized and measured self-efficacy and motivation of educators regarding STEM implementation.

CHAPTER 5: DISCUSSION AND IMPLICATIONS

Introduction

This study focused on how to improve quality STEM education in afterschool programs. One crucial step is to better understand the afterschool educator's motivation and self-efficacy for implementing STEM content and curricula. Informing and supporting educators in how to implement integrated STEM correctly and confidently is an essential first step to engaging students in STEM. Until educators become comfortable with guiding their students through the engineering design process, they will be less motivated to plan and implement quality STEM activities. Therefore, investigating motivation and self-efficacy of afterschool staff can inform future PD design and implementation. While current research is focused on engaging students in STEM, there is little knowledge regarding how to motivate educators to implement STEM effectively and there are few tools to measure educator STEM self-efficacy and motivation. To examine self-efficacy and motivation of STEM implementation meaningfully, it must be explicitly conceptualized and then translated into an instrument that appropriately operationalizes and measures this conceptualization.

The research question targeted in this study was: What evidence of validity supports the proposed *STEM Attitudes of Educators* instrument in evaluating educator motivation and self-efficacy regarding STEM implementation? To address this question, validity of an instrument was defined as the "strength of evidence that the scale score accurately represents the level an individual possesses of the construct of interest" (Carney et al., 2015).

Results indicated there is an acceptable level of evidence regarding internal consistency and construct structure of the proposed STEM Attitudes of Educators (SAE) instrument. This refers to evidence that the instrument items collectively measured a common construct (self-efficacy and motivation) and that there is minimal error around the set of items (reliability). In this study, Cronbach's alpha was calculated over multiple phases to measure internal consistency. Results supported the instrument's reliability and validity. In addition to Cronbach's alpha, multiple statistical techniques were used to examine construct validity. An EFA was employed to determine that the instrument measured all expected constructs. Results indicated that self-efficacy items loaded into one factor while motivation items loaded onto two factors. To further explore the construct validity, the instrument was further analyzed by a CFA. Results indicated a good fit for the proposed model suggesting evidence of construct validity for the STEM Attitudes of Educators instrument. Collectively, results support the validity of this instrument.

Limitations

Several limitations were encountered in this study that may have compromised the results and assertions made; nonetheless, the researcher attempted to eliminate these as much as possible.

Threats to internal and external validity were also taken into consideration. Internal validity is concerned with the degree to which results of this study are attributable to the independent variable, the STEM PD workshop-pilot study, as opposed to some external explanation. One internal validity threat may be the location and time of data collection. For example, results may vary if participants take post-surveys at the end of the PD workshop as opposed to waiting until they return to work days later. To protect against this threat, a mobile link was provided so participants could complete the survey on their phones as well as a paper copy for others at the end of the workshop. A second threat that could occur is changes in survey scores due to repeated testing as opposed to the intervention being effective. Unfortunately, threats to internal validity may always be present but the researcher attempted to minimize the threats when possible by choosing the most appropriate design for the study and standardizing conditions.

Threats to external validity, the extent to which results are generalizable, may also arise. One threat to external validity is selection bias. Participants were not selected randomly but volunteered to participate. Some participants volunteered because they were eager to learn how to effectively implement STEM and change their programs. A second threat to external validity may be how the researcher operationally defines the constructs being measured. When generalizing results, the researcher will only be able to generalize findings within the confines of the operational definition. The researcher will make all attempts to reduce threats to external validity.

Implications and Suggestions for Future Research

The findings in this study fill a gap in the literature and lend support to the argument that there is a need for valid and reliable tools to measure educators' self-efficacy and motivation regarding STEM implementation. In the pilot study, implementing a high quality PD workshop that centered around best practices improved educator self-efficacy, although little change was measured in educator motivation. Improving educator confidence in STEM implementation is an important step in improving quality STEM in afterschool time and in-school time.

Results are specific to educators and staff in afterschool programs and STEM education. Therefore, they cannot be directly generalized to in-school time educators or to other content areas and activities. Future research is necessary in order to determine how STEM self-efficacy and motivation impact in-school time educators, and further research is needed on improving STEM self-efficacy and motivation of afterschool program educators.

One suggestion for future research is to improve the STEM Attitudes of Educators instrument by adding additional questions to gather more insight into the impact that low self-efficacy and motivation has on STEM implementation in afterschool programs. The proposed final version of the SAE instrument has 22 items to assess educators' self-efficacy and motivation regarding STEM implementation. Twenty-two items may not be sufficient to accurately conceptualize educators' attitudes. Therefore, additional questions could be added, and additional factor analyses could be conducted to provide evidence of validity.

Another suggestion is to measure STEM attitudes of in-school time educators, which ultimately impact student learning during the school day. Research suggests that although some students are able to make links in their learning, students have difficulty connecting concepts from out-of-school learning with in-school learning (Fallik, Rosenfeld & Eylon, 2013). According to Fallik et al. (2013), bridging this gap provides multiple learning opportunities for a variety of learners and can increase student motivation for learning, expand student conceptions, and provide opportunities for students to develop new skills and abilities. One cause for this gap may be a lack of understanding, tools, or communication between staff to provide opportunities for bridging the in-school day with the out-of-school time. However, another cause of the gap may be in-school time educators' lack of knowledge regarding EDP, low self-efficacy, or low motivation to implement STEM. Therefore, additional research should be conducted to better understand in-school time educators' attitudes in regards to STEM implementation.

Finally, one additional suggestion for future research is to utilize the validated instrument before and after STEM focused workshops to measure changes in educator self-efficacy and motivation of STEM implementation. Informing and supporting educators in how to implement integrated STEM correctly and confidently is an essential first step to engaging students in STEM.

Results from the pilot study indicated that a STEM focused PD workshop improved educator confidence (self-efficacy) to implement STEM in the future. Overall, they became more confident in their knowledge and implementation of the EDP (Engineering Design Process)- an essential component in STEM education. However, pilot study results also indicated that there was not a statistically significant difference in motivation before and after the workshop. This result may be due to the fact that although educators are confident to implement STEM in their afterschool programs, the instrument measured current motivation to implement STEM. Therefore, additional research should be conducted to accurately measure educator motivation. To measure motivation of future STEM implementation, the survey should be given at several time points: before the workshop, immediately after the workshop, and in the future, after time has been allowed for educators to practice and implement what they have learned from the workshop. Additionally, to create a holistic conceptualization of educator STEM attitudes, a mixed-methods approached should be conducted. It is not enough to measure attitudes with an instrument. Educator interviews should also be conducted to look for themes of educator needs, self-efficacy, and motivation regarding STEM implementation. As mentioned in previous chapters, until educators become comfortable guiding their students through the engineering design process and other key components of STEM, they will be less motivated to plan and implement quality STEM activities. Therefore, investigating motivation and self-efficacy of afterschool staff can inform future PD design and implementation. With such a high emphasis on providing integrated STEM in the out-of-school time, stakeholders, policy makers, and educators should be aware of the foundations of providing maximum learning opportunities in STEM, which are teacher motivation and self-efficacy. Therefore, this research can inform practitioners, stakeholders, researchers, and policymakers about how to motivate afterschool program staff to effectively provide integrated STEM learning with confidence. Additionally, this research provides valuable information on how to effectively design and implement STEM focused workshops to provide opportunities for educators to build confidence and motivation to implement STEM.

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Appendix A

Initial draft: STEM Attitudes of Educators

STEM Attitudes of Educators

Demographic Questions

Name: ______________________ **Site/School:** ______________________

Gender:
- ☐ Female
- ☐ Male
- ☐ Other

Ethnicity:
- ☐ Asian / Pacific Islander
- ☐ Black or African American
- ☐ Hispanic or Latino
- ☐ Native American or American Indian
- ☐ White
- ☐ Other

Education:
- ☐ Some high school, no diploma
- ☐ High school graduate, diploma or the equivalent (for example: GED)
- ☐ Some college credit, no degree
- ☐ Trade/technical/vocational training
- ☐ Associate degree
- ☐ Bachelor's degree
- ☐ Master's degree
- ☐ Professional degree
- ☐ Doctorate degree

Program location:
- ☐ School-based
- ☐ Community-based
- ☐ Faith-based
- ☐ Combination

Role (Check all that apply):
- ☐ In-school-time teacher
- ☐ Afterschool program Coordinator
- ☐ Afterschool program teacher/assistant/aid
- ☐ Principal/Assistant Principal
- ☐ Other

Rate your degree of confidence for each statement below from "not confident at all" to "very confident."

Question	Not Confident at all	Somewhat confident	Confident	Very Confident
1. Implementing STEM activities that challenge students	1	2	3	4
2. Creating opportunities for students to engage in STEM practices (e.g. making observations, collecting data, sharing findings with peers, using the engineering design process, asking questions, planning/carrying out investigations)	1	2	3	4
3. Guiding students' reflections about STEM activities	1	2	3	4
4. Knowledge of the engineering-design process	1	2	3	4
5. Connecting STEM activities with the real-world	1	2	3	4
6. Creating hands-on/minds-on activities	1	2	3	4
7. Creating opportunities for student-choice in activities	1	2	3	4
8. Retaining student engagement throughout an activity	1	2	3	4
9. Fostering positive relationships with students	1	2	3	4
10. Fostering a student-centered learning environment	1	2	3	4

Motivation: Rate each statement below on a scale from "strongly disagree" to "strongly agree."

Question	Strongly Disagree	Disagree	Agree	Strongly Agree
1. I have the resources I need to implement STEM activities.	**1**	**2**	**3**	**4**
2. I give my students opportunities to engage in STEM activities.	**1**	**2**	**3**	**4**
3. I have staff to help me implement STEM activities.	**1**	**2**	**3**	**4**
4. I have space to implement STEM activities.	**1**	**2**	**3**	**4**
5. I think implementing STEM activities takes too much time.	**1**	**2**	**3**	**4**
6. I implement activities that allow students to engage in STEM practices. (e.g. making observations, collecting data, sharing findings with peers, using the engineering design process, asking questions, planning/carrying out investigations)	**1**	**2**	**3**	**4**
7. I understand the importance of student-choice in STEM.	**1**	**2**	**3**	**4**
8. I feel comfortable explaining the engineering-design process.	**1**	**2**	**3**	**4**
9. I am afraid of activities that involve "engineering."	**1**	**2**	**3**	**4**
10. I have the materials I need to implement STEM activities.	**1**	**2**	**3**	**4**
11. My students often participate in activates that incorporate science, technology, engineering and mathematics.	**1**	**2**	**3**	**4**
12. I don't have enough time to engage student in meaningful STEM projects.	**1**	**2**	**3**	**4**

STEM Attitudes of Educators

Question	Strongly Disagree	Disagree	Agree	Strongly Agree
13. I do not implement engineering activities because I am not confident to do so.	1	2	3	4
14. I do not implement STEM activities because I do not have people to help.	1	2	3	4
15. The engineering-design process is unfamiliar to me.	1	2	3	4
16. It is important for students to have a choice in materials and projects that they want to participate in.	1	2	3	4
17. There is not enough space at my site location to implement STEM activities.	1	2	3	4

Thank you so much for participating in this survey.

Appendix B

Second draft: STEM Attitudes of Educators

STEM Attitudes of Educators

Rate your degree of confidence for each statement below from "not confident at all" to "very confident."

Question	Not Confident at all	Somewhat confident	Confident	Very Confident
1. Implementing STEM activities that challenge students	1	2	3	4
2. Creating opportunities for students to engage in STEM practices (e.g. making observations, collecting data, sharing findings with peers, using the engineering design process, asking questions, planning/carrying out investigations)	1	2	3	4
3. Guiding students' reflections about STEM activities	1	2	3	4
4. Knowledge of the engineering-design process	1	2	3	4
5. Connecting STEM activities with the real-world	1	2	3	4
6. Creating hands-on/minds-on activities	1	2	3	4
7. Creating opportunities for student-choice in activities	1	2	3	4
8. Retaining student engagement throughout an activity	1	2	3	4
9. Fostering a student-centered learning environment	1	2	3	4

Motivation: Rate each statement below on a scale from "strongly disagree" to "strongly agree."

Question	Strongly Disagree	Disagree	Agree	Strongly Agree
1. I have the resources I need to implement STEM activities.	1	2	3	4
2. I give my students opportunities to engage in STEM activities.	1	2	3	4
3. I have staff to help me implement STEM activities.	1	2	3	4
4. I have space to implement STEM activities.	1	2	3	4
5. I implement activities that allow students to engage in STEM practices. (e.g. making observations, collecting data, sharing findings with peers, using the engineering design process, asking questions, planning/carrying out investigations)	1	2	3	4
6. I understand the importance of student-choice in STEM.	1	2	3	4
7. I feel comfortable explaining the engineering-design process.	1	2	3	4
8. I am afraid of activities that involve "engineering."	1	2	3	4
9. My students often participate in activities that incorporate science, technology, engineering and mathematics.	1	2	3	4
10. I don't have enough time to engage student in meaningful STEM projects.	1	2	3	4

Question	Strongly Disagree	Disagree	Agree	Strongly Agree
11. I do not implement engineering activities because I am not confident to do so.	1	2	3	4
12. I do not implement STEM activities because I do not have people to help.	1	2	3	4
13. The engineering-design process is unfamiliar to me.	1	2	3	4
14. It is important for students to have a choice in materials and projects that they want to participate in.	1	2	3	4

Thank you so much for participating in this survey.

STEM Attitudes of Educators

Gender:

- ☐ Female
- ☐ Male
- ☐ Other

Ethnicity:

- ☐ Asian / Pacific Islander
- ☐ Black or African American
- ☐ Hispanic or Latino
- ☐ Native American or American Indian
- ☐ White
- ☐ Other

Education:

- ☐ Some high school, no diploma
- ☐ High school graduate, diploma or the equivalent (for example: GED)
- ☐ Some college credit, no degree
- ☐ Trade/technical/vocational training
- ☐ Associate degree
- ☐ Bachelor's degree
- ☐ Master's degree
- ☐ Professional degree
- ☐ Doctorate degree

Program location:

- ☐ School-based
- ☐ Community-based
- ☐ Faith-based
- ☐ Combination

Role (Check all that apply):

- ☐ In-school-time teacher
- ☐ Afterschool program Coordinator
- ☐ Afterschool program teacher/assistant/aid
- ☐ Principal/Assistant Principal
- ☐ Other

Appendix C

Final draft: STEM Attitudes of Educators

STEM Attitudes of Educators

Rate your degree of confidence for each statement below from "not confident at all" to "very confident."

Question	Not Confident at all	Somewhat confident	Confident	Very Confident
1. Implementing STEM activities that challenge students	1	2	3	4
2. Creating opportunities for students to engage in STEM practices (e.g. making observations, collecting data, sharing findings with peers, using the engineering design process, asking questions, planning/carrying out investigations)	1	2	3	4
3. Guiding students' reflections about STEM activities	1	2	3	4
4. Knowledge of the engineering-design process	1	2	3	4
5. Connecting STEM activities with the real-world	1	2	3	4
6. Creating hands-on/minds-on activities	1	2	3	4
7. Creating opportunities for student-choice in activities	1	2	3	4
8. Retaining student engagement throughout an activity	1	2	3	4
9. Fostering a student-centered learning environment	1	2	3	4

STEM Attitudes of Educators

Motivation: Rate each statement below on a scale from "strongly disagree" to "strongly agree."

Question	Strongly Disagree	Disagree	Agree	Strongly Agree
1. I have the resources I need to implement STEM activities.	1	2	3	4
2. I give my students opportunities to engage in STEM activities.	1	2	3	4
3. I have staff to help me implement STEM activities.	1	2	3	4
4. I have space to implement STEM activities.	1	2	3	4
5. I implement activities that allow students to engage in STEM practices. (e.g. making observations, collecting data, sharing findings with peers, using the engineering design process, asking questions, planning/carrying out investigations)	1	2	3	4
6. I understand the importance of student-choice in STEM.	1	2	3	4
7. I feel comfortable explaining the engineering-design process.	1	2	3	4
8. I am afraid of activities that involve "engineering."	1	2	3	4
9. My students often participate in activities that incorporate science, technology, engineering and mathematics.	1	2	3	4
10. I don't have enough time to engage student in meaningful STEM projects.	1	2	3	4

STEM Attitudes of Educators

Question	Strongly Disagree	Disagree	Agree	Strongly Agree
11. I do not implement engineering activities because I am not confident to do so.	1	2	3	4
12. I do not implement STEM activities because I do not have people to help.	1	2	3	4
13. The engineering-design process is unfamiliar to me.	1	2	3	4

Thank you so much for participating in this survey.

STEM Attitudes of Educators

Gender:
- ☐ Female
- ☐ Male
- ☐ Other

Ethnicity:
- ☐ Asian / Pacific Islander
- ☐ Black or African American
- ☐ Hispanic or Latino
- ☐ Native American or American Indian
- ☐ White
- ☐ Other

Education:
- ☐ Some high school, no diploma
- ☐ High school graduate, diploma or the equivalent (for example: GED)
- ☐ Some college credit, no degree
- ☐ Trade/technical/vocational training
- ☐ Associate degree
- ☐ Bachelor's degree
- ☐ Master's degree
- ☐ Professional degree
- ☐ Doctorate degree

Program location:
- ☐ School-based
- ☐ Community-based
- ☐ Faith-based
- ☐ Combination

Role (Check all that apply):
- ☐ In-school-time teacher
- ☐ Afterschool program Coordinator
- ☐ Afterschool program teacher/assistant/aid
- ☐ Principal/Assistant Principal
- ☐ Other

Appendix D

Permission Letter to use DoS Figures

Guidelines for Citing & Distributing Findings
Provided by The PEAR Institute Data Reports

Thank you for your interest in sharing your findings from The PEAR Institute's survey and/or observational tools with your educational stakeholders or the public! If you plan to reference The PEAR Institute or would like to put your peer-review journal articles, we ask that you please adhere to the following general guidelines.

- **Evaluation findings shared with your organization by The PEAR Institute must not be altered in any way and should be reported with details concerning sample size and context.**
  - Any modification of the contents of the report (including graphs, tables, or text) should not be attributed to The PEAR Institute, Harvard Medical School, or McLean Hospital.

- **For survey-based tools, there should be a statement that your program/organization received permission from The PEAR Institute to use the survey tool, and/or that your organization participated in an evaluation with named sponsors. You may not publish or share individual items in reports, theses, or journal articles.**
  - Example 1: Permission to use the Holistic Student Assessment (HSA) was obtained from The PEAR Institute at Harvard Medical School and McLean Hospital.
  - Example 2: Permission to use the Common Instrument Suite (CIS) was obtained from The PEAR Institute at Harvard Medical School and McLean Hospital.
  - Example 3: Program XYZ participated in the 2016 Afterschool & STEM Evaluation to...As part of this work, Program XYZ used the Common Instrument Suite (CIS) survey developed by The PEAR Institute at Harvard Medical School and McLean Hospital.

- **For observation-based tools, there should be a statement that individuals collecting data were certified by The PEAR Institute to use the tools. This is important to demonstrate the reliability of the data. You may not publish or share rubrics in reports, theses, or journal articles or share rubrics with non-certified individuals.**
  - Example: Observations were performed by individuals certified by The PEAR Institute to use the Dimensions of Success (DoS) observation tool.
  - Example: All data collected using the Dimensions of Success (DoS) observation tool were collected by PEAR-certified observers.

- **If you have any opinions about the data – or draw any conclusions or make recommendations using the data – that were not explicitly stated in your report by our team at The PEAR Institute, then the following additional disclaimer must be used:**
  - **"***Any opinions, findings, and conclusions or recommendations expressed in this material are those of [the author(s) – Program Name/Organization] and do not necessarily reflect those of The PEAR Institute, Harvard Medical School, or McLean Hospital."*

- **If you are thinking about publishing the data/results provided to you by The PEAR Institute in a peer-reviewed journal, please contact Dr. Patty Allen, Research Manager, at pallen@mclean.harvard.edu.**
  - Note that secondary analysis and publishing of data (even if collected for educational purposes) requires Institutional Review Board (IRB) review and approval.

- **If you would like to share findings on social media, please tag The PEAR Institute so that we can "like" and promote your organization and evaluation findings!**
    - Facebook: https://www.facebook.com/PEARimpact
    - Twitter: https://www.twitter.com/PEARimpact
- **PEAR is now an institute at McLean Hospital, and our name has changed as of January 2016. Please refer to our organization as: The PEAR Institute: Partnerships in Education and Resilience at Harvard Medical School and McLean Hospital.**
    - Initial mentions of our organization in written text should use our full name: "The PEAR Institute: Partnerships in Education and Resilience." Subsequent mentions can just be PEAR or The PEAR Institute.
    - For instance, "Program XYZ partnered with The PEAR Institute: Partnerships in Education and Resilience, at Harvard Medical School and McLean Hospital, to measure the impact of out-of-school time (OST) STEM programming on students' science-related attitudes. PEAR, with funding from the STEM Foundation, aimed to ..."
- **If you have any questions or concerns about these guidelines, please email Dr. Patty Allen, Research Manager at The PEAR Institute, at** pallen@mclean.harvard.edu **or call The PEAR Institute at 617-484-0466.**

Recommended References

Holistic Student Assessment

- Noam, G. G., T. Malti, and M. Guhn. "From Clinical-Developmental Theory to Assessment: The Holistic Student Assessment Tool." *International Journal of Conflict and Violence* 6, no. 2 (2012): 201–13.
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Common Instrument (CI) and Common Instrument Suite (CIS)

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Dimensions of Success (DoS)

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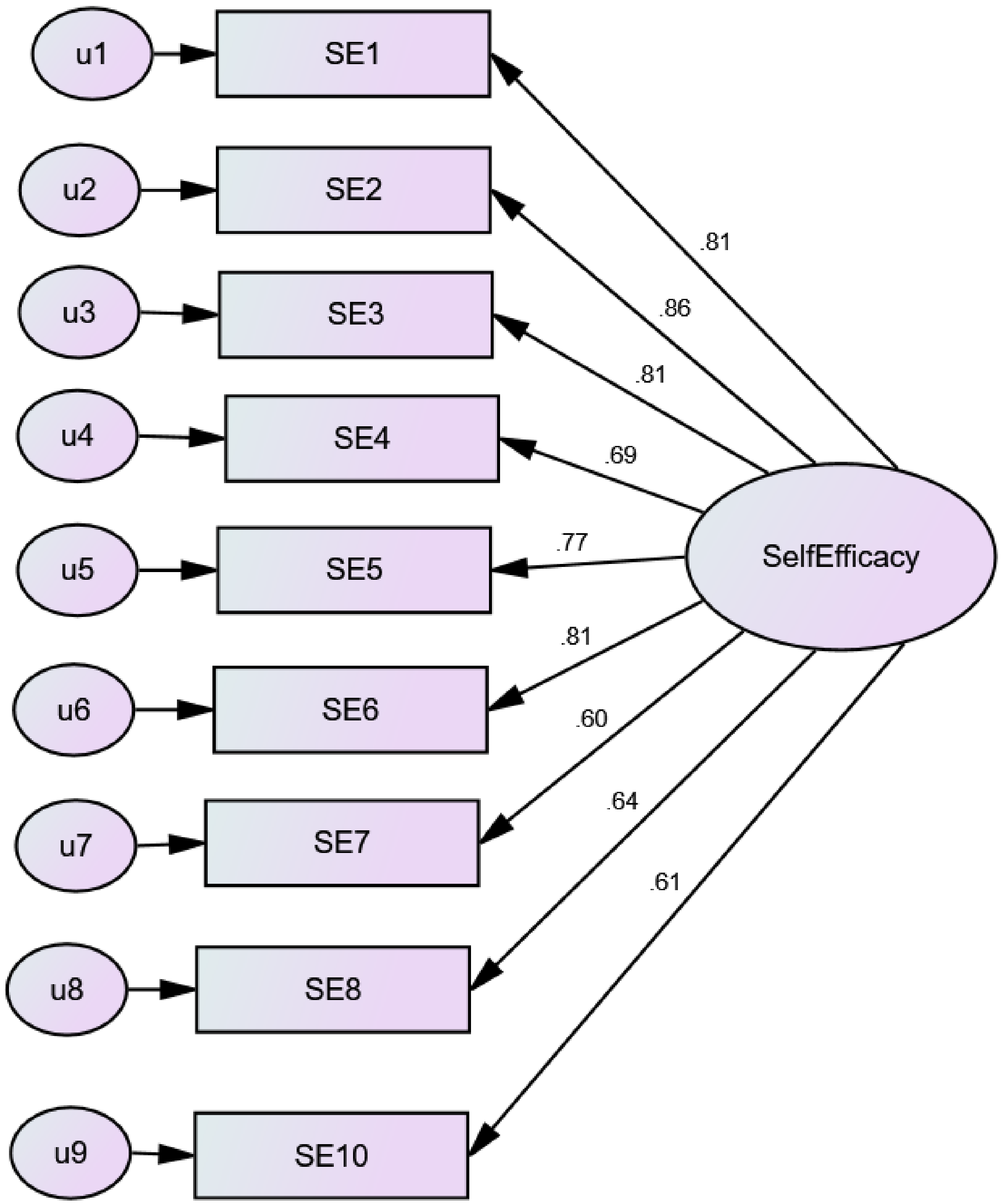
- Shah, A. M., Wylie, C. E., Gitomer, D., & Noam, G.G. (2016). Development of the Dimensions of Success (DoS) observation tool for the out of school time STEM field: Refinement, field-testing and establishment of psychometric properties. Belmont, MA: Program in Education, Afterschool & Resiliency, Harvard University and McLean Hospital.
- Papazian, A. E., Noam, G. G., Shah, A. M., Rufo-McCormick, C. (2013). The quest for quality in afterschool science: The development and application of a new tool. *Afterschool Matters, 18*, 17–24.

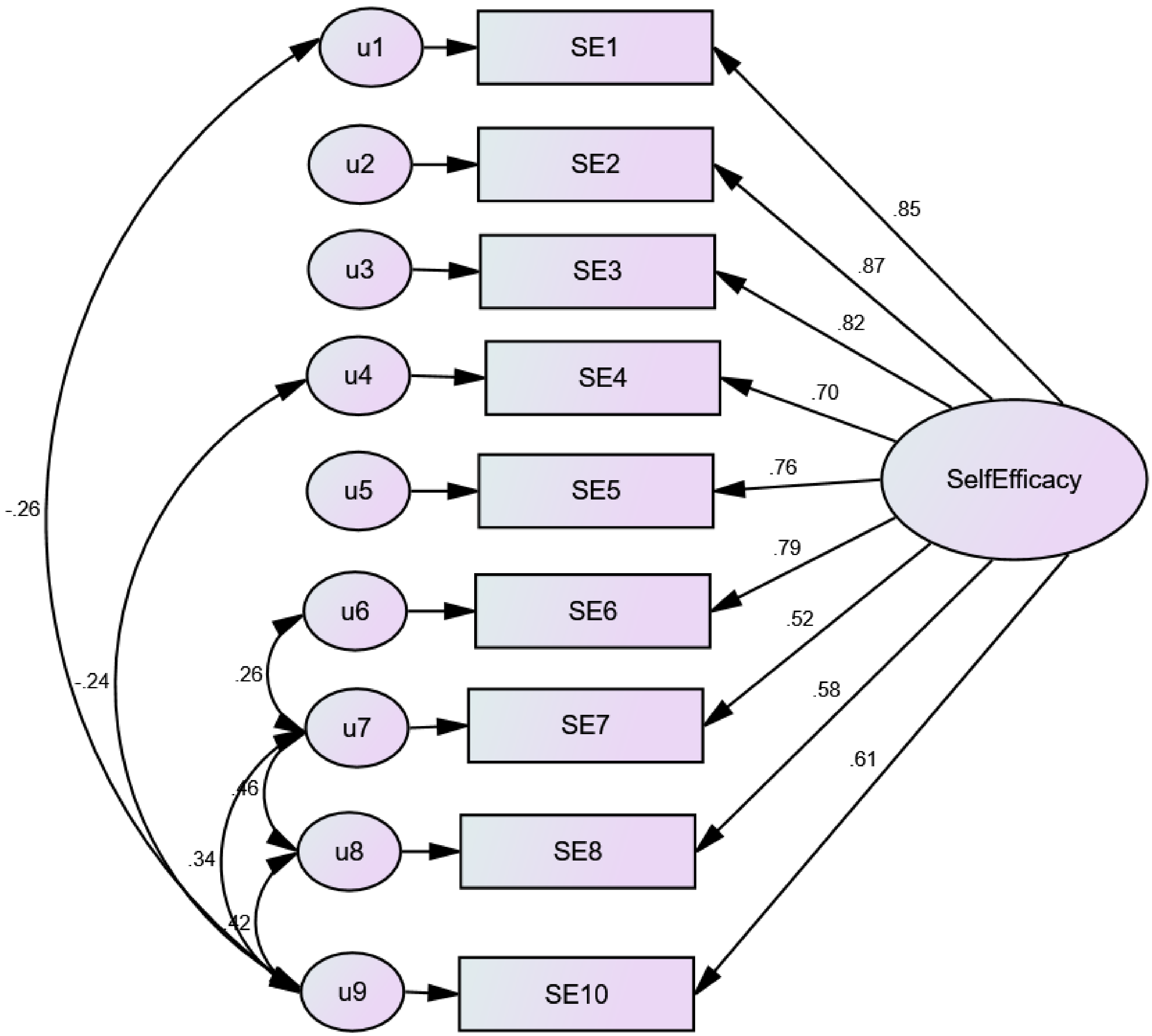
Appendix E

Confirmatory Factor Analysis Hypothesized Model: Self-Efficacy



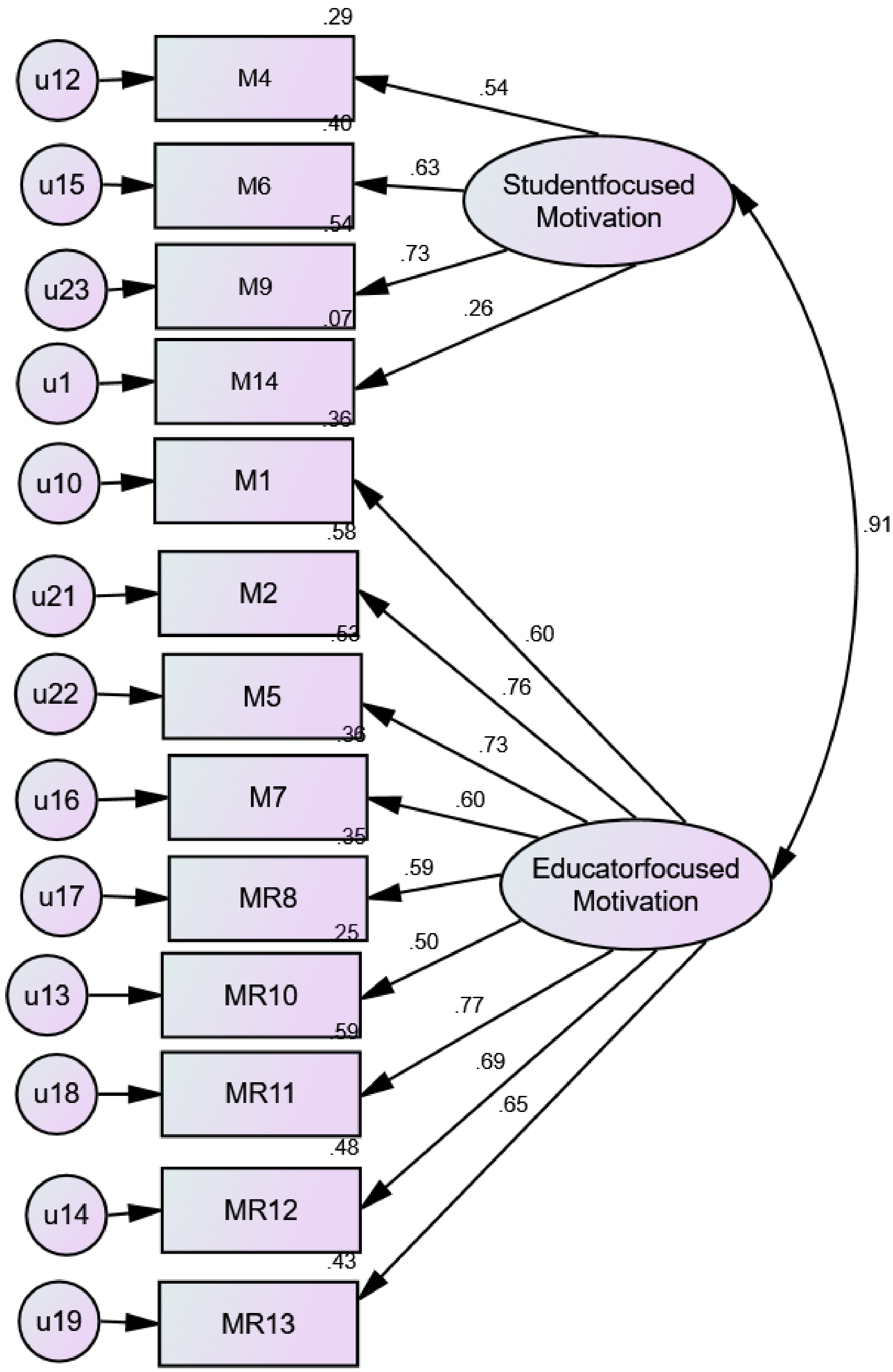
Appendix F

Confirmatory Factor Analysis Respecified Model: Self-Efficacy



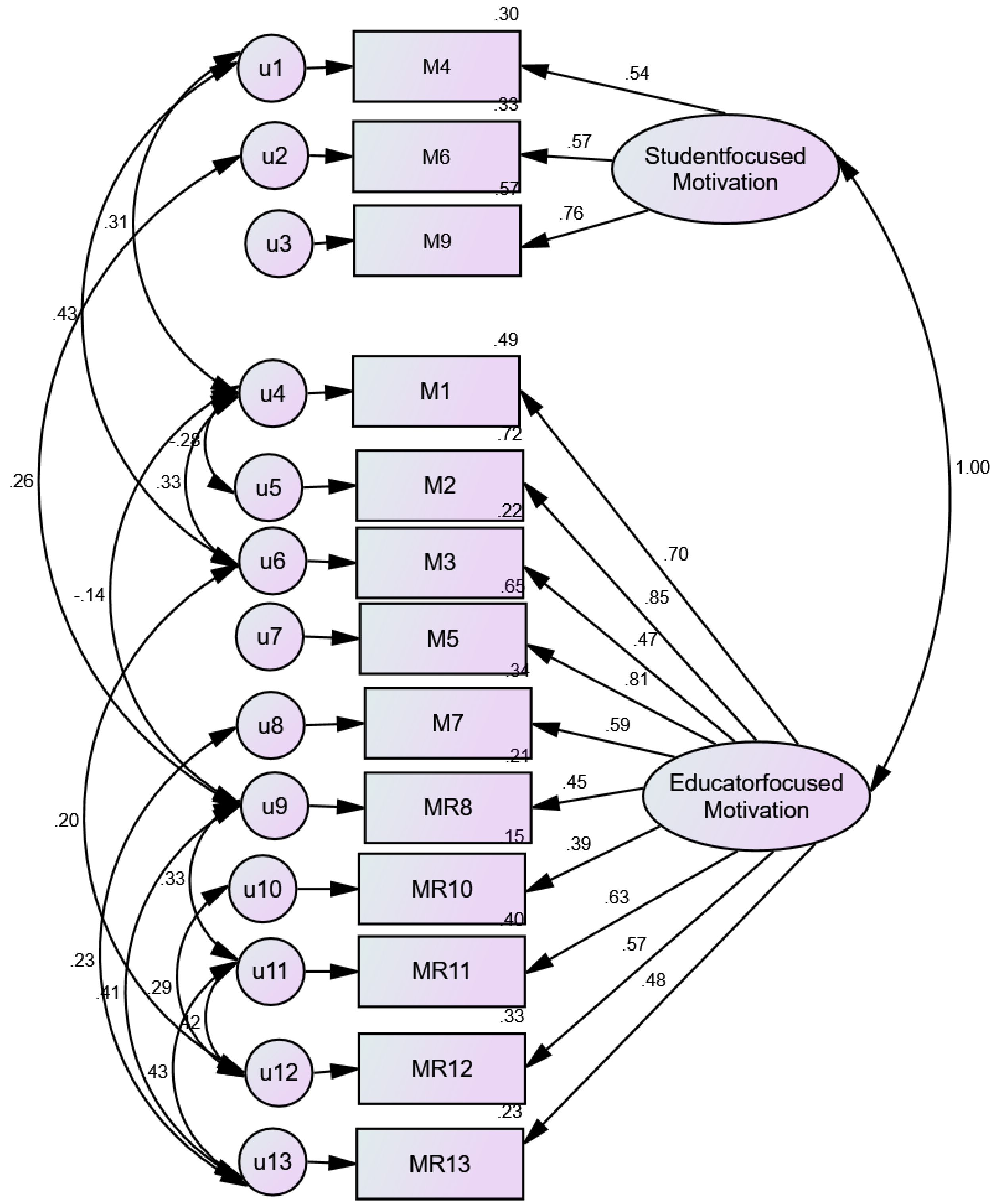
Appendix G

Confirmatory Factor Analysis Hypothesized Model: Motivation



Appendix H

Confirmatory Factor Analysis Respecified Model: Model



Appendix I

Institutional Review Board Approval to Conduct Research

AUBURN UNIVERSITY INSTITUTIONAL REVIEW **BOARD** for RESEARCH INVOLVING HUMAN SUBJECTS

REQUEST FOR EXEMPT CATEGORY RESEARCH

For Information or help completing this form, contact: THE OFFICE OF RESEARCH COMPLIANCE, 115 Ramsay Hall
Phone: 334-844-5966 e-mail: IRBAdmin@auburn.edu Web Address: http://www.auburn.edu/research/vpr/ohs/index.htm

Revised 2/1/2014 **Submit completed form to IRBsubmit@ auburn.edu or 115 Ramsay Hall, Auburn University 36849.**

Form must be populated using Adobe Acrobat *I* P ro 9 o r g r eater standalone program (do not fill out in browser). Hand written forms will not be accepted.

Proiect activities mav not begin until vou have receivedapproval from the Auburn Universitv/RB.

1. PROJECT PERSONNEL & TRAINING

PRINCIPAL INVESTIGATOR (PQ:

Name Shannon Bales Title Graduate Student Dept/School College of Education

Address 1463 Halev Center. Auburn Universitv AU Email smb0015@aubumedu

Phone 334-844-4104 Dept. Head Dr. David Virtue

FACULTY ADVISOR (if applicableJ:

Name Dr. Christine Schnittka Title A_s_s_oc_i_at_e_P_r_o_fe_s_so_r_ Dept/School College of Education

Address 5072 Halev Center. Auburn Universitv

Phone (334) 844-8277 AU Email cgs0013@aubumedu

KEYPERSONNEL: ListKeyPersonnel(otherthanPlandFA). Additionalpersonnelmaybelistedinanattachment

Name	Title	Institution	Responsibilities

KEY PERSONNEL TRAINING: Have all Key Personnel completed CITI Human Research Training (including elective modulesrelatedtothisresearch) withinthelast3years? [Z] YES D NO

TRAINING CERTIFICATES: Please attach CITI completion certificates for all Key Personnel.

2. PROJECT INFORMATION

Title: Self-efficacv and Motivation of Afterschool Educators Regarding STEM Implementation

Source of Funding [Z] Investigator D Internal D External

ListExternal Agency & Grant Number:__________

Listany contractors, sub-contractors, or other entities associate with this project.

Listanyother IRBs associated with this project (including those involved with reviewing, deferring, or determinations).

FOR ORC OFFICE USE ONLY

DATE RECEIVED IN O RC: _____by_____
DATE OF IRB REVIEW: _____by_____
DATE OF ORC REVIEW: _____by_____
DATE OF APPROVAL: _____by_____
COMMENTS:

APPROVAL
APPROVAL C
INTERVAL F

The Auburn University Institutional Review Board has approved this Document for use from
02/19/2018 to ---
Protocol # ----- 18-046 EX 1802

1 of3

3. **PROJECT SUMMARY**

a. **Does the research involve any special populations?**

D YES [Z] NO Minors (under age 19)

D YES [Z] NO Pregnant women, fetuses, or any products of conception

D YES [Z] NO Prisoners or Wards

D YES [Z] NO Individuals with compromised autonomy and/or decisional capacity

b. **Does the research pose more than minimal risk to participants?** DYES [Z] NO

Minimal risk means that the probability and magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests. 42 CFR 46.102(i)

c. **Does the study involve any of the following?**

D YES [Z] NO **Procedures subject to FDA Regulation** Ex. Drugs, biological products, medical devices, etc.

D YES [Z] NO **Use of school records of identifiable students or information from instructors about specific students**

☐ YES [Z] NO **Protected health or medical information when there is a direct or indirect link that could identify the participant**

☐ YES [Z] NO **Collection of sensitive aspects of the participant's own behavior, such as illegal conduct, drug use, sexual behavior or use of alcohol**

☐ YES [Z] NO **Deception of participants**

If you checked "YES" to any response in Question #3 STOP. It is likely that your study does not meet the "EXEMPT" requirements. Please complete a PROTOCOL FORM for Expedited or Full Board Review.

You may contact /RB Administration for more information. (Phone: 334-844-5966 or Email: IRBAdmin@auburn.edu)

4. **PROJECT DESCRIPTION**

a. **Subject Population** (Describe, include age, special population characteristics, etc.)

The population consisted of afterschool program staff in the state of Alabama that ranged in age from 21-70 years of age.

b. **Describe, step by step, all procedures and methods that will be used to consent participants.**

[2] **N/A (Existing data will be used)**

2 of3

c. **Brief summary of project.** (Include the research question(s) and a brief description of the methodology, including recruitment and how data will be collected and protected.)

The purpose of this study is to determine the impact of professional development on teachers' self-efficacy regarding STEM. Also, the purpose of this study is to teach educators how to use engineering design-based curriculum, help them overcome reluctance to teach engineering, help them understand the engineering design cycle, and teach them core science content.

The research questions related to this study include:

1. How well did the workshop improve teacher's science content knowledge?
2. How well did the workshop help teachers gain confidence to teach STEM activities?
3. How well did the workshop motivate teachers to teach STEM activities?

Educators from after school programs attended a one-day professional development workshop on April 1st, 2017.

The research questions will be answered through surveys that were administered after the workshop ended.

Participants were recruited based on their association with 21st CCLC grantee list. Emails and registration links (alabamaacn.org) were sent out to the selected schools and participants were encouraged to register for the workshop.

To protect the identity of all participants, the identities of participants will not be disclosed. The investigators protected participants' identities by creating a code that replaced their names. All data are stored on a secured, password protected computer dedicated to this project. Furthermore, the data do not include sensitive or risky information. The data are from surveys that are attached.

d. **Waivers. Check any waivers that apply and describe how the project meets the criteria for the waiver.**

- [Z] **Waiver of Consent (Including existing de-identified data)**
- D **Waiver of Documentation of Consent (Use of Information Letter)**
- D **Waiver of Parental Permission (for college students)**

Data were collected last year during a workshop conducted for the PI's work with the Truman Pierce Institute. Since then the PI has decided to focus her dissertation on the topic. The data are de-identified and codes replace the names. The PI no longer has access to a key linking the data with the original names of participants.

e. **Attachments.** **Please attach Informed Consents, Information Letters, data collection instrument(s), advertisements/recruiting materials, or permission letters/site authorizations as appropriate.**

Signature of Investigator ______ Digitally signed by Shannon Bales Date 01-31-18

Digitally signed by Christine

Signature of Faculty Advisor Christine Schnittka Date 02-01-18

Dr. David C. Virtue

Signature of Department Head Date 02-01-18

AUBURN UNIVERSITY INSTITUTIONAL REVIEW BOARD for RESEARCH INVOLVING HUM AN SUBJECTS

REQUEST FOR EXEMPT CATEGORY RESEARCH

For Information or help completing this form, contact: **THE OFFICE OF RESEARCH COMPLIANCE**, 115 Ramsay Hall
Phone: 334-844-5966 **e-mail:** IRBAdmin@auburn.edu **Web Address:** http://www.auburn.edu/research/vpr/ohs/index.htm

Revised 2/1/2014 **Submit completed form to IRBsubmit@auburn.edu or 115 Ramsay Hall, Auburn University 36849.**

Form must be populated using Adobe Acrobat / Pro 9 or greater standalone program (do not fill out in browser). Hand written forms will not be accepted.

Project activities may not begin until you have received approval from the Auburn University IRB.

1. **PROJECT PERSONNEL & TRAINING**

PRINCIPAL INVESTIGATOR (PI):

Name Shannon Bales **Title** Graduate Student **Dept./School** College of Education

Address 111 Hall Hill Ct Enterprise AL **AU Email** smb0015@auburn.edu

Phone 334-332-6368 **Dept. Head** Dr. David Virtue

FACULTY ADVISOR (if applicable):

Name Dr. Christine Schnittka **Title** Associate Professor **Dept./School** College of Education

Address 5072 Haley Center, Auburn University

Phone (334) 844-8277 **AU Email** cgs0013@auburn.edu

KEY PERSONNEL: **List Key Personnel (other than PI and FA).** Additional personnel may be listed in an attachment.

Name	Title	Institution	Responsibilities

KEY PERSONNEL TRAINING: **Have all Key Personnel completed CITI Human Research Training (including elective modules related to this research) within the last 3 years?** [X] YES [ ] NO

TRAINING CERTIFICATES: **Please attach CITI completion certificates for all Key Personnel.**

2. **PROJECT INFORMATION**

Title: Self-efficacy and Motivation of Afterschool Educators Regarding STEM Implementation

Source of Funding: [X] Investigator [ ] Internal [ ] External

List External Agency & Grant Number:

List any contractors, sub-contractors, or other entities associate with this project.

List any other IRBs associated with this project (including those involved with reviewing, deferring, or determinations).

FOR ORC OFFICE USE ONLY

DATE RECEIVED IN ORC:________ by________ APPROVAL #________

DATE OF IRB REVIEW:________ by________ APPROVAL CATEGORY:____ DATE OF ORC REVIEW:________

________ by________ INTERVAL FOR CONTINUING REVIEW:________

DATE OF APPROVAL:________ by________

COMMENTS:

The Auburn University Institutional Review Board has approved this Document for use from 09/24/18 to -------- Protocol # 18-375 EX 1809

1 of 3

3. **PROJECT SUMMARY**

a. **Does the research involve any special populations?**

- ☐ YES ☑ NO Minors (under age 19)
- ☐ YES ☑ NO Pregnant women, fetuses, or any products of conception
- ☐ YES ☑ NO Prisoners or Wards
- ☐ YES ☑ NO Individuals with compromised autonomy and/or decisional capacity

b. **Does the research pose more than minimal risk to participants?** ☐ YES ☒ NO

Minimal risk means that the probability and magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests. 42 CFR 46.102(i)

c. **Does the study involve any of the following?**

- ☐ YES ☒ NO **Procedures subject to FDA Regulation** Ex. Drugs, biological products, medical devices, etc.
- ☐ YES ☒ NO **Use of school records of identifiable students or information from instructors about specific students**
- ☐ YES ☒ NO **Protected health or medical information when there is a direct or indirect link that could identify the participant**
- ☐ YES ☒ NO **Collection of sensitive aspects of the participant's own behavior, such as illegal conduct, drug use, sexual behavior or use of alcohol**
- ☐ YES ☒ NO **Deception of participants**

If you checked "YES" to any response in Question #3 STOP. It is likely that your study does not meet the "EXEMPT" requirements. Please complete a PROTOCOL FORM for Expedited or Full Board Review.
You may contact IRB Administration for more information. (Phone: 334-844-5966 or Email: IRBAdmin@auburn.edu)

4. **PROJECT DESCRIPTION**

a. **Subject Population** (Describe, include age, special population characteristics, etc.)

The population will consist of afterschool program staff/educators that range in age. Some educators will be certified teachers while other employees will be staff hired from the community.

b. **Describe, step by step, all procedures and methods that will be used to consent participants.**

☐ **N/A (Existing data will be used)**

The survey that will be distributed via Qualtrics will contain an information letter. The letter (attached) will describe what is involved in participating, any known risks or discomforts, information regarding withdrawing from the study, and information regarding anonymity. By clicking on the "Next" button at the bottom of the homepage of the survey, participants give their consent to participate. Link to the survey: https://auburn.qualtrics.com/jfe/form/SV_9YLC8As0hjpXDCZ

c. **Brief summary of project.** (Include the research question(s) and a brief description of the methodology, including recruitment and how data will be collected and protected.)

The purpose of this study is to develop and validate a tool to measure STEM motivation and self-efficacy so that researchers can better understand how a STEM professional development workshop improves teachers' self-efficacy and motivation to implement STEM in their afterschool programs. The research question guiding this study is the following:

1. What evidence of validity supports the proposed STEM Attitudes of Educators instrument in evaluating educator motivation and self-efficacy regarding STEM implementation.

To answer these questions, participants will be recruited using a listserv of 21st Century Community Learning Center grantees. This listserv contains afterschool program staff across the state of Alabama. A link to the Qualtrics survey will be distributed via this listserv. The homepage of the survey will contain an information letter (attached) that will describe the study and what participation entails. By clicking the "Next" button, participants give their consent to participate. To protect participants' identities, no survey questions with identifiable information will be asked. Furthermore, we do not anticipate that the data will include sensitive or risky information.

d. **Waivers. Check any waivers that apply and describe how the project meets the criteria for the waiver.**

____ **Waiver of Consent (Including existing de-identified data)**

✔ **Waiver of Documentation of Consent (Use of Information Letter)**

Waiver of Parental Permission (for college students)

A survey letter (attached) will be used at the beginning of the survey to disclose the research objectives and any information regarding anticipated risks.

e. **Attachments.** **Please attach Informed Consents, Information Letters, data collection instrument(s), advertisements/recruiting materials, or permission letters/site authorizations as appropriate.**

Signature of Investigator ____ Digitally signed by Shannon Bales Date: 2018.08.29 14:32:44 -05'00' Date 8-29-18

Signature of Faculty Advisor ____ Digitally signed by Christine Schnittka DN: cn=Christine Schnittka, o=Auburn University, ou=Curriculum & Teaching, email=cgs0013@auburn.edu, c=US Date: 2018.09.04 14:30:06 -05'00' Date 9-4-18

Signature of Department Head Dr. David C. Virtue Digitally signed by Dr. David C. Virtue Date: 2018.09.05 16:00:38 -05'00' Date ____

Appendix J

The Estimation for Regression Weights of Final Model: Self-efficacy

			Estimate	S.E.	C.R.	*p*	Standardized Coefficient
SE8	<---	SelfEfficacy	.941	.102	9.255	***	.576
SE5	<---	SelfEfficacy	1.345	.155	8.670	***	.760
SE2	<---	SelfEfficacy	1.813	.192	9.463	***	.873
SE10	<---	SelfEfficacy	1.000				.606
SE1	<---	SelfEfficacy	1.613	.188	8.572	***	.851
SE3	<---	SelfEfficacy	1.649	.181	9.120	***	.821
SE4	<---	SelfEfficacy	1.526	.206	7.403	***	.698
SE6	<---	SelfEfficacy	1.353	.152	8.880	***	.788
SE7	<---	SelfEfficacy	.979	.123	7.970	***	.524

***p<.001

Appendix K

The Estimation for Regression Weights of Final Model: Motivation

			Estimate	S.E.	C.R.	*p*	Standardized Coefficients
M6	<---	Studentfocused_Motivation	.779	.121	6.434	***	.574
M4	<---	Studentfocused_Motivation	1.000				.544
MR13	<---	Educatorfocused_Motivation	.714	.111	6.450	***	.481
MR12	<---	Educatorfocused_Motivation	.777	.102	7.615	***	.572
M5	<---	Educatorfocused_Motivation	.955	.092	10.414	***	.808
MR10	<---	Educatorfocused_Motivation	.596	.112	5.316	***	.394
MR11	<---	Educatorfocused_Motivation	.779	.093	8.366	***	.632
MR8	<---	Educatorfocused_Motivation	.619	.108	5.754	***	.454
M7	<---	Educatorfocused_Motivation	.919	.118	7.779	***	.585
M2	<---	Educatorfocused_Motivation	.897	.091	9.893	***	.849
M1	<---	Educatorfocused_Motivation	1.000				.702
M9	<---	Studentfocused_Motivation	1.214	.160	7.583	***	.756
M3	<---	Educatorfocused_Motivation	.741	.100	7.390	***	.470

***p<.001