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The Impact of a Science Fair on High School Students' Feelings of Self-Efficacy in STEM

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THE IMPACT OF A SCIENCE FAIR ON HIGH SCHOOL STUDENTS' FEELINGS OF SELF-EFFICACY IN STEM

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Dedication

I dedicate this work to my loving and always supportive wife and as an example for my children to keep progressing in difficult times and to fearlessly pursue opportunities as they are presented.

Acknowledgments

To my wife and children: thank you for understanding that, when the opportunity to do a doctorate presented itself, it was my duty to pursue it! Thank you for all the encouragement and unwavering support. Without it, this dissertation would not have been possible.

To my parents: thank you for teaching me the value of hard work and perseverance, while serving others before yourselves. To my grandparents: thank you for all you sacrificed throughout the years to establish a better future for all of your kids and grandkids.

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Abstract

The purpose of this present action research study was to describe secondary students' feelings of self-efficacy in science, technology, engineering, and mathematics (STEM). Through a curriculum linked to a science fair project, the teacher-researcher focused on student-participants' perceptions of perseverance and task completion linked to STEM courses and postsecondary STEM careers. A Likert scale pretest (n=44) and posttest (n=33) based on Bandura's model of four categories of self-efficacy (mastery experience, vicarious experiences, verbal/social persuasion, and emotional/psychological states) was administered to middle to low income students at a high school in Pennsylvania in the fall of 2018.). Data was also collected data through semi-structured interviews, informal interviews, teacher journal entries, observational field notes, and concept maps. Findings revealed that there was a 3.29% decrease across the cumulative average of all participants in STEM self-efficacy, and a 0.32% increase in the cumulative average of the economically disadvantaged group.

Three domains were measured in this action research: social, academic, and emotional. For the social domain, there was a 0.84% decrease in scores across the entire population, with scores of 33.75 on the pretest and 33.47 on the posttest. Within this domain, average scores for the economically disadvantaged population increased by 5.81% pretest to posttest from 33.83 to 35.8, respectively. Academic domain scores decreased by 3.27%, from 33.18 pretest to 32.10 posttest. In the same domain, economically disadvantaged students decreased from 3.61%, from 33.75 pretest to 33.54

posttest. Lastly, emotional scores dropped 5.99% among the entire population, from 31.09 pretest to 29.23 posttest, and emotional scores in the economically disadvantaged decreased by 4.79%, from 30.25 pretest to 28.8 posttest. This data was polyangulated through semi-structured interviews, informal interviews, teacher journal entries, observational field notes, and concept maps.

To improve participation of economically disadvantaged students in STEM science fairs, an action plan of researching, developing, and sharing strategies for self-efficacy in learners will be developed.   This data is helpful as it provided a platform for an action plan to be facilitated to improve the Science Fair preparation process to promote STEM self-efficacy.

KEYWORDS: *Bandura self-efficacy, Bloom Taxonomy; metacognition, secondary education, STEM education, science fairs and self-efficacy*

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Key Terms

Affective Domain	The *affective domain* is part of Bloom et al.'s Taxonomy of Educational Objectives (Bloom, 1956; Krathwohl, Bloom, & Masia, 1964; see Anderson & Krathwohl, 2001 for revised Taxonomy), a classification of educational objectives for identifying, understanding, and addressing how people learn. The other objectives are the cognitive domain and the psychomotor domain. Teaching in the affective domain incorporates feeling and emotion, allows students to express themselves, encourages participation and response, and gives students the opportunity to draw their own conclusions.
Cognitive Domain	The *cognitive domain* is the second part of Bloom et al.'s Taxonomy of educational objectives (Bloom, 1956; Krathwohl, Bloom, & Masia, 1964; see Anderson & Krathwohl, 2001 for the revised Taxonomy; also see *affective domain*, this section). The cognitive domain involves the acquisition and recognition or recall of knowledge and the development of a student's skills and abilities. Teaching in the cognitive domain typically involves standardized tests and assessments.
Economically Disadvantaged	In Pennsylvania, it is at the discretion of the District to determine if a student is *economically disadvantaged*. Poverty data sources such as Temporary Assistance for Needy Families cases, census poor, Medicaid, children living in institutions that are neglected or delinquent, those supported in foster homes or free/reduced price lunch eligibility may be used. The District determines the percentage of economically disadvantaged students based on October enrollment. The percentage is calculated by dividing the number of students identified as economically disadvantaged in the district divided by total district enrollment (Pennsylvania Department of Education, 2016).
Holistic	A *holistic* approach to learning focuses on the entire student, including psychological and social factors. Holistic teaching emphasizes social interactions, community, active learning, emotion, and social justice (Dewey, 1938).

Metacognition	*Metacognition* means awareness of one's own thought process. Literally, it means students are "thinking about thinking" so they can improve the quality of their thinking and learning (see Flavell, 1979).
Pragmatism	*Pragmatism* is an American philosophical movement founded by C. S. Peirce and William James. The doctrine holds that the meaning of conceptions is to be sought in their practice bearings, that the function of thought is to guide action, and that truth is preeminently to be tested by the practice consequence of the belief (pragmatism, n.d.). *Pragmatism* in education means that reality must be experienced and that students learn by doing. John Dewey (1938) believed that human beings learned through a "hands on" approach.
Psychomotor Domain	The *psychomotor domain* is the third part of Bloom et al.'s Taxonomy of educational objectives (see Bloom, 1956; Krathwohl, Bloom, & Masia, 1964; see Anderson & Krathwohl, 2001 for revised Taxonomy; also see *affective domain and cognitive domain*, this section).
Self-efficacy	*Self-efficacy* means one's belief in his/her ability to succeed in specific situations or accomplish a task (Bandura, 1997).
Social Justice	In education, *social justice* means promoting equal opportunities to reduce inequality. It means equal educational opportunities in the form of access and equity for every child regardless of race, class, gender, or sexual orientation (US Department of Education, 2009).
Social Meliorism	*Social meliorism* curriculum theory holds that the goal of education is to bring about change and societal improvement (Kim, 2018).

Chapter One: Introduction

Current student assessments at Highland High School (Highland) rely on student application of specific science concepts and the recall of memorized information. Following famed educator John Dewey's (1938) holistic approach, many of us who teach at Highland have recently discovered the benefits of a sociocultural model of learning and as such, we aim to combine our curricular designs with inquiry-based pedagogical practices that are designed to enhance student learning and to address the psychological influences that adult curricular decisions have upon our students' feelings of efficaciousness. I agree with Barth (2001) who argues that, "good education is more than good scores and good teaching is more than generating good scores" (p. 156). Further, I believe that, to increase achievement, educators must build a student's self-efficacy. According to Bandura (1997):

> It is not enough for individuals to possess the requisite knowledge and skills to perform a task; they also must have conviction that they can successfully perform the required behavior(s) under typical and, importantly, under challenging circumstances. (p. 193)

Today, in public schools in the United States, science instructors are required to further their students' scientific knowledge and to prepare them for secondary and post-secondary coursework and careers in science, technology, engineering, and math (STEM). In addition to building cognitive fortitude, successful teachers are expected to nourish and support the development of the affective domain by using activities that build their students' psychomotor domains and positive sense of self by using a hands-on, constructivist pedagogy that enables students to work in collaborative groups (Anderson & Krathwohl, 2001).

Action Research

According to Mertler (2017), action research involves teachers "gathering information about how their particular schools operate, how they teach, and how their students learn" (p. 4). As such, teachers often engage in action research to improve educational practices within their classrooms or schools (McMillan, 2004)

As a science teacher at Highland, I created this action research study because it was unclear to me whether my school's science fair curriculum and pedagogy had an impact on my student's feelings of self-efficacy. Thirty-five percent of my school's students qualify for free or reduced meals. As children of working class parents, many of my past students have expressed to me that the Science Fair wasn't for "the likes of them." This is one of the reasons I became interested in students' feelings of self-efficacy regarding STEM courses and careers and began to consider the Science Fair as an exploration into that world. In alignment with the theory of social meliorism (Kim, 2018; Stuhr, 2016), I believe that STEM opportunities, like Science Fair, present a unique opportunity to do good in the world while supporting one's self.

In the present study, I explored my students' preparation for the Science Fair, their feelings of self-efficacy about preparing for it, and their feelings about STEM in general. I also examined feelings of self-efficacy among students from different economic backgrounds.

My participants and I, in classes of 18 to 25 students, met for 35 minutes (one classroom period), twice every six days. Students could also opt to meet for a third "laboratory period" day. Forty-four of my 46 students (17 males and 27 females) agreed to participate in the study. Twelve participants, or 27%, qualified as economically disadvantaged.

Science Fairs

A longitudinal study by George (2003) measured students' science self-concepts, achievement motivation, attitudes, perceptions of teacher encouragement, and motivation towards the utility of science. Using survey data to extract data from 444 students from middle school through 11th grade, he found strong connections between science activities and attitudes. George highlighted the connection between positive attitudes towards science and participation in science activities like science fairs. The study showed increases in positive attitudes, perception of teacher support/encouragement, and self-concept. Studies by Marsh, Xu, and Martin (2012) further showed a positive relationship between academic performance and levels of self-concept, which Berk (2008) and Sigelman and Rider (2009) defined as a representation of oneself as a whole.

Students develop self-concept through six domains: physical, personal, moral, family, social, and academic (Fitts & Warren, 2003). Self-concept can be changed from negative to positive (Franken, 2007), which is critical for motivation (Huang, 2011), self-control (Fitts & Warren, 2003), student behavior (Bidell & Deacon, 2010), and academic performance (Marsh et al., 2012). Sorge, Newsome, and Hagerty (2000) explained that academic achievement and career selection are all based on self-concept. Thus, to promote the highest possible outcomes for students, it is imperative for teachers to foster positive self-concept.

Tan and Barton (2010) demonstrated higher levels of student engagement in the learning process when they based principles of authentic science practices and selection of topics on student interest. Lee and Songer (2003) bolstered these results when they found that authentic science practices improved engagement more than traditional study. Lastly, according to Schmidt and Kelter (2017), science fairs helped increase understanding of student inquiry, positively influenced student attitudes, and opened up possible careers paths in scientific fields.

Science fairs offer an opportunity to blend inquiry and authentic science and provide opportunities to build self-efficacy. Allowing students to explore inquiry-based projects while receiving support from teachers, equal access to resources, and positive encouragement, can help produce a more positive self-concept (Akinoglu, 2008). Terzian (2013) explained that offering after school STEM clubs and requiring science fair projects is likely to result in more students pursuing STEM related careers. Further, creating a successful Science Fair experience at Highland could provide a methodology to reduce the marginalization of economically disadvantaged learners and provide previously unimaginable STEM opportunities for all students. Using curriculum and pedagogy to address economic inequalities could be a step towards breaking the cycle of poverty. Barton (2001) explained that these inequalities lead to lower achievement, resources available, expectations, and an overall negative learning environment.

I believe that Science Fairs provide a unique opportunity to find out how Science Fair preparation influences efficacy and I intend to use this knowledge to increase STEM efficacy among economically disadvantaged students at Highland and beyond. I will use the findings from the present study to lead educational change, by analyzing self-efficacy in relationship to the Science Fair at Highland and to STEM education. This will add to the breadth of knowledge within this area. I intend to conduct future case studies, in order to improve my curriculum and pedagogy and to further promote student STEM self-efficacy. This will provide me with a platform to better understand how to provide continual support for economically disadvantaged students and to promote equality, participation, and success for all students, so they develop an efficacious attitude towards STEM classwork and careers. As Schmidt and Kelter (2017) explained, science fairs may play a major role in generating interest and promoting the skills needed to succeed in STEM related fields.

The History of Science Fairs in the United States

The earliest recorded public exposition of scientific investigation in the United States was in 1828 at the American Institute of the City of New York's first industrial fair. This exposition provided awards based upon the evaluation of technological and scientific innovations (Bellipanni & Lilly, 1999). Since that time, science expositions have evolved in both scope and sequence and are a familiar aspect of many science curriculums. They were often championed as a way to explore the scientific process and to improve positive attitudes towards science (Abernathy & Vineyard, 2001; Bellipanni & Lilly, 1999; Bruce & Bruce, 2000). These science fairs largely focused on promoting industrialization in the United States. Still today, many competitions have corporate sponsors who provide cash awards, mentorships, and scholarships to students based on merit.

The evolving role and focus of Science Fairs and expositions also has its roots in economic, industrial, and wartime initiatives (Terzian, 2009; Society for Science, n.d.-a; Silverman, 1986). Following the devastating destruction of World War I, scientist Morris Meister established the first science clubs in New York City, thereby introducing a higher level of rigor within the public school curriculum (Terzian, 2013). In 1921, journalist Edward W. Scripps and zoologist William Emerson Ritter founded an organization called the Science Service, with the goal of communicating scientific information and advancements to the public. Science Service subsequently published a newsletter for distribution to libraries, schools, and individuals (Society for Science, n.d.-b). In 1928, the American Institute of New York City held its first children's Science Fair; students exhibited projects relating to nature, conservation practices, and agriculture (Silverman, 1986). The successful fair became an annual event and is now regarded as the model for all subsequent Science Fairs (Silverman, 1986).

The 1939–1940 World Fair in New York City was designed to promote U.S. citizens' confidence in military and industrial capabilities (Terzian, 2009). The science fair there, organized by the American Institute, with support from Westinghouse Electric and Manufacturing Company, showcased student work in various scientific fields, including biology, astronomy, chemistry, and physics. By highlighting science fairs, clubs, and talent searches, the American Institute hoped to demonstrate the prominence of the extra science curriculum (Terzian, 2009). At the Fair, Westinghouse also created a "120-foot-high Tower of Singing Light," which showed how electricity was received and transmitted. Westinghouse hoped the tower would generate student interest in science and the scientific method and promote future careers in science (Terzian, 2009).

In 1941, the location for the popularization of science shifted from the American Institute in New York to the Science Service in Washington, D.C. and, in 1942, the Science Service and Westinghouse created the Westinghouse Science Talent Search, to reward high school seniors through a merit-based scholarship contest (Society for Science, n.d.-d). The Science Talent Search's stated purpose was to encourage talented students to pursue a career in science or engineering (Society for Science, n.d.-a). The Talent Search was building off the popular science club momentum, which was already boosting the number of students entering engineering and science fields. In 1950, the first International Science and Engineering Fair took place in Philadelphia (Society for Science, n.d.-e). By this time, science fairs had started entering the major science curriculum at the national level. In 1964, in Seattle, Washington, finalists from over 200 affiliated fairs presented their projects, which represented the finest displays out of almost one million students who had advanced to the National Science Fair-International. These finalists were from 208 regional Science Fairs and represented 17 foreign countries, American Samoa, and Guam (Brown et al., 1986). In 1959, in response to the Cold War, U.S. Science Fairs emphasized innovation and touted individual contributions, to emphasize the future of these scientists and, ultimately, the country.

Bellipanni (1994) studied the 1993 International Science and Engineering Fair (ISEF) to collect data to find out if a relationship existed between those who received awards and various variables. To do this, Bellipanni used the science fair survey created by Gifford and Wiygul (1992), which he administered to participants in the International Science and Engineering Fair. Bellipani collected information about variables such as time, cost, individual characteristics, and access to facilities. In 1999, Elmer's Glue, Discovery Communications, and Science Service established the Discovery Channel Young Scientist Challenge; a competition focused on promoting middle school science and innovative solutions to solve practical and daily problems. 3M, the contest's co-sponsor, provided ten students with internships within their research science department. The final winner was deemed “America's Top Young Scientist” and received a prize of $25,000.

Science Fairs Today

Today, science fairs are a relatively common educational practice within U.S. science education. With objectives ranging from curriculum requirements to optional competitions, these fairs help students learn about the scientific method, foster positive attitudes towards science, and increase student interest in the subject (Abernathy & Vineyard, 2001; Bellipanni & Lilly, 1999; Bruce & Bruce, 2000).

Bruning, Shaw, and Ronning (1995) explained that, by using the research process to compose factual knowledge based upon personal interest, science fairs provide another method of learning. Bellipanni (1994) outlined seven major parts of a science fair: title, purpose, hypothesis, procedure, data, results, and conclusion. Wilson, Cordry, and Uline’s (2004) added 10 steps to the Science Fair process by mandating that students:

- outline their problem,
- choose variables,
- create hypothesis,
- explain variable manipulation,
- explain results,
- keep a logbook,

- evaluate data,
- create charts/graphs,
- determine conclusions, and
- decide about future studies.

Other critical components of the science fair process include inquiry-based skills, teamwork, data collection, analyzing, research, concluding research (Sumrall & Schillenger, 2004), and fostering an interest in science (Bellipanni & Lilly, 1999). Science fair presentations include a display board, which is logically organized and supported by visual graphics (Wilson et al., 2004). In a 2015 White House Science Fair address, President Barrack Obama addressed the student population and framed science fairs as a "critical way to understand and explore and engage with the world" (United States Office of the Press Secretary, 2015). He highlighted the importance of science education and stressed that it was an essential component of assuring America's future and its success within the global society. Despite President Obama's use of the U.S. Science Fair platform to outline the initiatives for STEM, which included a multitude of diverse career and educational paths for all students, many fail to acknowledge the connection between the two areas of science education, and thus view them as separate entities. As Schmidt & Kelter (2017) stated, "The research base regarding the effectiveness of Science Fairs in supporting student learning and attitudes towards STEM is scant" (p. 126).

Problem Statement

As the advisor for all high school students in the Highland School District who enroll in the Science Fair course and science fair competitions (Science Fair), I know first-hand how excited our students get about these competitions. Over the years, I have witnessed students become frustrated by time-consuming projects and overwhelmed by a lack of metacognitive, cross-curricular, higher-order thinking skills that are necessary to successfully complete advanced level science fair projects. I have also witnessed the emotional swings when a student's project does not go according to plan; and I have seen students feel inferior and inadequate when they compare their work to that of their peers. These feelings often lead to negative attitudes towards STEM. My experiences at Highland with the Science Fair and STEM led me to question the ways in which I might better enable my students—particularly my economically disadvantaged students—to be successful in STEM courses and postsecondary careers. Specifically, I wanted to know (a) how my existing practices (or lack thereof) influenced my students' feelings of STEM self-efficacy, (b) what role economic background played in student's feelings of STEM self-efficacy through the Science Fair experience, and (c) how I could improve my pedagogy and curriculum to help all of my students.

Statement of Purpose

In the high-stakes testing environment at my present school in Pennsylvania (Highland School District), curricular decisions increasingly rate student achievement based on standardized state and national assessments (Brandt, 2016). I believe that the STEM curriculum and its influence upon my students' sense of self-efficacy is equally as important and should be included in any measure designed to enable my students to achieve equity and access to advanced coursework and post-secondary schooling. I also think that science educators could use Science Fair preparation as an alternative assessment measure to enable economically disadvantaged and other marginalized groups of students to gain access to advanced STEM coursework and careers. Therefore, the purpose of this action research study was to explore the effects that a popular curriculum staple, the Science Fair preparation process, had on my high school students' feelings of self-efficacy. My secondary purpose in conducting this study was to explore alternative assessment strategies for my STEM students.

Research Question

What effects did the preparation for a Science Fair have on my high school students' feelings of STEM self-efficacy?

Sub-Question: Were there any differences in the response patterns between students from different economic backgrounds?

Scholarly Literature

Self-efficacy is the analysis of one's beliefs regarding one's abilities to achieve desired outcomes and goals (Bandura, 1997). Bandura (1986) hypothesized that self-efficacy helps predict what people will do with their skills and knowledge and explained how this expertise and experience might develop. He later stated that, "It is widely assumed that beliefs in personal determination of outcomes create a sense of efficacy and power, whereas beliefs that outcomes occur regardless of what one does result in apathy" (Bandura, 1997, p. 431).

Bandura (1997) argued that the foundation for success lay in a learner's skills and knowledge and in the underlying thought process that activated them. He explained that self-efficacy and its link to achievements are subsets of the learning environment, which must be examined for maximum educational effectiveness (Bandura, 1993). He also studied teachers' self-efficacy and how it affected the learning environment, stating, "the task of creating learning environments conducive to development of cognitive competencies rests heavily on the talents and self-efficacy of teachers" (p. 24).

In this study, I relied heavily on Bandura's research, including his four principles of self-efficacy: (a) mastery experience, (b) vicarious experience, (c) verbal/social persuasion, and (d) emotional and psychological state (Bandura, 1997). Mastery experience, which is dependent upon personal accomplishments, is the most successful way to build a sense of efficacy. Bandura (1994) explained that, because self-efficacy is constructed upon success and failures, it allows students to create a measure of their capabilities. Thus, experiences have the ability to shape positive or negative experiences, and are critical for any self-analysis of ability and self-efficacy—the student who believes that she/he will succeed is much more likely to do so.

Vicarious experiences, on the other hand, compares individual success to another's perceived abilities. In a vicarious experience, as the observer increasingly identifies similarities between him/herself and the desired model, there is a corresponding increase in desired success (Bandura, 1997). By modeling the goals and behaviors of peers, students have the ability to boost their self-efficacy. As Schunk (1987) stated, "the most accurate self-evaluations derive from comparisons with those who are similar in ability or characteristics being evaluated" (p. 149). Further, vicarious experiences that are exploratory and adaptive build the sense of science self-efficacy that strongly correlates to the design of this study (Britner & Pajares, 2006).

Verbal/social persuasion is the psychological influence one person has to influence the self-efficacy of another. Bandura believed that, as difficulties arose, if students can verbalize and discuss strategies to overcome challenges, a positive shift could occur (Bandura, 1977). In addition, Bandura argued that students who receive verbal praise experience an increase in perceived ability.

Finally, emotional and psychological influences may affect self-efficacy and future learning. As self-efficacy develops, so too, do values and beliefs. In turn, the emotion state assesses a student's comfort level within a class environment; for students who are naturally supportive and collaborative, self-efficacy increases (Bandura, 1994).

Because I was also interested in how science self-efficacy in high school students related to future educational and career choice, I sought out studies concerning this area, including Leong and Barak (2001), who believed that almost all individuals perceive a lack of abilities in certain areas and that these perceptions could limit careers and other success. Taylor and Betz (1983) also studied people's beliefs about themselves and the corresponding effects on success and career decisions. They found that, as efficacy in the desired career fields increased, so did the likelihood that one might pursue that path. Likewise, Betz (1992) found that career self-efficacy escalated through accomplishments, emotional connections, verbal affirmations, and vicarious experiences.

Students develop self-concept through six domains: physical, personal, moral, family, social, and academic (Fitts & Warren, 2003). Reshaping self-concept is critical for motivation (Huang, 2011), self-control (Fitts & Warren, 2003), student behavior Bidell & Deacon, 2010, and academic performance (Marsh et al., 2012). Sorge, Newsome, and Hagerty (2000) explained that academic achievement and career selection are all based on self-concept. Thus, to promote the highest possible outcomes for students, it is imperative to foster positive self-concept.

George (2003) conducted a longitudinal study that measured students' science self-concept, achievement motivation, attitude, perception of teacher encouragement, and motivation towards the utility of science. Using survey data to extract data from 444 students from middle school through 11th grade, he found strong connections between science activities and attitudes. In this study, George specifically highlighted the connection between positive attitudes towards science based upon participation in science activities such as science fairs. The study showed increases in positive attitudes, perception of teacher support/encouragement, and self-concept. Studies by Marsh et al., (2012) further showed a positive relationship between academic performance and levels of self-concept, which Berk (2008) and Sigelman and Rider (2009) defined as a representation of oneself as a whole.

Tan and Barton (2010) demonstrated higher levels of student engagement in the learning process when the researchers based principles of authentic science practices and selection of topics on student interest. Similarly, Lee and Songer (2003) found that authentic science practices improved engagement more so than traditional studies. Lastly, according to Schmidt and Kelter (2017), science fairs helped increase understanding of student inquiry, positively influenced student attitudes, and opened up possible careers paths into scientific fields.

Potential Weaknesses

One potential weakness in the present study was the familiarity and existing predispositions between me and my students. Another was the varying level of difficulty and workload among the students' Science Fair projects. A further weakness was the students' personalities and/or attitudes toward science. Students who were more reserved and/or who did not like science or the research project were less likely to participate fully, if at all.

Another potential weakness, which proved beyond the scope of this study, was not furthering a discussion of the intersectionality of social class and income inequality among my White middle class and working-class student-participants and the possible resulting power struggles among these students. Acknowledging how a hidden curriculum at the micro level dictates norms and structures, as experienced through the intersectionality within Whiteness, may provide a valuable starting point for such a discussion (Zwier & Grant, 2014).

Significance of the Study

The purpose of this study was to explore the Science Fair preparation process and examine its effect on students' self-efficacy. The Science Fair program at Highland is an elective independent research course with no prerequisites for enrollment. Removing these restrictions tripled student enrollment between 2014 and 2018. During this four-year period, Science Fair students received approximately 1.5 million dollars in college scholarship awards. These scholarships directly influenced the direction and career trajectory of many students. I believed, as a teacher-researcher, that there was a positive correlation between the current Science Fair structure and student self-efficacy and that, if the Science Fair process increased self-efficacy, it would then increase student participation in STEM classes and careers.

To obtain feedback regarding the Science Fair experience, I interviewed two former students who graduated from Highland and had returned to help judge Science

Fair competitions. One student was working in the professional sector as a writer for a newspaper and one was in college as a business major. I asked both students (student names are pseudonyms):

- What is your profession/major?
- Looking back, what were your feelings then and what are they now towards science fair projects?
- Has the science fair experience helped you in your professional life?
- What do you remember being intimidating/problematic?
- Did those problems influence your belief in your ability to do science?
- What do you feel was the most beneficial part of the Science Fair experience?
- Is there anything you think could have been done better or could be told to students going forward?

When I asked the first student (Matt) about his science fair experience and its relationship to his professional life, he surprised me when he said instead how the process helped him within his personal life. Matt explained that he had just recently used the scientific method, which he learned through the Science Fair, to evaluate a home he planned to purchase. He stated that the skills he learned through the STEM approach improved his proficiency to evaluate home options. Using principles of the scientific method, he used technology to find the home; engineering to evaluate insulation, heating systems, and floor plans; and mathematics to evaluate cost, interest rates, and purchase price. These connections are ones that my student made, which I never would have attributed to the Science Fair process.

The second student (Joe) said that he felt that the most beneficial part of preparing for a Science Fair was the development of his own ability and confidence to present to and interact with others. Joe told me proudly that he never prepared note cards anymore for presentations. He said that he was able to have conversations that challenged his ideas, without getting flustered or upset. He explained that the Science Fair process helped him in this area because he had received constructive criticism for his projects. He attributed his positive experiences and relationships to the presentations he participated in during Science Fairs.

These conversations were insightful and motivating to me as a teacher and revealed important constructs within the Science Fair program. The communications further fueled my interest in and inquiries into the influence of science fairs upon students' self-efficacy towards STEM related majors and career choices.

Conclusion

As Lefrancois (2000) summarized, most of what teachers do, directly and indirectly, influences students' perception of their own competence. Indeed, teachers have the ability to manipulate curricular practices to provide challenging yet achievable tasks, which can increase motivation and self-efficacy upon their completion. The task of preparing for the Science Fair is one such task. It structurally aligns with common best practices within education, including inquiry-based learning, independent research, and cross-curricular education.

In this study, I wanted to know if preparing for the Science Fair affected my high school students' self-efficacy towards the Science Fair and STEM. In Chapter One, I introduced the identified problem, set forth my research question and the purpose of the study, and discussed the history of science fairs in the United States. In Chapter Two, I describe my theoretical framework, review the literature about STEM and self-efficacy, examine Bloom's Taxonomy in relationship to the Science Fair, and discuss economic disadvantage and how it affects education. In Chapter Three, I discuss action research methods of data collection, reflection, and analysis. In Chapter Four, I detail the present study's findings and implications. In Chapter Five, I summarize the present study, draw conclusions, and describe the action plan for future Science Fair preparation and professional teacher development.

Chapter Two: Theoretical Framework and Literature Review

Introduction and Background

In Chapter Two, I discuss my theoretical framework and review the literature that provided a rationale and informed the design of my study. I created this action research study because it was unclear to me whether the curriculum and pedagogy involved in the preparation for our high school Science Fair was having an impact on my student's feelings of self-efficacy. I also wanted to know if there were differences in the feelings of STEM self-efficacy between students based on economic background.

To prepare for the study, I reviewed research on science fairs, student self-efficacy, and economic status and its impact upon education. To locate relevant research, I consulted a variety of sources, including textbooks, journals, the Education Resources Information Center (ERIC) database, EBSCOhost Research Interface, Google Scholar, and various electronic and print materials. I then selected and organized information, according to the parameters of the present study.

Theoretical Framework

I based this study on two theoretical combinations: the construct of self-efficacy within social cognitive theory and the principles that guide authentic science within a science fair approach. I explored a curriculum staple—the Science Fair—within the affective domain of teaching, to find out if the Science Fair process at Highland increased my high school grade students' self-efficacy, in order to help them succeed in the classroom and beyond.

I studied Benjamin Bloom's (1956) work on the influence of the affective domains of learning on the learning experience. Bloom identified three major domains: cognitive, affective, and psychomotor. The cognitive domain focuses on knowledge, skills, and intellectual abilities. The psychomotor domain relies upon the ability to apply motor skills or the ability to manipulate. The third domain, and the one analyzed in this study, is the affective domain. This domain outlines the values, interest, and attitudes of learners. I found that Bloom's taxonomy aligned with the theoretical framework of the present study due to the structural format of Science Fair projects within my classroom and that Science Fair preparation incorporated all three of Bloom's domains through laboratory and learning practices (Grounlund, 1991). Theoretically framed, the Science Fair aligned to Bloom's taxonomy because the project required students to receive phenomena (listen and respect others), internalize values (accept values and revisit judgements), and value/understand differences in individuals (Karthwhol et al., 1964). Applying Bloom's upper level frameworks (analysis, synthesis, and evaluation) to create pedagogy resulted in more authentic and meaningful activities for students to apply knowledge (Lord & Baviskar, 2007; see Figure 2.1).

My theoretical framework also relies heavily upon studies of social cognitive theory by Bandura (1977, 1986, 1991, 1995, 2002, 2006). For social cognitive theory's relationship to the construct of self-efficacy, I again consulted Bandura (1977, 1993, 1994, 1997, 2001, 2006), as well as Britner and Pajares (2006) and Schunk (1985, 1987).

Self-Efficacy Within Social Cognitive Theory

Social cognitive theory. Bandura (1986) defined social cognitive theory as an individual's judgement regarding their own belief of their capability to perform or produce (Bandura, 1986). Heslin and Klehe (2006) described it as the most powerful motivational predictor of performance on almost every undertaking. Bandura (1991; see also Lent, Brown, & Hackett, 1994; Jones, 1989) outlined an essential component of his social cognitive theory, which detailed how psychological and observational learning processes influence student learning. He explained that cognitive, behavioral, and environmental factors affect learning, which is then shaped by attention, retention, reproduction, and motivation.

Bandura (2006) believed that people are not simply onlookers of their behavior. Instead, he argued, they are self-organizing, proactive, self-regulating, and self-reflecting. They are contributors to their life circumstances, and not just products of them. Bandura called this human agency and stated that, to be an agent, an individual must intentionally influence his/her functioning and life circumstances (Bandura, 2006, p. 164). In Bandura's (1977, 1997, 2001) social cognitive theory, individuals reach goals due to their actions (Bandura, 2001, 2006). He stated that personal agency, working together with other sociostructural influences, increases performance towards goals that an individual believes are personally important (Bandura, 2012).

Self-efficacy. Embedded within social cognitive theory and the actions defined by human agency, is the construct of self-efficacy. Social cognitive theory, which examines the ability of individuals to "exercise control over the nature and quality of one's life" (Bandura, 2001, p. 1), also defines self-efficacy (Bandura, 1997). Ng and Lucianetti (2016) stated that the following three tenets are pertinent to beliefs regarding self-efficacy. First, that behavioral intensity and self-efficacy beliefs strongly correlate to behavioral intensity. Second, that anxiety and fear directly relate to a lack of growth in self-efficacy, due to the connection between poor performances and diminishing self-efficacy. Third, that there is a collective orientation between self-efficacy and agentic expectations (Ng & Lucianetti, 2016).

Bandura (1986) explained that human agency directly influences an individual's actions. Leveraging Bandura's studies allows for a better understanding of the influence of human agency over various beliefs upon the construct of self-efficacy. Bandura (2012) also said that efficacy drives behavioral intensity, especially when an individual's beliefs align strongly with a desired behavior and/or outcome. This is often dependent on valuing each individual and promoting platforms so they can freely create their ideas. Bandura further opined that the influence individuals have upon their behaviors correlates to the level of efficacy beliefs they possess (Bandura, 2012). This in in accordance with Ng & Lucianetti (2016), who argued that, to promote innovative characteristics, belief in an individual's creative self-efficacy must accompany an increase in perception of ability in oneself before there is a similar increase in idea creation and implementation.

Bandura (1995) explained that, to achieve goals within innovation, individuals must put tremendous amounts of effort over long periods, while demonstrating resiliency through times of uncertain results. Showing empathy for or understanding towards individuals who experience negativity, anxiety, or frustration shows growth within variables of self-efficacy (Bandura, 1977). Overcoming fears and anxieties is a critical component before building efficacy, which influences believe in an individual's ability for growth and capacity for attainment of goals. Diminishing anxiety within various settings usually results from building trust and respect within the affective domain of individuals (Edmondson, 1999). When a sense of mutual respect is established, anxiety levels decrease. Environments that are void of criticism and function on respect are less likely to incubate fear and anxiety, which diminishes creation of confidence and efficacy (Ng & Lucianetti, 2016). Individuals in these environments are more willing to voice their opinions, due to the protection from embarrassment, rejection, and punishment, which can foster a more positive sense of self about human agency (Edmondson, 1999). When individuals perceive their organization as worthy of their trust and respect, they will be less anxious and fearful. This will promote innovation and ultimately improve levels of self-efficacy (Bandura 1977, 1997).

As Bandura (1997, 2001) stated, agentic individuals are intentional and act with premeditation, which guides their action processes (Bandura, 2001, 2006). Understanding that personal agency functions within a larger structure of social cognitive structures, is critical to understanding the level upon which individuals will work to achieve goals (Bandura, 2001, 2012), both collectively and individually. Understanding and valuing individuals within an agentic approach provides an ability to foster efficacy and may ultimately increase performance towards collective goals (Ng & Lucianetti, 2016). Knowing how individuals relate to the collective organization is critical in investigating a relationship to human agency and self-efficacy, and collective visions must account for personal importance to understand the influence upon self-efficacy (Bandura, 2001). This collectivistic orientation and concept of agentic state has influence upon the psychological influence upon the value individuals place upon themselves (Ng & Lucianetti, 2016) and is a critical component of human agency and self-efficacy.

These factors influencing self-efficacy also form the concept of human agency, which is rooted in the social cognitive theory (Bandura, 1982, 1986). Personal agency reflects individual efforts, is influenced by environment and ability, and directly influences individual cognition and behavior (Bandura, 1989). The second theory of human agency is collective agency, where interdependent efforts are present within a group, community, or organization (Bandura, 2000).

Self-efficacy may reflect the most critical components of human agency, but it does not consume all qualities of it (Bandura, 1997). Factors of human agency that shape self-efficacy involve motivation, self-regulation, and action, all of which shape human development (Bandura, 2001). It is critical to understand human agency and how it influences individuals and their self-efficacy before one reaches a desired outcome from interdependent and coordinated efforts (Bandura, 2002). This understanding is essential to comprehend the phenomenological aspects of an individual, including their purpose, value, interest, attitude, and emotional and cognitive characteristics (Bandura, 2002). Understanding performance experience relies upon the concept that success builds efficacy, while failures weaken efficacy (Bandura, 1977). Achieving success derives from an individual's belief in their capabilities, which provides resilience and perseverance (Bandura, 1997). Understanding this is crucial to fostering and improving students' Science Fair and STEM self-efficacy.

Self-efficacy and learning. Bandura (1977) defined self-efficacy as one's belief in one's ability to succeed in specific situations, or to accomplish a desired goal or task. He maintained that individuals cultivate self-efficacy, depending on perceived strengths and abilities. Subsequent researchers found that students' negativity about their STEM perceptions increased as they progressed through school. Studies by George (2006) and

Gogolin and Swartz (1992) similarly revealed that this negativity builds in U.S. public schools and carries over to secondary and post-secondary schooling.

Schunk (1991) found that increased self-efficacy improves skill development and sustains a student's interest in learning, which applies to STEM. Similarly, Mumcu and Aktas (2015) emphasized that one factor that affects student achievement is the student's efficacy perceptions towards his or her lessons. Self-efficacy predicts what people will do with their knowledge and skills (Bandura, 1986) and is linked to achievements, perceived capabilities, and predicted level of attainment (Bandura, 1997). For this study, I used instructional methods to increase self-efficacy indicators and addressed variations as they arose, which gave me ideas for improving curriculum and instruction.

Self-efficacy and metacognition. Bandura and Schunk (1981) found that students with a higher level of self-efficacy were more likely to complete a task than those with lower self-efficacy, and Pintrich and De Groot (1990) discovered a correlation between self-efficacy and performance levels through metacognitive strategies. These studies were enriched by similar research, including that of McCormick and McPherson (2003), who, in their study of 332 instrumentalists, discovered that self-efficacy was the best forecaster of performance; and Hofmann and Spatariu (2008), who found that self-efficacy and strategy accounted for 31% of the variance in students' academic attainment in mathematical problem-solving.

Metacognition is the knowledge of an individual's own self-regulation, thinking, and subsequent monitoring of his or her own cognition (Flavell, 1979). Providing opportunity for students to engage in an inquiry-based curriculum that emphasizes metacognition benefits students' learning, especially with regard to traditionally low achievers (White & Frederiksen, 1998). According to Pintrich and DeGroot (1990), "self-regulated learning includes students' metacognitive strategies for planning, monitoring, and modifying their cognition." Further, "different aspects of the expectancy components have been linked to students' metacognition, use more cognitive strategies, and are more likely to persist at a task" (Pintrich & DeGroot, 1990, p. 34). This is applicable to an activity like the Science Fair in the present study. Using self-efficacy indicators and measuring variances during the preparation for the competition, gave me insight into students' beliefs in their abilities to complete the given tasks.

Student self-efficacy. A student's belief in his/her abilities is the essence of the concept of self-efficacy, which serves as the foundation for student motivation and academic achievement (Bandura, 1997). According to Clickenbeard (2012), "In order for students to maintain a high level of self-efficacy, [they] need to believe they are equipped with the skills and talents for a specific task"(p. 625). School systems must also evaluate, educate, and promote programs that strengthen students' feelings of self-efficacy (Hoy, 2004). Feelings of self-efficacy serve as motivators, to help individuals persevere through difficult situations (Bandura, 2002).

Bandura (1993) emphasized that expectations regarding self-efficacy affect efforts, attitudes, and student topic and course selections. Similarly, Brinter and Pajares (2006) and Bandura (1997) argued that self-efficacy serves as a strong predictor of academic achievement, course selection, and career options across various student grade levels. Indeed, a recent study showed a strong correlation between career choices and self-efficacy values amongst middle school students (Hiller & Kitsantas, 2015). When students perceive an increase in self-efficacy, they make more challenging course selections, which may ultimately affect their future career decisions. Patrick, Care, and Ainley (2011), applying this theory to scientific achievement, found that students' self-efficacy directly affected the students' secondary science and career options.

Previous experiences and perceived competencies significantly influence the probability that a student will follow a particular career path. According to Bandura, Barbaranelli, Capara, and Pastorelli (2001):

> The higher people's perceived efficacy to fulfill educational requirements and occupational roles, the wider the career options they consider pursuing, the better they prepare themselves educationally for different professional careers, and the greater their staying power in challenging career pursuits. (p. 188)

The American Association for the Advancement of Science (1993) explained that science fairs provide a unique opportunity for students to reflect upon the entirety of the educational experience. This opportunity to reflect allows students to achieve their academic goals. Siegle and McCoach (2007) stated that, "goals that include specific performance standards are more likely to increase self-efficacy than more general goals because progress is easier to evaluate" (p. 284).

Bandura (1997) explained that efficacy beliefs directly relate to the effort individuals put forth, the length of perseverance when encountering difficulty, and the resiliency they demonstrate when facing adversity. As students achieve goals, they are more inclined to have an increased belief in their abilities. According to Bandura (2006)), as individuals demonstrate higher levels of self-efficacy, their adoptions of higher goals and their fortitude to reach these goals is stronger.

Designing lessons and activities that foster efficacy is one of the most critical components of student success (Huang, 2015). Building motivation, decision-making ability, and cognitive development helps to expand options for future goals and careers (Bandura, 2006). Students with the same cognitive ability may show different achievement measures based on self-efficacy beliefs (Zimmerman, 1995); this has an effect on how students shape their goals and may ultimately affect their outlook on life (Usher and Pajares, 2009). Morales (2014) emphasized this further, stating that, within a student's disposition, self-efficacy is the most important quality to develop. Developing self-efficacy within students allows an individual to better perform desired actions and tasks (Bandura, 1994). Bandura (1997) defined this construct as the confidence individuals have towards the level of control they feel they have to accomplish a task or reach a goal. High self-efficacy levels strongly relate to academic achievement and to positive behaviors (Bandura et al., 1996). Bandura (1993) explained that self-efficacy and achievement result from a learning environment that is strongly shaped by a learner's skills and knowledge and the underlying thought processes that activated them. Bandura's research, including his four principles of self-efficacy (mastery experience, vicarious experiences, verbal/social persuasion, and emotional and psychological states), help build or diminish an individual's level of self-efficacy (Bandura, 1993).

The most successful way to build a sense of efficacy is mastery experience. Mastery experience allows students to create measures of their capabilities, based on past successes and failures (Bandura, 1994). Experiences and achievements can add or diminish values of self-efficacy (Lane, Lane, & Kyprianou, 2004) and may ultimately influence career decisions (Dawes, Horan, & Hackett, 2000). In a study by Luzzo, Albert, Bibby, and Martinelli (1999), interventions to build science self-efficacy were more beneficial when the researchers exposed students to mastery experience. Specifically, Luzzo et al.'s group used multiple completion tasks, which they structured to increase mastery experience through proximal goal modification, to provide students with a high probability of success. They explained each task as an evaluation of math ability, but only half of the participants were told the minimum passing score (which was the completion of six tasks). The remaining students received no information regarding their measure of mastery. Only telling half the students demonstrated manipulation of the proximal goal. Students who received the manipulation of proximity goals reported greater self-efficacy immediately after the investigation and one month after the intervention. These positive experiences, as demonstrated by these findings, suggest that even minimal, deliberately created interventions, can influence self-efficacy. Positive and negative experiences are critical for any self-analysis of ability and self-efficacy—the student who believes that she/he or she will succeed is much more likely to do so (Bandura, 1977, 1997, 2003).

Vicarious experiences compare individual success to another's perceived abilities (Bandura, 1977). In a vicarious experience, an observer models a desired behavior within a domain to instill confidence within the individual, by identifying similarities between him/herself, which correspond to an increased level of desired success (Bandura, 1997). Using vicarious modeling/experiences, by modeling the goals and behaviors of peers, students are able to boost their self-efficacy by comparing themselves to those of similar characteristics or abilities (Schunk, 1987). Vicarious experiences and modeling, when adaptive and exploratory, can build science self-efficacy (Britner and Pajares, 2006).

Verbal/social persuasion is the psychological influence one person has to influence the self-efficacy of another. With verbal/social persuasion, students can verbalize and discuss strategies with the model to overcome challenges as they arrive, resulting in a positive shift in self-efficacy (Bandura, 1977). Using persuasive language to convince individuals of their ability can influence efficacy within students. According to Bandura (1977, 1986, 1997), students who receive verbal praise experience an increase in perceived ability. Although this method seems the easiest to use, it has proven less effective than mastery and vicarious experience (Bandura, 1997).

Finally, emotional and psychological influences may affect self-efficacy and future learning. If a student associates feelings of anxiety with a certain task, this will affect his/her judgment of the ability needed to complete the task (Bandura, 1986). For students who are naturally supportive and collaborative, self-efficacy increases within a class environment (Bandura, 1994).

The intersection of self-efficacy and economic status. I designed the present study to better understand how preparation for the Science Fair influenced my students' science and STEM self-efficacy. I also wanted to know if there were differences in the feelings of STEM self-efficacy between students of different economic backgrounds, specifically between those students who had been classified as economically disadvantaged and those who had not. The study data and findings will help me create interventions and secure needed grants to improve the Science Fair process for economically disadvantaged students.

Economic status. The Pennsylvania Department of Education allows students to be classified as economically disadvantaged at the discretion of individual school districts. Students can be classified as economically disadvantaged if they are in need of temporary assistance; poor (according to U.S. Census); receiving Medicaid; living in an institution or foster home; neglected or delinquent; or eligible for free or reduced lunch . The District determines the percentage of economically disadvantaged students based on October enrollment. The percentage is calculated by dividing the number of students identified as economically disadvantaged in the district divided by total district enrollment (Pennsylvania Department of Education, 2016).

Access and equity for all Highland students. Within my original research question, I wanted to know if there would be a difference in perceived student science and STEM self-efficacy, based on different economic backgrounds. I originally added this query to pursue future grant opportunities for my students from the Society for the Science and the Public. As stated on the Society's webpage: "Through the Society's Advocate Grant Program, educators and scientist mentor and expand opportunities for underrepresented and low-income students who have potential to excel in STEM fields with additional support" (Society, n.d.-c). The localized goal of this present action research study provides an opportunity to directly improve the lives of Highland students who are classified as economically disadvantaged by the Pennsylvania Department of Education (Pennsylvania Department of Education, 2016).

Economic status and education. The Coleman report (Coleman, 1966) identified socioeconomic status as one of the most accurate predictors of academic success. The report established a set of 48 established income thresholds, which were uniform across the United States, with a variance for family size and age of family members (United States Census Bureau, 2016). These thresholds are still used today; to formulate discussions on poverty and socioeconomic discrepancies within the U.S., it is critical to establish new, federally accepted, universal thresholds (Betson, 1997). To start this discussion, society must investigate the impact and influence of poverty on our children.

Children are dependent on their parents and guardians for their economic predisposition (Betson & Michael, 1997); they have no choice regarding the situation into which they are born. The discrepancies start from birth, as economically disadvantaged families do not receive equal prenatal care (Crooks, 1995). Starfield et al. (1991) identified a strong correlation between low birth weights and socioeconomic status. Brooks–Gunn & Duncan (1997) reported that low birth rates correspond to a higher probability of health problems during childhood. Studies that followed these students revealed that they had difficulties with spelling, reading, and math problems on an equal or greater level with their peers (Bowen, Gibson, & Hand, 2002). Thus, economic inequality creates an unequal playing field for students within an educational setting. Such children are more likely to demonstrate problems in both behavior and emotional regulation, even if the economic hardship is for a brief period (Brooks–Gunn & Duncan, 1997). Brooks–Gunn and Duncan (1997) also found that impoverished areas expose youths to higher levels of drugs and crime. This cycle is repetitive because parents from economically disadvantaged neighborhoods are often limited in their ability to select neighborhoods with greater opportunities. This economic disadvantage strongly correlates to diminished academic success (Altschul, 2012).

Economically disadvantaged students are more likely to be marginalized than their more affluent peers (Buxton & Lee, 2010). This marginalization is evident in lower test scores (Barton, 2001; & Seiler, 2001), a lack of interest in science, disengagement, and the students' lack of self-efficacy regarding their abilities (Basu & Barton, 2007; Seiler; 2001; Barton & Yang, 2000). Addressing the affective domain—particularly self-efficacy—is one way to decrease the marginalization of economically disadvantaged students (Reis, Colbert, & Thomas, 2005). Vancouver, Thompson, and Williams (2001) emphasized that positive self-efficacy promotes one's ability to accept challenging goals and to maintain the firm resiliency to meet these goals. Similarly, Reis et al. (2005) argued that resilient students were more likely to rise above challenges and to respond positively to adversity.

Skrla and Scheurich (2001) argued that that socioeconomic status is the largest predictor of student performance (Skrla & Scheurich, 2001). According Reis et al. (2005), economically disadvantaged students need the following critical components to succeed in school regardless of racial or ethnic identification:

- adult support,
- ability to enroll for advanced/elective courses,
- placements with higher-achieving students,
- extracurricular opportunities,
- strong sense of self-efficacy and a general belief in themselves, and
- resiliency to address challenges.

I believe that the current structure of Highland's Science Fair course addresses the first four of these as part of Science Fair preparation.

Inherent in my question regarding self-efficacy and economically disadvantaged students, is my belief that if more students who are classified as economically disadvantaged can be supported during the Science Fair process, it will demystify the process for them and allow them to succeed. For the present study, I needed to measure the fifth and sixth criteria: "[the students'] strong sense of self-efficacy and [the children's] general belief in themselves." With this, I was able to improve the curriculum and pedagogy for future students and to develop a model of efficaciousness.

Self-efficacy, economic status, and academic success. Reis et al. (2005) emphasized that a strong sense of self-efficacy is critical for the academic success of economically disadvantaged students. Economically depressed students demonstrate lower graduate rates (National Education Association, 2015) and earn less money in their professional careers (Rouse & Barrow, 2006). According to Redd, Karver, Murphey, Moore, and Knewstub (2011), approximately two-thirds of adults living in poverty had a maximum of a high school diploma, and one-tenth had earned a bachelor's degree. Nurturing students by addressing the needs of the affective domain could shift these statistics.

As Heslin and Klehe (2006) explained, individuals with high levels of self-efficacy typically demonstrate a strong work ethic and persevere through difficult situations. Students who have negative self-efficacy beliefs generally display learned helplessness, inadequate feelings, and experience higher levels of stress (Cedeno, 2016). Wiederkehr, Darnon, Chazal, Guimond, and Martinot (2015) found that junior high school students' self-efficacy served as a mediator between socioeconomic disadvantages and anticipated performance. Bandura (2001) explained:

> In social cognitive theory, sociostructural factors operate through psychological mechanisms of the self system to produce behavioral effects. Thus, for example, economic conditions, socioeconomic status, and educational and family structures

affect behavior largely through their impact on people's aspirations, sense of efficacy, personal standards, affective states, and other self-regulatory influences. (p. 15)

In addition, students from economically disadvantaged backgrounds may have limited access to highly qualified teachers, scientific equipment, and/or the materials they need to participate in inquiry-based science fairs (Barton, 2001; Darling-Hammond, 1999). Bencze and Bowen (2009) confirmed this when they found strong correlations between student access and success in science competitions.

Students from economically disadvantaged backgrounds benefit from learning science in a method that accounts for their previous experience, their areas of interest, and the needs of their families/community (Zacharia & Barton, 2004). Using their own visions to guide the context in which science is applied develops greater interest within the context of their projects (Basu & Barton, 2007).

Understanding the role of self-efficacy in students, the connection between self-efficacy and learning, and the correlation between economic background and student success gave me an opportunity to improve the Science Fair and STEM curriculum for all my students.

Authentic Science Within Science Fairs

I accessed a variety of sources to help me better understand the relationship between authentic science and the structure of science fairs. Those that proved most helpful to my own study included Anderson (2001), Barton (1998), Lord and Orkwiszewski (2006), and others. For general information regarding science fairs, I consulted multiple sources; those I relied on most heavily included Abernathy and

Vineyard (2001), Bellipanni (1994), Bellipanni and Lilly (1999), and Grote (1995). I built off my own experience from the Pittsburgh Regional Science and Engineering Fair (see Kosick, 2016), which was helpful regarding the topics presented at the fairs.

Authentic science relies upon the experience of the learner, to build learning that is better understood, through inquiry in real-world situations. Creating inquiry activities that are grounded in inquiry-based learning improves practices and can improve attitudes towards the scientific process (Buxton, 2006). As a teacher-researcher, I believe that the role of the Science Fair is grounded in authentic science principles that are cross-curricular. Students are able to use their abilities to serve as scientist by constructing new knowledge based upon their inquiries versus using preconceived laboratory experiments (Kielborn, Orr, & Childs, 2002). With authentic science, students are active participants in a self-directed role, where the instructor serves as a facilitator. Using this approach empowers students to direct their learning and communicate with the authority of scientist, while building knowledge on previous experience by interpreting new concepts and ideas as an independent learner.

Multiple authors informed my understanding of the history of science fairs in the United States, including Bellipanni and Lilly (1999); Society for Science (n.d.-a, b); and Terzian (2009), in combination with the works of Albert Bandura (1977; 1986; 1993; 1996; 1997; 2002) and Bandura and Schunk (1981). Throughout my investigations, Bandura's extensive research, evaluations, and subsequent reviews and revisions of studies in self-efficacy and its associated influences, guided the evaluation of indicators of self-efficacy.

Studies by Lent, Brown, and Larkin (1986) and Bandura (1993) provided connections between the influence of self-efficacy and career choices, which guided my inquiries into these subjects. Finally, Lord and Orkwiszewski (2006); Hsu, Roth, and Mazumder (2009); and Wilson, Cordry, and Uline (2004) offered information on the epistemology of authentic science practices.

Science fair topics. In a science fair, students first choose or receive a topic to investigate, and then display the results of their scientific investigation. Fairs typically involve students who range in age from elementary to high school (Bellipanni, 1999). Categories include:

- Sixth grade:

  behavioral and consumer science, biological science, chemistry, physical science and engineering.

- Seventh and eighth grade (intermediate level):

  behavioral and social science, biology, computer science/math, engineering/robotics, medicine/health/microbiology, and physics.

- Ninth through twelfth grade (senior level):

  behavioral and social science, biology, computer science/math, earth/space/ environment, engineering/robotics, medicine/health/microbiology, and physics. (Kosick, 2016)

Pros and cons of science fairs. *Positive aspects of science fairs.* There are many positive aspects of science fairs: they nurture student interest in science; help develop written, oral, organizational and research skills; and encourage social ability (Abernathy & Vineyard, 2010). These positive experiences can give students a sense of accomplishment, provide opportunities for networking, and assist in future career decisions (Abernathy &Vineyard, 2010). In elementary school, science fairs publicly recognize students for their inquiry-based projects, promote an interest in science, and foster social skills (Perry, 1995).

Science fair projects allow students to explore areas and inquiries of interest within a research framework (Bruning et al., 1995). Bruce and Bruce (2000) opined that a student's interest in science often corresponds to a science fair experience. Cognitively, students who participate in science fairs must connect their previously acquired knowledge to similarities and differences within their newly acquired knowledge to better analyze and present their findings. These findings and ownership in answering student-driven inquiry are a fundamental strength of science fairs. Grote (1995) explained that when students learn the scientific method through science fair projects, it promotes their interest in science.

In addition to learning about science and the facts associated with it, the main cognitive principle behind science fairs is to teach students how to think (Tant, 1992). According to Abernathy and Vineyard (2001), the survey data of participants in science fairs yielded findings that students viewed the science fair as fun and interesting, as they learned new things. Huler (1991) and Marsa (1993) found that participants who competed in the Westinghouse Talent Search subsequently pursued and excelled in science fields. Participation in Science fairs helps define the mechanism behind a constructivist approach to learning, where students use previous knowledge to examine and associate with new findings.

Criticisms of science fairs. Despite the above, many judges, students, teachers, and parents criticize science fairs and the science fair process, particularly regarding individual competition. Many feel that science fairs should be reflective of collaborative teamwork, which fosters a higher level of quality. Others point out that many of the articles that analyze the effectiveness of science fairs contain subjective opinions and are not backed by objective research (Abernathy & Vineyard, 2001; Czerniak, 1996). (See also, The National Middle School Association (1991) which recommends that evaluations should be focused on individual progress versus a comparison to peers.)

Opponents are also concerned about the intellectual skills required to complete science fairs. McBurney (1978) wrote about mandated performances in science fairs and questioned the impact of using skills that may not be appropriately developed. Critics of science fairs point to the disparity of science fair projects, which, they argue, can vary widely in terms of complexity and the degree of inquiry-based thinking. McBurney (1978) argued that science fairs must serve as reinforcements for previous learning and must provide the groundwork for building future knowledge. He also stated that science fairs could not be justified unless the focus is placed on the learning experiences of students, regardless of parents and community components (McBurney, 1978).

In addition, there are issues regarding the determination of science fair places and prizes. The nature of competition draws into question the psychological and emotional impact of poor performance ratings and their long-term effects on student self-efficacy and eventual career choices. Czerniak (1996) found that science achievement is inversely related to anxiety. According to her study, it is probable that the pressure on students to excel ultimately exacerbates stress levels. Further, Chiappetta and Foots (1984) indicated that science fairs might have an unintentional negative consequence for the majority of students who do not win prizes and may create confusion due to the subjective nature of competition, which invariably excludes students who produce quality work (Wang & Yang, 2003). A study by Lee, Mahotiere, Salinas, Penfield, and Maerten-Rivera (2009) suggested that both high school and elementary school science instruction included barriers due to a lack of time, limited scientific equipment, and pressure to perform on standardized tests. The time and complexity of science fair projects may cause increased stress levels and negative attitudes towards scientific fields (Schmidt & Kelter, 2017). Studies continue to emerge that outline barriers to science fair participation.

Another criticism of science fairs is that it historically favors individuals from privileged backgrounds. A study by Sayer and Shore (2001) identified that students listed time as the biggest constraint towards completion of a science fair project, which was followed by a concern regarding the expense of creating a project. Science fair competitions do not restrict entry, but most participants come from privileged backgrounds, with more highly educated parents (Czerniak, 1996).

Authentic science. Authentic science is grounded in inquiry-based approaches, which can increase achievement and critical thinking skills (Lord & Orkwiszewski, 2006) by engaging students with instruments and processes that duplicate similar or actual scientific practices (Woolnough, 2000). Authentic science has a clear similarity to the real world application of science, with a strong resemblance to jobs performed in science fields (Hsu et al., 2009).

In Chinn and Malhotra's (2002) study of nine middle and upper elementary schools, the authors discovered that many textbooks provided activities with obvious conclusions, instead of the inquiry-based investigations that are critical for authentic science. They theorized that learning from textbooks frequently creates an oversimplified version of scientific reasoning, because the lessons bear little correlation to authentic, inquiry-based tasks (Chin & Malhotra, 2002). The researchers concluded: "much work remains to be done to transform schools into places that nurture epistemologically-authentic scientific inquiry" (Chin & Malhotra, 2002, p. 214). Hofstein and Lunetta (2004) evaluated changes in science education and found that, by conducting their own investigations, students formulated ideas, studied the natural world, and used data to defend and justify theories through procedures that guided authentic science.

Science reforms strongly favor student-centered, inquiry-driven, knowledge-based, exploratory epistemology knowledge (National Research Council, 2001). According to Lord and Orkwiszewski (2006), a classroom defined by research activities demonstrates increased academic performance, increased performance outcomes, and positive perceptions when compared to students in traditional courses. As described by Schukaijlow, Leiss, Pekrun, Blum, Miller, and Messner (2012), the value a student perceives directly relates to the motivation the student displays. A science fair approach to authentic science empowers students and provides them with an opportunity to learn more about what they consider important (Barton, 1998). Hands-on science that is also "minds-on" provides authentic learning experiences that are both content-specific and relevant to principles of authentic science (Rodriguez, 1998).

Authentic science learning models. Authentic science experiences include canonical, student-centered, and contextual models (Buxton, 2006; Barton, 1998; Anderson & Krathwohl, 2001). The canonical model involves inquiry, experimentation, and problem solving, which combine to foster students' critical thinking and problem solving skills (Lee & Songer, 2003; Toth, Suthers, & Lesgold, 2002). This model emphasizes that authentic science is bias-free and develops science knowledge that resembles that of a scientist (Buxton, 2006). The canonical model helps connect students to professionals in the field and to other scientists (Lee & Songer, 2003).

In the student-centered model, students are empowered to drive questions and inquiry and are allowed to open investigations into what they believe is important (Buxton, 2006; Barton, 1998; Eisenhart, 2001). This inquiry model often provides a platform for students to pursue areas of interest that are important within their local area (Eisenhart, 2001).

Lastly, the contextual structure, which is the one I chose for my study, is a blend of the student-centered and canonical models. In the contextual model, community is the guiding principle; it combines knowledge, guidance, and expertise form students, educators, and scientists to help shape projects within the students' interest (Anderson, 2001; Buxton, 2006). Students first develop the problem for experimentation, then use and expand science knowledge, enhance the investigation, and perform the investigation as a relationship to a personal or community interest. As Reeve and Halusic (2009) explained, goal setting, supportive behaviors, and encouraging autonomy are all beneficial to student achievement.

Bloom's taxonomy Benjamin Bloom (1956) and colleagues, developed a framework that could be used to identify behaviors that were essential to the learning process. The framework consisted of three domains: cognitive, affective, and psychomotor. The cognitive domain was composed of six levels, which increase by creating verbs that indicate more complex and cognitively demanding tasks. Those levels, from least cognitive load to most is knowledge, comprehension, application, analysis, synthesis, and evaluation (see Figure 2.1).

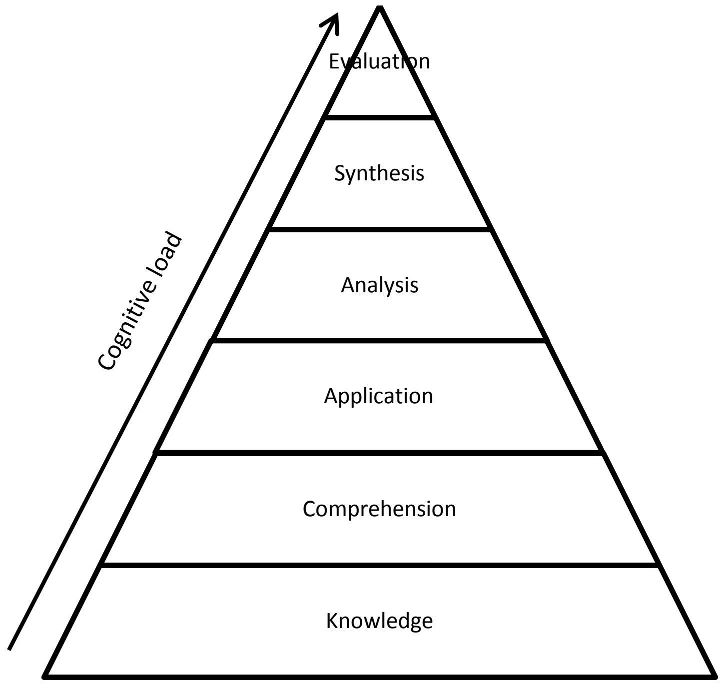

Figure 2.1. Categories in Bloom's (1956) cognitive domain.
Note. Adapted from Bloom (1956).

According to Lord and Baviskar (2007) who studied college undergraduates and found that they do not effectively remember what they learned in their high school science courses, due to the lack of emphasis placed on the upper level frameworks that are outlined by Bloom's Taxonomy. The authors suggested that this was due to an unintended focus on factual content that was focused on detail, where students frequently were called upon to recall and summarize their knowledge. As teacher-researcher, I believe that instructors should be encouraged to create pedagogy that aligns with the upper levels of Bloom's Taxonomy to counteract the inability of students to apply their knowledge, as demonstrated within the undergraduate studies (Lord & Baviskar, 2007).

In the first level in Bloom's cognitive domain, Knowledge, students recognize or recall behaviors and knowledge (Bloom, 1956). The second level, Comprehension, is where students use their knowledge to communicate the critical information. The third measure, Application, is the ability to apply the knowledge to appropriate situations. This is directly applicable to the science fair process, where students explain scientific phenomenon in terms of the appropriate scientific processes, as outlined within authentic science practices. The fourth level in Bloom's cognitive domain is Analysis; this is where students establish relationships between concepts and the ideas that form them. This is akin to using the theoretical framework of the scientific method to answer scientific inquiries within the science fair process. The fifth level on the taxonomy, Synthesis, is where students use principles to guide their creations or formulations of a new products or ideas, just as they would within the science fair process. The final level on the cognitive domain taxonomy is Evaluation, which requires students to use their work to make sense of their findings. In a science fair project, this would be the conclusion, where results are tested for validity and presented to a panel of judges.

Authentic science fairs. Researchers believe that authentic science activities, like those displayed within Highland's Science Fair, can influence students' attitudes towards learning science and help shape their perceptions of who can and cannot become scientists (Buxton, 2006; Chinn & Malhotra, 2002; Sadler, Burgin, McKinney, & Ponjuan, 2010). Science fairs like the Science Fair course provide an opportunity for students to perform independent research projects, which allows them to establish a personal connection with their research, by following an authentic learning experience.

This authentic learning experience allows students to pursue their interests, promotes inquiry-based investigations, and improves data analysis and public speaking skills.

Science Fairs like Highland's make science relevant to students and connect them to the world. As explained by Grote (1995), most teachers feel that science fairs promote an interest in science, while teaching the critical components of the scientific method. Abernathy & Vineyard (2001) conducted survey research and found that students enjoyed learning new things as part of the science fair process. According to Grote (2005), "Science fairs promote enthusiasm about science, give students experience in communication skills, and give the opportunity to interact with other students [who are] interested in science" (p. 274). Generating this interest in STEM may lead to a STEM-related career (Terzian, 2013). This interest and involvement in science and STEM education is a focus nationwide, which the Next Generation Science Standards highlights (Next Generation Science Standards, 2016). Many schools are currently attempting to improve existing science and implement new programs that align to the new science and education initiatives (Hiller & Kitsantas, 2015).

Self-Efficacy and Science Fairs

In the present study, the Science Fair represents an authentic learning experience because students choose topics that are unique to their particular experiences and work on solving problems using the scientific method. For example, projects may include testing water in a student's community for lead levels, testing reaction time in correlation to video gaming, measuring levels of nitrates of local streams after rainfall, investigating bacterial colonies within the student's school, or other student inquiries that engage the learner in science. These experiences, in which the student is interested or feels it is critical to apply science to a certain subject, are authentic science experiences. Students define these experiences through inquiry, frame them using the scientific method, and use scientific tools and calculations to arrive at conclusions.

Schmidt & Kelter (2017) set forth the four subthemes for science inquiry: (a) evidence of procedural knowledge, (b) designing an experiment and collecting and analyzing data, (c) increasing the correctness of a hypothesis, and (d) increasing general science knowledge. Science reforms strongly favor this student-centered, inquiry-driven, exploratory epistemology, which is outlined by a depth of knowledge and is framed around inquiry (NRC, 2001). According to Lord and Orkwiszewski (2006), these activities increase academic performance, improve performance outcomes, and generate more positive perceptions when compared to students in traditional courses.

Research on Science Fairs

Despite the plethora of books and guides to assist students and parents in conducting successful science fair projects, there are few studies available on science fairs themselves (Schmidt & Kelter, 2017). Following are a few that were helpful for my own research.

Grote. Michael Grote (1995) investigated the relationship between the perception teachers have towards science fair projects and the value the teachers placed upon the projects. He administered a Likert scale survey to 600 randomly selected, Ohio high school department chairs; approximately 30% of the sample group returned the survey. The majority of respondents (84%) were from public schools and 55% of those responding had done science projects as students. Respondents reported positive and negative science fair experiences. A slight majority of respondents felt that science fair projects had an inherent value. The positive responses included the development of communication skills, promoting interest in science, and providing a platform for interaction between other students who were interested in science (Grote, 1995; Czerniak, 1996; Abernathy & Vineyard, 2001). Respondents also indicated that science fair projects were better suited for junior high students (versus high school). They said that independent projects were preferable, although small group projects (of three to four students) were acceptable. Some respondents felt that an outside judge for science projects provided a more positive situation. Although respondents indicated that science fairs were best suited for junior high students, the majority responded that high school students benefitted from independent research projects. Half of the respondents were unsure if independent research projects were supportive of a constructivist view of education. A slight majority of respondents felt that judging science fairs were counterproductive and awards and ratings should be removed (Grote, 1995).

Syer and Shore. Syer and Shore (2001) conducted a study to examine the role of cheating in science fairs. They wanted to understand the challenges students faced during the science fair process, by identifying difficulties and areas of need, as identified by students. They also hoped to explore the ability of students to overcome difficulties that were prohibiting them from completing science fairs. Their premise was that, by understanding why a student would cheat, the teacher could address and resolve the issue, resulting in a stronger and more authentic learning experience. The researchers distributed 266 consent forms to participants at regional science fairs in the Montreal area; of the 29 returned forms, 27 students agreed to participate. Participants then received a questionnaire, which asked them to classify statements as “fair” or “unfair.” A follow up questionnaire asked about the challenges they personally experienced during science fairs and elicited a "yes" or "no" response.

More than 20% of the students (five out of 24), admitted to making up data or results during the science fair process. The reasons given for this included: (a) the pressure to meet deadlines, (b) the desire to perform at a high level, and (c) being unable to find outside help. Out of these factors, the most reported obstacle by students was the "pressure of time" (Syer & Shore, 2001, p. 207). Based on these results, Syer and Shore concluded that (a) students participating in science fair needed more direct assistance and (b) science fair participation should not be compulsory.

Yasar and Baker. There is little research available on the benefits of science fairs to students versus the effort, time, and money spent on them. However, there is some research on the (lack of) effectiveness of the fairs themselves upon student understanding of the scientific method. Yasar and Baker (2003) tested 456 seventh-grade students from four schools; students were of varying socioeconomic status and were nearly equally male and female. The researchers used a pretest/posttest design, with the pretest at the beginning of science class and the posttest after the science fair. After analyzing the results, the researcher found that the science fair did not significantly improve the students' understanding of the scientific method or alter their attitudes towards science (Yasar & Baker, 2003). These findings affirm those of Abernathy and Vineyard (2001), who explained that the effectiveness of science fairs was based upon opinion and not facts. Interestingly, the researchers found a drop within both genders in the posttest regarding knowledge of the scientific method. Regarding attitude towards science, males demonstrated better attitudes towards science before the science fair, yet the female students' attitude scores stayed the same.

Conclusion

The purpose of this action research study was to explore how a popular curriculum staple, the Science Fair preparation process impacts high school students' feelings of self-efficacy.

Self-efficacy serves as a basis of human motivation, which is defined by what students believe is and is not true (Blackwell & Pinder, 2014). This belief in their own ability to complete tasks is critical for students to achieve equity and accessibility to advanced coursework and post-secondary schooling and careers. Raising awareness of the correlation between the influence of instructional practices and the impact upon students' self-efficacy values is needed today more than ever, due to ever-increasing achievement goals, reliance on various learning strategies, and self-regulatory processes (Zimmerman, 2000). Educators who guide students in improvement tasks within the science field are crucial for developing self-efficacy (Hiller & Kitsantas, 2015). Evaluating self-efficacy practices will allow for improved curriculum, instruction, and evaluation. By using a popular curriculum staple (the Science Fair), teachers can reflect upon decisions that might influence their students' STEM self-efficacy and subsequently evaluate and improve their classroom practices to make them accessible for all students.

Chapter Three:

Research Methodology Introduction and Background

Introduction

In Chapter Three, I describe the action research methods I used in the present study. As the advisor for all high school students in the Highland School District who enroll in Science Fair competitions, I know first-hand how excited our students get about these competitions. Over the years, I have witnessed students become frustrated by time-consuming projects and overwhelmed by a lack of metacognitive, cross-curricular, higher-order thinking skills that are necessary to successfully complete upper level Science Fair projects. I have also witnessed the emotional swings student's experience when a project does not go according to plan; and I have seen students feel inferior and inadequate when they compare their work to that of their peers. These feelings often lead to negative attitudes towards STEM.

For these reasons, I wondered if the District and I should be measuring student's self-efficacy towards STEM curriculum, and if that would help us better serve our students as learners. Specifically, I wanted to know how my existing practices influenced students' feelings of STEM self-efficacy, what role economic status played in STEM self-efficacy, and how I could improve my pedagogy and curriculum to help all of my students. I believe that it is critical to improve student self-efficacy, in order for students to achieve equity and accessibility to advanced coursework and post-secondary schooling and careers. Thus, the purpose of this action research study is to explore how a popular curriculum staple, the Science Fair preparation process, impacts high school students' feelings of self-efficacy. It is my belief that improvements can allow economically disadvantaged and other marginalized students to use the Science Fair as a method to gain access to advanced STEM coursework and careers.

My experiences at Highland with STEM and the Science Fair led me to question the ways in which I might better enable my students—and in particular my economically disadvantaged students—to be successful in STEM courses and in postsecondary careers. Specifically, I wanted to know (a) how my existing practices (or lack thereof) influenced my students' feelings of STEM self-efficacy, (b) what role economic status played in student's feelings of STEM self-efficacy through the Science Fair experience, and (c) how I could improve my pedagogy and curriculum to help all of my students.

Action Research Design

Famed educator John Dewey, in conjunction with Ella Flagg Young, Jane Addams, and other social workers, argued for social justice components in Chicago's public schools over one hundred years ago. Dewey's progressive educational philosophy is at the root of today's action research methods because he argued for teachers to be active scholars and researchers in their schools and classrooms and believed that this research should be cyclical, iterative, and reciprocal with schools and/or other social institutions. As early as 1938, Dewey stated that,

> Educators have a primary responsibility to be aware of the general principles shaping experience through environmental conditions, and to recognize how growth is manifested by experience and a person's surroundings. It is imperative

that the understanding is extracted connecting the physical and social, to contribute to building up experiences that are worthwhile [for students]. (p. 40)

Lewin (1946), building on Dewey's theory and research, studied intergroup relations in the United States in the 1940s. He discussed research for social practice, as opposed to research that was more appropriate for more traditional, positivistic, quantitative social science research techniques. Lewin characterized this research (today, known as action research), as "research for social management or social engineering. It is a type of action-research, a comparative research on the conditions and effects of various forms of social action, and research leading to social action" (p. 35). Also following Dewey (1938) and the early action research tradition, Tripp (1990), discussed socially critical action research, stating that, "Because education is a social practice, its techniques are not socially neutral [teachers] need to have some understanding, influence over and responsibility for the social conditions and outcomes of education" (p. 165).

After studying various research methods, I found that a quantitative approach through a Likert scale survey, followed by qualitative measures using observational field notes, student interviews, and observations would be most appropriate for this action research study. The combination of qualitative, quantitative, and observations helped define my semi-structured questions and allowed me to polyangulate (Mertler, 2017) my data. By polyangulating, which overcomes the deficiencies of a single measure (Mertler, 2017), I will enrich, contribute to, and further clarify my findings. Newman, Ridenour, Newman, and DeMarco (2003) followed a similar design, in which they showed the sequential collection and analysis of quantitative data, followed by the same procedure with qualitative data. (See Figure 3.1 for my modification of this design, which I used for my own research.) Using this design allowed for an iterative, cyclical model, which aligned with the pragmatist theory, where there is no terminus but rather a bricolage.

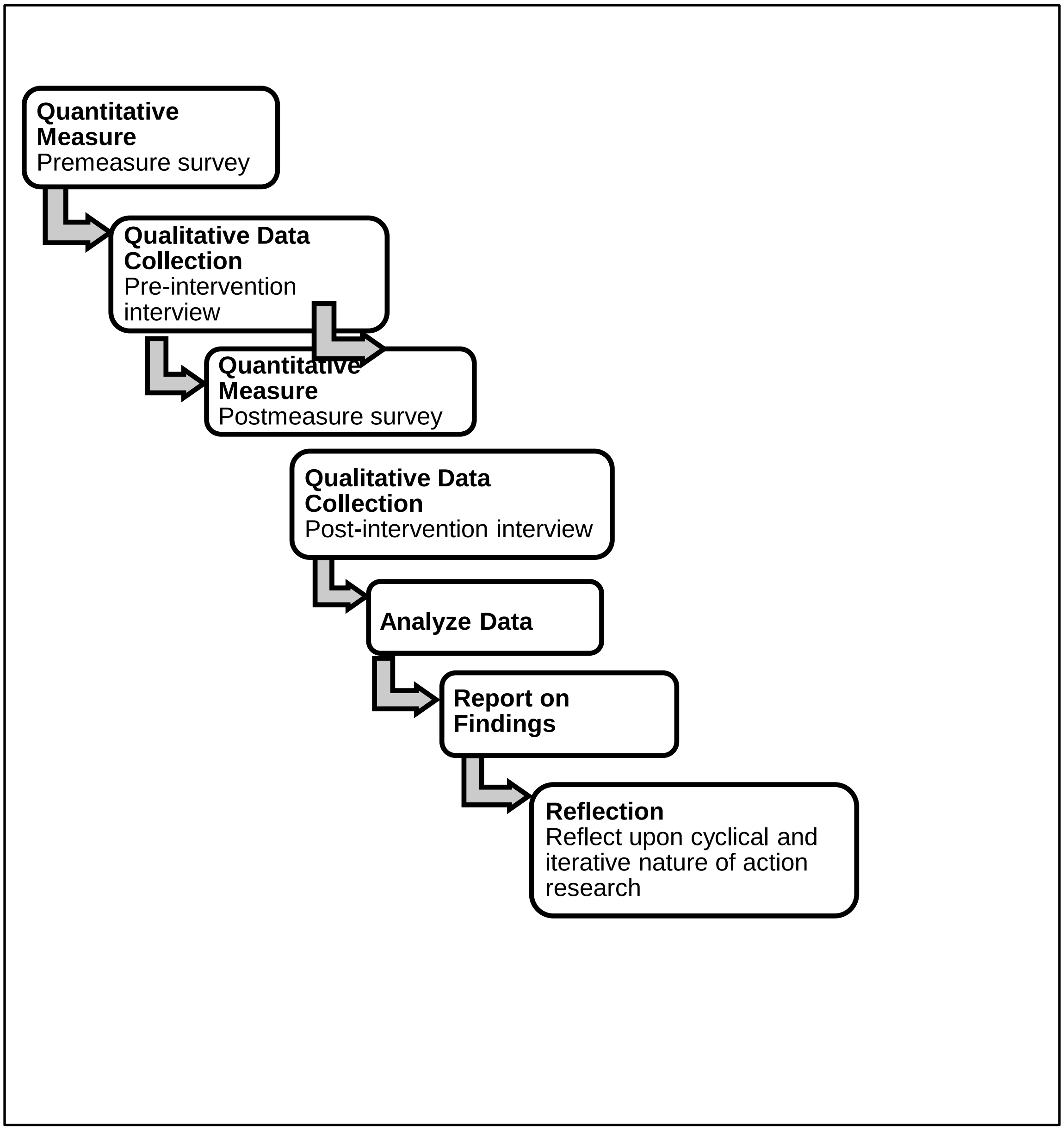

Figure 3.1. Action research design.

Using both types of data—quantitative and qualitative—provided me with a greater understanding of how Science Fair participation influenced my students' science self-efficacy.

Quantitative Measure

I conducted a class-wide survey before and after the Science Fair project, in which I focused on eliciting responses regarding my students' feelings and ideas towards the Science Fair. Many of the questions prompted responses involving one of the four categories outlined by Bandura, who explained that self-efficacy and its link to achievements are subsets of the learning environment, which must be examined for maximum educational effectiveness (Bandura, 1993). The subsets are found within the survey and are used to measure the students' perceptions of their mastery, vicarious experiences, verbal/social persuasion, and emotional and psychological states, using a five-point Likert scale response structure (Bandura, 1997).

The Likert scale survey for this study evaluated the student-participants' self-efficacy across the emotional, social, and academic domains. These domains and expressions were reliant on Bandura's four principles of self-efficacy (Bandura, 1993). I modified the SEQ-C (Muris, 2001), which is a survey that measures self-efficacy and the academic, emotional, and social domains. I used a five-scale indicator, with "Strongly Disagree" = 1; "Disagree" = 2; "Undecided" = 3; "Agree" = 4; and "Strongly Agree" = 5. Examples of statements included:

1. Science Fair offers me an ability to become friends with other students.
2. I can easily get my science teacher to help when I don't understand a part of the Science Fair project. (For the complete survey, see Appendix A.)

As Mertler (2017) explained: "A Likert scale begins with a statement and then asks individuals to respond on an agree/disagree continuum. The Likert scale typically ranges from strongly agree to strongly disagree. I typically recommend using a 5-point scale" (p. 145). Following the format of pretest/posttest allowed me to extract for data regarding self-efficacy to better describe the influence of the Science Fair upon STEM self-efficacy. I designed the quantitative measures to elicit responses about students' feelings towards the Science Fair by evaluating social, emotional, and academic indicators as measured by the survey I created. The data allowed me to better describe the influence of the Science Fair upon STEM self-efficacy.

Qualitative Measures

I conducted individual interviews with a subgroup of student-participants before and after the Science Fair project. For the interview questions, I expanded upon student-participants' answers from the quantitative survey (see Appendix A) and added some semi-structured interview questions (see Appendix B). Follow up questions to the survey included:

1. In the survey, you expressed [X].
    a) Can you tell me about that?
    b) Have you always felt that way?
    c) Are there certain parts that you do like?
2. Do you feel ready to start your project?
3. You said you do not feel comfortable with [X]. Why?

I audiotaped the interviews, then reviewed and transcribed them immediately afterward. I observed the students before, during, and after the Science Fair process. I kept a daily journal of my observations, making notes about my own interactions, communications, and emotions as the teacher-researcher. After I transcribed the interviews, the students member checked them for accuracy.

Data Collection

Quantitative Survey

Before I administered the survey, I explained to students that I was collecting information about their overall thoughts towards how they felt about science and being a scientist, and about other areas they experienced during the Science Fair preparation process. I explained the Likert scale survey and showed students some sample questions and responses. I explained that all data was confidential and I told each student that I would choose a number and write it on top of their surveys. This number was known only to me. I reminded students that the survey was voluntary and that they could stop me or ask questions at any point during the process. To neutralize possible academic limitations, I read each survey questions and the response options aloud. Lastly, I explained that it would take 15 to 20 minutes to complete the survey. At the end of the survey, I locked students' responses and the hard copies in a desk drawer. To ensure anonymity, I placed consent forms in a different location, in a locked desk.

Semi-Structured Interviews

For the interviews, I again used pseudonyms and numerical codes to protect the participants' identities, following Bandura's (2006) directive that, "self-efficacy judgements [be] recorded privately without personal identification to reduce social evaluative concerns.

I selected two students who exhibited the most positive scores, two who demonstrated the most negative scores, and two who were closest to the neutral scores, to help polyangulate the study. I gave students the option not to partake in the interview, if they did not feel comfortable. I did this before starting the Science Fair preparation and again upon the completion of a competition ready project. I was aware that self-efficacy perceptions could vary across different domains related to role (Bandura, 1997).

Journals and Classroom Observations.

I maintained a teacher journal so I could reflect upon observations, feelings, and interpretations associated with the observations (Mertler, 2017). The setting in which the data was collected was approximately a 450 square foot area, which had computers arranged in a "U" shape around the outside walls of the room. The environment of this room was semi-formal, with most information/directions coming from instructions posted within Google Classroom. Students then came into class and began the posted work at their own pace until they completed the task. Students could talk and assist each other within the process; during this time, I collected observations. I circulated with a clipboard and documented interactions, conversations, and feelings that the students expressed. I started doing this two weeks before the project, so the students were used to it. I followed Mertler's (2017) suggested protocol and recorded what I saw, which I later analyzed to identify patterns that emerged over time. I divided my observational field notes into two columns. The left column was for observations, and the right column recorded my post-analysis interpretations. "The separation of these two types of commentaries is critical so that actual observations are not confused with what you think the observed event means" (Mertler, 2017, p.131). The use of unstructured/semi-structured observations allows the practitioner-researcher the flexibility to engage in intense, yet brief, observations of free flowing information (Mertler, 2017).

I also kept a daily journal, in which I recorded students' actions, behaviors, mannerisms, and expressions. I recorded my observations in a single ring binder, which I kept in a locked drawer in my desk. For each entry, I noted the date, time, location, and student's number. I kept track of all quantitative and qualitative data using a checklist, on which I noted the name of the measure and the date I collected it (see Appendix C). I retained a paper copy of this log in my locked desk drawer with the other project files.

Data Analysis

Quantitative Data Analysis

I recorded responses from each student-participant from pre and posttest surveys, using an Excel spreadsheet. I compared positive and negative growth percentages using a simple t-test. Using this data will strengthen my professional practice by providing scaffolding to improve student experience.

Qualitative Data Analysis

To identify themes and unique narratives from the student interviews, I used thematic context analysis upon completion of the interviews. I coded the interview responses according to Bandura's (1997) four categories: mastery experience, vicarious experience, verbal/social persuasion, and emotion/psychological state. After verifying for accuracy, I coded interviews and analyzed them for emergent trends. I analyzed the data as a whole, instead of focusing on comparing the growth or decline of individual students, unless situations arose that were worth reporting.

The Teacher-Researcher

I am a White male and I have been teaching at the Highland school district for ten years; I have an additional four years of experience in other districts. I teach five sections of general science and one section of high school research, in which I mentor high school students in the composition of a competitive Science Fair project. I also serve as my school's sponsor and advisor for students participating in the Pennsylvania Junior Academy of Science and the Pittsburgh Regional Science and Engineering Fair competitions. This action research took place within my school, which provided the opportunity to serve as an insider. Having this insider position allowed me to control data collection and to maintain ongoing dialogue throughout the study. In addition, the familiarity with students helped in data collection through observational field notes and semi-structured interviews. Having a regularly scheduled course helped improve data collection, due to the frequency and schedule.

From the outsider positionality, I serve as a regional and state judge for students who enter these competitions. This gave me insight into a varied approach, both in project topics and methods, which allowed me to return and improve my current practices. In addition, I serve as an outsider for enrollment within this course. Students chose to take the course, without any persuasion from myself.

Positionality

As a proud alumnus of Highland, I made a choice to return home to Pennsylvania in 2008. This decision was not easy, for it came with less advancement opportunities and fewer financial incentives than in previous locations. However, after teaching away from home, I had a strong desire to live where I was raised. I was hired in the summer of 2008 as a mid-level science teacher, where I continue to serve. In 2014, my teaching duties were expanded due to the resignation of a colleague. I was assigned to teach the High School Independent Research Course, where students enroll in the elective course, which requires the composition of a competitive Science Fair project. This was a challenge for me, for I was the only middle school teacher who was assigned courses from the high school.

Over the past four years, I have witnessed the transformative power that competitive Science Fairs have had in reducing marginalization within economically disadvantaged populations. One student, in particular, changed my entire perspective of this program. This student was not planning to attend college due to the cost and burden on his family. His aspirations were to go to work, save money, and then attend college later. As a senior, he completed an engineering project and presented at the Pittsburgh Regional Science and Engineering Fair. This student received a full tuition scholarship to a school specializing in science and technology. Currently, he is in his junior year as he pursues a degree in Biotechnology.

This student defined the moment as an educator where my passion met my purpose. This was one of the first times I felt I had a direct impact upon a student's career and life. Over the past four years, I have removed all predispositions for enrollment in the Science Fair class, to attract students from varying backgrounds. My goal has been to expose as many students as possible to STEM networks through exposure to Science Fair projects. It is my hope that this experience, and potential financial incentives, will demystify STEM education and provide opportunities students would not have received otherwise. The exposure and networks available at Science Fair competitions are beginning to strongly influence my students' pursuit of STEM related careers. Many have been offered internships, presented to boards of trustees, received scholarships, and received assistance in advancing their projects.

To increase my effectiveness in reaching and maintaining the enrollment of students from all backgrounds, I have had to improve my own professional practice. The 2018–2019 school year was my tenth year at Highland. During that time, the Science Fair program has grown from 15 students to a record 46 students this year in 2018–2019 and has received nearly 1.5 million dollars in college scholarships for the students. In that same period, I have received two Master's degrees, one in education and one in curriculum and instruction, and I am now completing my Doctoral degree. I serve as the adviser and mentor for students who have voluntarily decided to enroll in Science Fair competitions. I have twice been named as the Conservation Educator of the Year, was identified as an Outstanding Educator by a local university, have written international curriculum for *Johns Hopkins University,* was selected for a National Science Foundation Grant (Research Experience for Teachers), and was recently published in the Carnegie Museums Magazine (Summer 2018) for my role as an advisor in Science Fair.

I would be remiss not to express how this dissertation came to fruition out of my own reflection. The Science Fair program was offered while I was in high school at Highland, however under very different criteria. This program was offered only to students who were "high performing" and who were selected by the instructor. At the time (1996–2000), students were hand selected or needed recommendations to participate in these competitions. This created a culture where the Science Fair was a mythical opportunity that was only reserved for those determined to be the best and the brightest in the school. Many of these students have gone on to achieve successful lives in STEM related careers after their Science Fair experiences. I often wonder how my own self-efficacy and career options could have evolved, had I been selected, encouraged, or guided to pursue these opportunities.

The role of self-efficacy in my classroom is a professional platform I strongly desire to improve in my professional career and to build within the students in my care. I am very passionate about this and it stems from an event that I remember well. One critical juncture regarding my own self-efficacy occurred during my junior year of high school, when I expressed interest in going to medical school to become an Optometrist. When I expressed my interest in pursuing Optometry, I was greeted with two questions I still remember today. First, the teacher asked what experience I had in this area, which made me question my own mastery of the courses that would be associated with the degree. Secondly, the teacher asked if I “really believed I had the ability” to get into medical school and become an optometrist. Reflecting upon this conversation, these two questions changed the entire direction of my life. They called into question my own self-efficacy to complete the work required. Looking back now, I believe it was a blessing, for I love teaching; however, I often think how this simple action had such a dramatic influence upon my career and my life.

This conversation left a lasting impact, but now serves as a driving influence upon my philosophy as an educator. It is now my goal to grow the affective domain (specifically self-efficacy) within my students in addition to the cognitive domain towards STEM courses and majors. I must also admit that, as a parent to two young boys, the more I know about self-efficacy, the better I can prepare my children to pursue their interests in life. By fostering efficacy in the students in my care and in my own children, I believe I can help them learn more effectively, gain confidence, and demystify opportunities that they may otherwise view as unattainable.

The present study focused on students' perceptions of Science Fair preparation, which is consistent with the National Education Association (NEA) Code of Ethics (National Education Association, 2018) standards for teaching. The NEA standards are highlighted by two principles, "A commitment to the student and a commitment to the profession" (Dana & Yendol–Hoppey, 2014, p.148). As a teacher-researcher, I am committed to following Dana and Yendol–Hoppey's (2014) directive, that, "the best interest of the students you teach means carefully and systematically investigating your teaching and the relationship it has to your own students' learning" (p.148). Lastly, as an experienced advisor/sponsor to these state and regional competitions, I am familiar with local review boards and followed the same process for approval, to protect the student-participants.

Research Site

The research site was my classroom, in a middle school in a rural town in Pennsylvania called Highland School District. The student population at Highland was 319, with 98.94% students identifying as White, 0.64% as multi-racial, and 0.21% as Hispanic. Within the school, 35 % of students qualified as economically disadvantaged (Pennsylvania Department of Education, 2016), which is 21.5 % higher than the national average (United States Census Bureau, 2016).

Participants

As a teacher-researcher, I used action research methods to investigate how preparation for a Science Fair influenced 44 high school students. These students were grouped heterogeneously for one period, which met twice every six-day rotation, with the flexibility to participate a third day for a "laboratory period." Class size was consistent, with approximately 18 to 25 students per class and the teacher-researcher as the sole science teacher for the Science Fair research class. The class included 46 students (17 male and 29 female). Twenty-six percent or 12 of 46 students were classified as economically disadvantaged. All participants received the same funding for their project materials and have equal time to complete their projects. Students completed all scheduled project activities and tests during the traditional school schedule and I accommodated each student's home and family commitments, as much as possible.

Participant Selection

A few weeks prior to the beginning of the project, I informed students about the research project and asked for volunteers. I explained that the study was voluntary and that if students wanted to participate, I needed their parent/guardian's consent. I gave two copies of the consent form (see Appendix D), to each student—one to be signed and returned to me and the second, for their parents/guardians. One week before the consent form deadline, I sent a reminder home with students.

Conclusion

For this study, I followed a descriptive design that consisted of three data sets. I used a quantitative survey as my primary data set, which I administered before and after the Science Fair. I analyzed the survey along with teacher journaling and school artifacts, and polyangulated (Mertler, 2017) the findings about student efficacy (Creswell, 2009). I collected quantitative data first, so it could guide my understanding in collecting the second set of data, and help with my evolving action research plan. Analyzing the data with my student-participants provided a better understanding of how Science Fairs influenced my students-participants' feelings of self-efficacy about STEM courses and careers. Doing this allowed me to improve pedagogy by modifying my existing instructional model.

Chapter Four: Results

Background and Introduction

As the advisor to students who compete in Science Fair competitions, I provide instruction based on authentic science principles and in accordance with the scientific method. I have witnessed the excitement and frustration that students experience during the Science Fair preparation process. I have also seen former students display emotional swings when projects do not go according to plan and look dejected when they feel inferior or inadequate in comparison to their peers. These feelings often lead to negative attitudes towards STEM curriculum. Based on what I have seen and experienced, I believe that students are often overwhelmed during the Science Fair process because they lack the cross-curricular, metacognitive, and higher-order thinking skills required to compete in advanced level Science Fair projects and upper-level STEM curriculum.

My experiences at Highland School District led me to question ways in which I might better enable my students—particularly my economically disadvantaged students—to become more successful in STEM courses and postsecondary careers. Specifically, I wanted to know (a) how my existing practices (or lack thereof) influenced my students' feelings of STEM self-efficacy, (b) what role economic status played in the student's feelings of STEM self-efficacy through the Science Fair experience, and (c) how I could improve my pedagogy and curriculum to help all of my students. I chose Bandura's self-efficacy model as the model for my own study, due to its focus on a learner's ability to acquire new skills and knowledge, achieve, persist, and successfully apply knowledge (Bandura, 1977; 1986; 1993; 1996; 1997; 2002).

The Science Fair project study followed theories of pragmatism (MacGilvrary, 1999) and social meliorism (Kim, 2018; Stuhr, 2016). Pragmatic theory holds that thoughts are grounded in predictions and problem solving versus a representation, mimicking, or description of reality. These predictions form the objects that compose conception. Pragmatism within education means that learning occurs through real-life problems, experiments, and hands-on learning (Dewey, 1938). Science Fairs allow students to use reason in a pragmatic format and to use logic as a way to evaluate experiences, hypothesize, and conclude meanings, which may vary widely across different cultures. The curriculum theory of social meliorism is that education is a tool to reform society and to create change for the better, and that curriculum should be reflective of a new vision for society (Kim, 2018). Pragmatic meliorism within education means that students are empowered to identify, recognize, and work towards improving inequalities and social justice issues.

In this Chapter, I discuss how I collected and analyzed data in an attempt to find a possible relationship between Science Fair preparation and student self-efficacy. I discuss the findings, which were twofold. Although the survey results showed a negative relationship between Science Fair preparation and self-efficacy, the student-participants' responses suggested many areas of improvement when addressing student self-efficacy. These findings suggest ways that teachers can begin the cyclical, iterative, and reciprocal process of improving both curriculum and pedagogy to better address the needs of learners.

To improve my curriculum and pedagogy, I will use students' perceptions to formulate an action plan (see Chapter Five). To do this, I will create a model of self-efficacy, which I will design to increase students' desires to participate in upcoming Science Fair competitions. I will share this model at local and state conferences, to advance scientific approaches towards Science Fairs and promote STEM education.

Data Collection Strategy

The primary dataset of the study was through a quantitative data collection via a Likert scale Survey, which I polyangulated (Mertler, 2017) through observational field notes and student interviews, to refine student expressions. I selected student-participants from heterogeneously mixed classrooms ranging from 18 to 25 students per class. I administered the surveys during class time, reading aloud each question for the class. I numbered each survey before handing them out; the numbers aligned to a master list, which identified each student-participant by number. The pre and posttest surveys gave me insight into academic, social, and emotional indicators of self-efficacy. I analyzed a group of economically disadvantaged students separately, to see if this could develop into a future case study to help reduce marginalization. I further clarified results through posttest interviews, observations, journaling, transcription, audio recording, and observational field notes. Mertler (2017) stated, "The main goal of action research is to address local-level problems with the anticipation of finding immediate solutions" (p.12). Accordingly, I did not design this study to prove or disprove any theory, but rather to present findings that are immediate and prepared for direct application (Mertler, 2014) and to promote my professional ability as a science teacher.

Quantitative Measures

I used a quantitative Likert scale survey (see Appendix A) as my primary data collection method for this action research study, which allowed me to collect, organize, simplify, and summarize the data and descriptive statistics.

For the survey, I distributed a questionnaire based on *A Brief Questionnaire for Measuring Self-Efficacy in Youths* (SEQ-C, Muris, 2001). The survey assessed academic self-efficacy (8 questions), emotional self-efficacy (8 questions), and social self-efficacy (8 questions). Forty-four students (two chose not to participate) rated each statement on a scale of 1 (Strongly Disagree) to 5 (Strongly Agree). For example, I interviewed six students, using a semi-structured interview format, to clarify responses in more detail. After the initial interviews, I re-interviewed some students to clarify responses. I supplemented this data with observational field notes.

Qualitative Measures

I further refined the quantitative responses through semi-structured interviews and observational field notes. Upon completion of the quantitative survey, I convenience sampled six students, to provide more information regarding the influence of the Science Fair process on student self- efficacy. I did this in accordance with Mertler (2017): "When gathering truly qualitative data, interviews are probably best conducted following semi-structured or open-ended formats" (p. 134). I recorded, transcribed, and verified these expressions before coding them within Bandura's (1997) four categories that guide self-efficacy: mastery experience, vicarious experiences, verbal/social persuasion, and emotional and psychological states (Bandura, 1997). The information from the semi-structured interviews worked to polyangulate my findings to reveal more accurate reflections of the data (Mertler, 2017). I developed the coding themes and then identified and categorized additional themes as they emerged within the information. To further clarify the interpretation of results, I used other qualitative measures, including observation, journaling, transcription, audio recording, and observational field notes. Students also completed a concept map to further elaborate upon their expressions.

Ongoing Analysis and Reflection

The goal of this action research study was to better understand how preparation for a Science Fair influenced students' science and STEM self-efficacy. I also wanted to know if there were differences in the feelings of STEM self-efficacy between students based on economic status.

I teach students in sixth grade and students from ninth to twelfth grade. Of the 46 students who enrolled in the course, 44 students obtained consent and were willing to participate in the study. These individuals completed a Likert scale survey (see Appendix A). After the survey, I selected six students for semi-structured interviews regarding their feelings towards the Science Fair and STEM-related topics. I chose the two highest scoring individuals, the two lowest scoring individuals, and two students who were classified as economically disadvantaged. I recorded the interviews digitally, transcribed them into Google Documents, and coded them according to expressions that aligned with Bandura's four areas of efficacy. I placed the expressions in a concept map as a form of member checking, to polyangulate the findings. The survey results provided insight regarding efficacy changes among the student-participants and for improving curriculum and instruction around Science Fair projects.

Data Analysis

I used an assembly of data, including a pre and posttest survey (see Appendix X), interviews, and observational field notes. I administered the survey before and after the composition of a competition ready Science Fair project. I administered the pre and post survey twice to measure efficacy changes through the study (see Table 4.1) and changes per question (see Table 4.2). I then collected and analyzed the data to hypothesize if there was a relationship between Science Fair preparation and student self-efficacy.

Analysis of Pre and Posttests

On the pre and posttest surveys, items 1–8 measured social self-efficacy, 9–16 measured academic self-efficacy, and 17–24 measured emotional self-efficacy. Students (n=33) indicated a 0.02% change in social self-efficacy, a -0.24% change in academic self-efficacy, and a -6.98% change in emotional self-efficacy. Table 4.1 demonstrates the average score per category.

Table 4.1

Average Responses Among Self-Efficacy Categories

Major Reporting Category	Pretest Averages	Posttest Averages	Change%
Social Scores	32.6315895	32.63636636	0.02
Academic Scores	31.89473684	31.81818182	-0.24
Emotional Scores	31	28.90909091	-6.98

Knowing that behaviors influence cognitive ability and attitudes helped me to better understand personal influence within an environment. A more supportive environment can be fostered using this data, to improve educational practices within specific settings.

Table 4.2 provides a breakdown by survey question and offers clarification upon students' feelings of efficacy (to see all student responses, see Appendix A). Table 4.3 (See *Data Interpretation*) displays the percentage change per question.

The survey gave me insight into the application of efficacy in various situations, from social, emotional, and academic standpoints. Students noted the following as the most critical areas for improvement:

- "I have the ability to control how nervous I am when presenting my project." (3.5)
- "It is easy to improve my attitude if something goes wrong with my Science Fair project." (3.63)
- "I am able to give a 'pep-talk' to improve my feelings before a Science Fair presentation." (3.68)
- "I believe my project deserves a first place or scholarship." (3.81)
- "I am able to ignore possible bad things that may happen during my presentation." (3.84)

Coding and Semi-Structured Interviews

Coding Interviews

I coded semi-structured interviews to provide inductive analysis of this study and to place patterns into four categories of self-efficacy. Each pattern represented perceived strengths and weaknesses of efficacy. I used semi-structured interviews where I asked several base questions and then followed up a given response with alternative, optional questions (Mertler, 2014). Bandura (1993) explained that self-efficacy and achievement result from a learning environment that is strongly shaped by a learner's skills and

Table 4.2

Average Response of Self-efficacy by Question

Question #	Likert Scale Averages Before Science Fair Preparation	Likert Scale Averages After Science Fair Preparation
1	4.318181818	4.366666667
2	3.977272727	4.366666667
3	4.704545455	4.566666667
4	4.25	3.966666667
5	3.909090909	3.833333333
6	4.5	4.433333333
7	4.045454545	4.1
8	4.045454545	3.833333333
9	4	3.633333333
10	3.977272727	3.75862069
11	4.386363636	4.4
12	4.295454545	4.266666667
13	4.431818182	4.2
14	4.113636364	4.266666667
15	4.159090909	4
16	3.818181818	3.571428571
17	3.636363636	3.333333333
18	3.886363636	3.461538462
19	3.5	3.5
20	4.181818182	3.8
21	3.681818182	3.433333333
22	4.136363636	3.9
23	4.227272727	4
24	3.840909091	3.8

Note. Items 1–8 related to Social Self-Efficacy, 9–16 to Academic Self-Efficacy, and 17–24 to Emotional Self-Efficacy.

knowledge and the underlying thought processes that activated them. Bandura's research, including his four principles of self-efficacy: (a) mastery experience, (b) vicarious experiences, (c) verbal/social persuasion, and (d) emotional and psychological states, help build or diminish an individual's level of self-efficacy (Bandura, 1993).

These patterns help identify areas of strength and weakness and areas for improvement within the classroom. In addition, using the flexibility of a semi-structured approach, I was able to use information that may be unique to each student, based upon his or her experience.

Mastery experience. Mastery experience, which is dependent upon personal accomplishments, is the most successful way to build a sense of efficacy. Bandura (1994) explained that, because self-efficacy is constructed upon success and failures, it allows students to create a measure of their capabilities. Thus, experiences have the ability to shape positive or negative experiences, and are critical for any self-analysis of ability and self-efficacy—the student who believes that she/he will succeed is much more likely to do so.

Vicarious experience. Vicarious experiences, on the other hand, compare an individual's success to the perceived ability of another individual or peer. In a vicarious experience, as the observer identifies similarities between him/herself and the desired model, there is a corresponding relationship to desired success (Bandura, 1997). By modeling the goals and behaviors of peers, students have the ability to build their own self-efficacy through association. As Schunk (1987) stated, "the most accurate self-evaluations derive from comparisons with those who are similar in ability or characteristics being evaluated" (p. 149). Further, according to Britner and Pajares (2006), vicarious experiences that are exploratory and adaptive build the sense of science self-efficacy, which strongly correlates to the design for this study.

Verbal/social persuasion. Verbal/social persuasion is the psychological influence one person has to influence the self-efficacy of another. Bandura believed that, as difficulties arose, if students could verbalize and discuss strategies with the model to overcome the challenges, a positive shift could occur (Bandura, 1977). According to Bandura, students who receive verbal praise experience an increase in perceived ability.

Emotional/psychological state. Finally, emotional and psychological influences may affect self-efficacy and future learning capabilities. As self-efficacy develops, so too, do values and beliefs. In turn, the emotion state assesses a student's comfort level within a class environment; for students who are naturally supportive and collaborative, self-efficacy increases (Bandura, 1994).

Interviewing Student-Participants

Note: the following interviews were my first interviews with each participant. All names are pseudonyms.

1. Vince.

Demographics. Vince was an 18-year-old high school senior who had voluntarily enrolled in the class and competitions for the past four years. He had an IEP for learning difficulties; however, over the past three years, he had been awarded scholarships and sponsorships for his projects.

Pre-science fair perceptions. Vince scored a combined efficacy of 39.33 on his Likert scale survey and rated his STEM skills as a 9/10. I asked Vince, as an experienced science fair participant, is there anything he would change from the previous year or any suggestions he had for new individuals taking the course. He identified the importance of the correct emotional/psychological influence when he said, "if you have a bad mindset and don't want to do something that day, it will ruin or screw-up your entire project." This mirrors Bandura's (1994) explanation that understanding and addressing the emotional influence upon values and beliefs, helps create more inviting learning environments, increased learning, and improved self-efficacy.

Vince was motivated to pursue a career as an electrician. He stated that his pursuit of an electrical career came from working with people. He named two other students who worked well with him, and said that they would be successful working together. He said that would like to work with these individuals, for they all "get it." As Bandura (1997) explained, this reflects the similarities between the individual and the goals and behaviors of their peers. As we were discussing careers, I asked Vince if he would consider science as a backup option. He responded, "No, I don't think so, my grades would stop me, I'm not the smartest kid." Previous accomplishments or lack thereof, demonstrates a reflection upon mastery skills, as outlined by Bandura (1997).

When asked about his reflection upon his teacher preparation for STEM classes, Vince stated that at this point, his teachers can't do anything. He stated that it is up to him and his own brain to learn. I found this statement to be very revealing, as Vince was aware of his own cognition and reflected upon his own abilities, as defined by self-concept (Sorge, Newsome & Hagerty, 2000). In addition, when asked if and how had this process helped, Vince stated that "it's given me a bigger perspective of people in the world, all different ethnicities there, and I made a lot of friends to talk to all of them, like people all there doing the same thing as me." This reflected the vicarious aspect outlined by Britner & Pajares (2006), as Vince was forming self-efficacy through experiences with other people.

Post science fair perspective. Upon the completion of the science fair study, Vince felt his STEM skills were around an 8 or 9 because he felt he knew how to do things. Throughout the thematic coding, he continually referenced the vicarious aspect with the most nodes of information. As I questioned Vince more about his score, he continued to explain that he actually felt like a 5 or 6 towards science, which depended on what he was doing, but an 8 or 9 when he could research things he knew about, like in Science Fair. “If it is something familiar I am more about an 8 or 9. In this class, I am an 8 or 9, because I know how to do it.” When I asked Vince about his desire to pursue a STEM career, he stated, “they are important, because we need people in those careers, but we also have too many individuals in those careers.” I asked if he felt he was good at STEM, he said, “no, I’m not the smartest in a lot of things, I’m not going to say I’m great at a lot of things, I am good at about five things; that is about it.” As Zeldin, Britner, and Pajares (2006) explained, “the potential of self-efficacy and its antecedents to influence how people select or eliminate future activities has been used as a heuristic model in understanding career decisions” (p. 1037). Vince also verbalized that he “deals with engineers all the time, so I don’t have a problem with engineering.” He further explained that he is not good at math and that he views as a major limitation. Lastly, Vince mentioned that, as a senior, he still had not passed his state mandated Biology exam. His body language changed as he mentioned this and I could sense a feeling of frustration. Vince explained that he didn’t like Biology, but he didn’t care because he wanted to go into a technical field. He further elaborated that he felt too many individuals were going into STEM and that the technical fields were “where the jobs will be.”

2. Patrick.

Demographics. Patrick was a 17-year-old male high school senior who was classified as economically disadvantaged. He had enrolled in the class for the past five years. He participated in technical training for half days and spent the other half days at Highland.

Pre-science fair perceptions. Patrick expressed that he felt like he understood information easily in science class, and rarely needed things explained more than once. "I would give it a 9/10. Most of the times I can understand it, but then some things I need to have explained more than once." When asked why he felt he was good at science, he stated, "It's something I have been working at a while, so you sort of understand how things work." Patrick attributed his ability to figure things out and an inquiry to think how things work as a critical component. Out of the areas on the survey, he explained that he felt comfortable with all areas. However, if he had to identify an area for improvement, he would choose socially (although, he emphasized he had no reservations in that area). Patrick quickly followed this statement with an explanation about how this class "has helped within his public speaking ability" because of the "extensive practice" he had, which was reflective of mastery experience (Bandura, 1997). When asked what things could keep him out of a STEM career, Patrick responded, "advanced math." When I asked him why, he explained that it was more confusing and he felt less comfortable understanding information. Association of the emotional/psychological domain may have been influencing this decision, based on Patrick's reflection of his comfort level in the class environment, combined with a previous lack of mastery (Bandura, 1994). Patrick's opinion was that "Science Fair was valuable because it could be used in other things—like using the process to figure out something, no matter how simple it may be, and figuring out how things could be made better." This statement, of applying model-based learning in other contexts, reflected a vicarious experience (Schunk, 1987).

Post science fair perspective. Patrick rated his STEM skills as a 9 and viewed science as "pretty easy" but acknowledged that sometimes he "has a little more to figure out." As he further explained the value of Science Fairs, he further explained that it "helps with the scientific method," especially applied to other courses. "Like in this class, we are focusing a lot, like my environmental class on the scientific method. Since I already have a background on that, it helps me a lot." Patrick acknowledged the role of the subtheme of procedures outlined by Schmidt and Keller (2017) regarding procedural knowledge and valuing the design, collection, and analysis of data. "Science Fair helps you figure out how things work, what works, and how to present it and put it all together." Although he did not plan on pursuing a STEM career, and planned on pursuing a career in carpentry, towards the end of the interview, he acknowledged the valuable roles STEM skills played in construction: "Yeah I guess there is a lot of engineering and math too" in construction. This aligned with Zeldin, Britner, and Pajares (2006), who stated that "self-efficacy beliefs of men in these male-dominated domains are created primarily as a result of interpretations they make of their ongoing achievements and successes" (p.1036). Patrick made it to the state competition the preceding two years, by receiving first place finish at Regional competitions with his carpentry Science Fair projects. He stated that he didn't plan to pursue STEM careers, because he had better opportunities in carpentry, stating, "it's hands on and I can make a lot of money with it."

3. Isabelle.

Demographics. Isabelle was a female high school junior, who was classified as economically disadvantaged. She had enrolled in the class for the past two years and followed the high school's academic track.

Pre-science fair perceptions. Isabelle had participated in science fairs before, and stated that presenting was the area that made her uncomfortable. She explained, "Whenever I am presenting, I don't like to present, I get nervous. Because if I know what I am talking about, judges questioning me, makes me really nervous." She did feel that she could correct this or take more time to review her topic. She said that practice with others and in front of others could help. Isabelle rated herself a 7 out of 10 in STEM knowledge, stating, "There are some areas I struggle and some that I really accomplish what I really know. Like I don't struggle, but some areas I am better in. I am not good at chemistry at all, because of the numbers. I am not good at math either." This expression of self-efficacy beliefs, through vicarious experience associated with the STEM field, demonstrated a reflection upon increasing or decreasing an ability to influence efficacy beliefs (Britner & Pajares, 2006). Isabelle also said that the key to her doing a good project was to get things done on or ahead of time, to save stress from staying up late, because rushing made her feel stressed and unprepared. Demonstrating this self-concept, which reflected the constructs of anxiety and stress, is valuable in understanding efficacy beliefs in the emotional/psychological domain (Britner & Pajares, 2006).

In describing STEM courses, Isabelle mentioned a teacher last year who made math "really fun and interesting." This emphasized the importance of teachers and the role of having positive teachers who promote self-efficacy, for they more effectively transfer knowledge, skills, and capabilities to their students (Türer & Kunt, 2015). When asked about pursuing a STEM career, Isabelle stated, "Yes, it is my passion, it is what I love and I can't imagine doing anything else." This connection of academics with the psychological domain, reflects Bandura's (1986; 1997) connection about academic expectations being linked to psychological and behavioral processes. This is insightful regarding efficacy, for it is more common to relate self-efficacy to associated career interests that encompass the performance accomplishment experiences provided by a particular intervention (Dawes, Horan, & Hackett, 2000).

Isabelle said that she plans on going into the pharmaceutical or environmental field and in obtaining one of these degrees. I believe that Isabelle's self-efficacy and career choice is the result of academic self-efficacy (Dawes, Horan, & Hackett, 2000). When I asked her if there was anything she was nervous about or something that could slow down her pursuit of STEM goals, she said "maybe financial stuff, but that shouldn't be a problem . . . I don't think."

Post science fair perspective. Isabelle elected not to participate in the post Science Fair interview. She stated that it made her "really anxious" to answer questions aloud. I explained to her that was not a problem, and thanked her for her time. I then selected another student with similar pretest efficacy scores. This student also classified as economically disadvantaged. This individual ranked his skills as an 8 or 9 out of 10, "it depends on the topic, but I like science, it is something I am good at. Sometimes I am a little bad at it, but higher topics I may have a tough time with." When questioned, he had the most frequent expression within the social/verbal category; he said he "worries about stuttering" because he gets nervous. As a sub question, this individual added a lot to my study. He explained how he would like to be a marine biologist and that Science Fairs allowed him to study the subject. He wanted to be a “marine biologist, and deal with all that technology and how they use things to go to the bottom of the ocean, it deals with science and math.” He also mentioned this as a concern because, as “technology advances, I won’t be able to use it if I had to use it.” I got some insight into how important he thought Science Fairs were when he stated, “because they help students that wouldn’t be able to go to college, because some people don’t get the chance to go for something they are good at.” As Thomas (2005) argued, a strong sense of self-efficacy is critical for the academic success of economically disadvantaged students.

4. Betty.

Demographics. Betty was a 14-year-old female high school freshman, who was classified as economically disadvantaged. This was her second year competing in the Science Fair.

Pre-science fair perceptions. Betty told me that she was between an 8 or 9 out of 10 regarding her science ability. She felt that her biggest area of improvement for the Science Fair was to make her project bigger, by adding and having more numbers than last year, so she would have more to talk about. She said that last year, she felt like she ran out of topics to talk about because she lacked extensive data. She also said she would greatly benefit from studying her charts so she could figure them out and give exact details. This insight demonstrated that Betty perceived an area of weakness within her project, based upon feedback she received the previous year. These strong abilities to identify areas of weakness, address areas that require perseverance, and push through more difficult situations, promote one’s confidence (Britner & Pajares, 2006).

As the conversation dove into various topics, Betty mentioned that technology was the area that made her nervous, because she "doesn't have much experience" with it. She further explained that a lack of experience in robotics limited her topics. When I again asked about how she felt she was at STEM related skills, she said she was "a lot better than she thought she was" because of her finish the previous year. This was reflective of Bandura (1997) when he explained that efficacy beliefs determine attitudes, which shape behaviors and the environment, which are influenced by knowledge and happenings within an individual's own life.

Betty said she wanted to pursue a science career because science topics amazed her. When I asked how she compared to her peers in science, she said, "my project last year taught me to solve things by making a project that other people might not even know how to do." When asked what made her good at science, she said, "my project did well last year and the payoffs that came from it, I didn't expect, I did pretty good and I got pretty far." This is in accordance with Britner & Pajares (2006), who hypothesized that mastery experiences were the strongest and most accurate predictors of self-efficacy, as was explained by Bandura (1986, 1997). To finish the interview, I asked Betty, "how is this class going to help you"? She responded, "[it] opens up new majors and scholarships to help me choose a career in college." When Betty mentioned this—about new majors—it reminded me again that curriculum decisions in high school have historically resulted in limited opportunities for young women (Dawes, Horan, & Hackett, 2000). When I followed up on the importance of a scholarship, Betty said, "I do have some saved up for it [college], but it would really help maybe get into a really good college, like a top college, but I do have some money set aside."

Post science fair perspective. Betty felt her STEM skills were an 8. When I asked what prevented her from achieving a 10, she stated that she "just gets confused" when trying to use charts, forms, and Google Sheets to calculate the mathematics component of the Science Fair. She expressed that to improve, she wants to "get more data and more numbers in my project and not have only a little data. I feel like my project was short and it was cut short because I didn't have enough data." Betty felt that she could improve her feelings towards STEM if she "could explain better her data charts and numbers, because I know what I did, but putting in words makes it harder. I need to study my data charts more, so I can study them, and tell what I did." Betty had many expressions of vicarious situations, where she could reference related skills and professionals multiple times. This aligned with Zeldin, Brinter, and Pajares (2008), when they stated, "an analysis of these narratives revealed that social persuasions and vicarious experiences were critical sources of women's self-efficacy beliefs" (p. 1039). Betty said that the success in Science Fairs in the past allowed her to do better in STEM courses, and that she felt teachers should enhance STEM opportunities. She acknowledged that Science Fairs "give a boost" about knowing more for preparation of a STEM career. As an improvement, she said that she needed more training on formulas on a computer, because right now, she was better off "doing them on her own." Betty did have one mastery expression, when she said that Science Fairs helped her improve, because "like I didn't" know how to assess last year".

5. Lacy.

Demographics. Lacy was a female high school freshman, who had no previous experience with Science Fairs. She demonstrated the third lowest self-efficacy scores

(27.33).

Pre-science fair perceptions. Lacy rated herself a 9 out of 10 for science skills. As a follow up to the survey, I asked about Lacy about her feelings regarding each of the reporting categories. She explained that she was "most nervous about public speaking, because she didn't like people judging her." She also explained that she had always been good in science. "Like in the past I have done well in science." Following up with STEM fields, I asked about her areas of weakness. Lacy stated, "engineering, because I always struggle with weird areas." Lacy further explained that she didn't have experience in that area. When I asked if she felt she would be good at it if she were taught, she said "maybe." When I asked if she planned on a STEM career, she said "no, I want to be a teacher, I like all subjects." When I asked what stopped her from pursuing a STEM career, she said that she would get bored doing the same thing every day and she liked diversity in the day. Then she said, "I'm not bad at STEM, but I feel weird feelings towards it."

At the end of the interview, Lacy said, "teachers never made it interesting and just did stuff out of the books and didn't make science fun. Your sixth-grade class was the first time I liked science, because it was hands on." Proudly, I smiled, for this was a validation for how I conduct my mid-level science class. It also aligned with Türer and Kunt (2015), who explained that, for students to demonstrate positive attitudes towards a teacher or course, the teacher must reflect the attitude towards the profession and an interest in generating self-efficacy towards science education. Science education self-efficacy is the teachers' beliefs in themselves considering their teaching—that it can be a positive influence on changing students' behaviors and attitudes and on training highly successful individuals (Türer & Kunt, 2015). When asked about why she pursued the Science Fair opportunity, Lacy stated "I was going to join it last year, but I didn't know if I could or not, and I saw my friends do it, so I figured I could. Science isn't my best subject, but I'm not bad at it".

Post science fair. Lacy decided not to interview again. She stated that she had a lot of things going on, so her time was really tight. I explained that it was "totally ok" and not a problem.

6. Sally.

Demographics. Sally was a female high school freshman, who decided to participate in the elective course. This was her first year participating in the Science Fair. She exhibited the lowest self-efficacy score (24.67).

Pre science fair perceptions. When reviewing the categories, Sally explained that she was most worried about the "social aspect by talking in front of people." She was reluctant to answer how I could help with this problem. As I circled back to this question for clarification, Sally stated, "just make sure I am prepared." As an educator, I feel that this is a critical point because, by providing successful experiences, teachers can help increase self-efficacy, which provides mastery experiences that are easily attainable (Britner & Pajares, 2006).

It was difficult to obtain information in Sally's interview, but through rephrasing questions, I was able to clarify her answers. Sally felt that she was good at solving problems in logical manners. She stated that is what she "has done before, but I can't explain a logical answer to the problem." This previous success cultivates efficacy with regard to persistence, as the success and/or failure results directly in information obtained

(Yogurt, 2013). Sally said that she thought she would go into a STEM field, which she **c**lassified as a "nursing or psychological field." This insight provides the educator with a framework to nurture students' beliefs in their abilities, while envisioning success as being obtainable (Britner & Pajares, 2006). Sally explained that science is important in these fields, but "social aspect, just making sure I am prepared could help, and if you just make sure the project is ok." This follows Britner & Pajares (2006): providing social persuasion, including verbal expressions could serve as an important asset to building self-efficacy. Sally felt that if teachers would help her better comprehend subject materials, she would be more likely to succeed. As Britner & Pajares (2006) explained, self-efficacy is a way that teachers and parents can increase a student's success and ensure that students base course taking and career decisions on choices regarding their interest and ability, versus a lack of confidence or fear of science.

Understanding that a more effective science education program will lead to long-term improvements should be a goal **(**Türer & Kunt, 2015). Self-efficacy researchers believe that if they are able to succeed in science tasks or activities, the effort and perseverance they show will be evident through tough situations, which is the ultimate success in science (Britner & Pajares, 2006).

Post science fair perspective. Sally had seven nodes of vicarious mentions for efficacy connections. This aligns with Zeldin, Britner, and Pajares' (2008) study, in which the authors studied vicarious experiences among male and female students and found a stronger expression in females. Uniquely, Sally had expressions of an 8/10 on STEM skills, because "there are some topics that there is not enough reasoning behind it for it to make sense." She identified her issues with STEM fields in the application of mathematics, specifically with the rules for proving and disproving things. She explained that this class would help her in pursuing nursing, because of its connection to the scientific method. Sally told me that she thought her STEM teachers should give actual college prep work and not just bookwork. Lastly, she said that Science Fairs are important because you can "meet people and meet people from outside of our own town, like meet people from other places. It also can help you prepare for Science Fairs."

Reflective Stance

Schwandt (2015) defined reflexivity as "the process of critical self-reflection on one's own biases, theoretical predispositions, and so forth . . . [it] can be a means for critically inspecting the entire research process" (268). I endeavored to do this throughout the study.

I used various data collection methods to capture expressions of STEM self-efficacy linked to a Science Fair project. Themes that informed the study came from various sources, including: Likert scale surveys, interviews, observational field notes, and concept maps. The analysis of the data provided valid themes and categories supported by the polyangulation of various data collection methods (Mertler, 2014). I used this data to describe how Science Fairs may influence STEM self-efficacy.

Specifically, this study relied upon Likert scale expressions of self-efficacy through the academic, emotional, and social domains. I coded and interpreted semi-structured interviews, informal interviews, teacher journal entries, observational field notes, and concept maps within Bandura's theoretical framework, to help polyangulate findings. I documented student responses, phrases, and patterns within the categories and themes in the context of self-efficacy. I used Bandura's (1997) four principles of self-efficacy for context: (a) mastery experience, (b) vicarious experiences, (c) verbal/social persuasion, and (d) emotional and psychological states, which served as a theoretical framework to better understand student-participants' expressions. These principles served as the codes, when categorizing the student-participants' expressions during semi-structured interviews.

The initial interim analysis of the semi-structured interviews lacked a depth of expressions. I attributed this to students being uncomfortable in the first two weeks of school and to being overwhelmed with the initial coursework. I revisited and re-interviewed students before member checking, to allow themes and categories to emerge from their previous statements. I also reviewed interviews with each student, which I followed with expansion probes like, "tell me more about that" or "why do you feel this way?" Revisiting their initial responses led to deeper expressions of efficacy, within the aforementioned categories/themes outlined by Bandura (1997).

During the coding process, I reflected upon the initial coding methodology, due to positive and negative expressions from students. Many students showed initial expressions of efficacy within the categories/themes, which supported the survey data. I member checked this, using a concept map that elicited expressions from student-participants. Reflecting upon this will allow for insight towards the development of an action plan, aimed at improving this educational process in Highland High School. I believe that this insight, from both objective and subjective viewpoints, can begin a cyclical, reciprocal, and iterative approach to improving the facilitation of Science Fair preparation.

I collected data through pre and posttests, as measured by Likert scale surveys, semi-structured interviews, and observational field notes. I summarized data in a concept map, which allowed me be more objective and seek further input, by emphasizing the reciprocity nature of the action-research paradigm. Analyzing the initial pretest survey process required me to elicit responses from each individual in each of the three different domains/categories (social, emotional, and academic). I cumulated each value within the three domains. These category scores provided a starting value of self-efficacy in each domain for each student, while providing data for the class value per category of self-efficacy. Each category had a maximum possible score of 40 points. According to the Likert scale average, social self-efficacy had the highest score (33.75), followed by academic (33.18), and emotional (31.09).

After completing the survey, I selected six students to complete semi-structured interviews: two with the lowest self-efficacy scores, two with the highest self-efficacy scores, and two who were considered economically disadvantaged, as defined by the Pennsylvania Department of Education (Pennsylvania Department of Education, 2016). I audio-recorded student interviews, then transcribed and coded them based upon the four influencers of self-efficacy outlined by Bandura (1997). In the initial interview (before the Science Fairs), students indicated 18 nodes of mastery experience, 18 nodes of vicarious experience, 9 social indicators, and 19 emotional/psychological indicators. I combined and summarized these emergent themes and expressions in Figure 4.1.

I revisited data collection with participants through the form of a concept map during member checking, as part of the interview process. I did this by asking students to

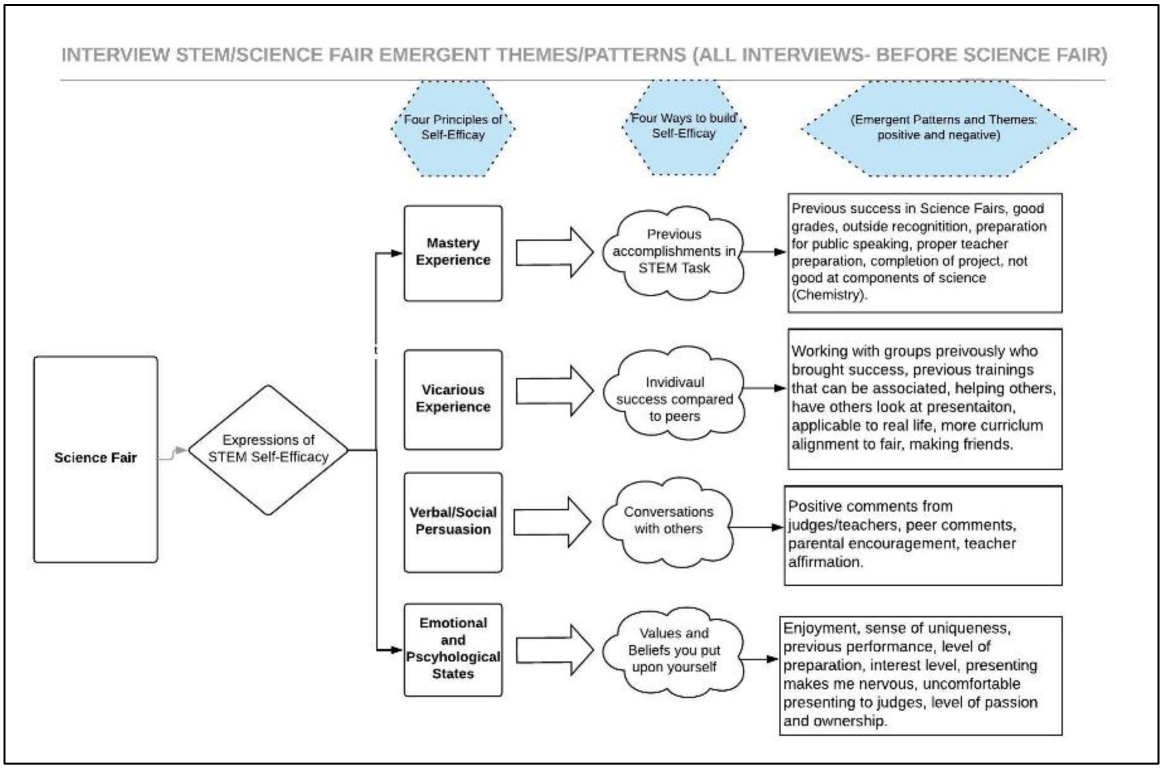

Figure 4.1. Emergent patterns, themes, and phrases of study participants.

choose themes (see Figure 4.2) and then elaborate upon their selection, to elicit more detail. By clarifying students' expressions of perceived strengths and weaknesses, this Emoji icon survey, which represented students' emotions within the four major research categories, helped me fill holes and gaps in the data, and improve the reciprocity of action research.

Data Interpretation

Quantitative Data: Pre and Posttest Surveys

I administered the pretest on the first day of the course, to analyze students' self-efficacy before starting the Science Fair project. Many students (n=27) had previously enrolled in this course and had elected to enroll again. The remaining students (n=19)

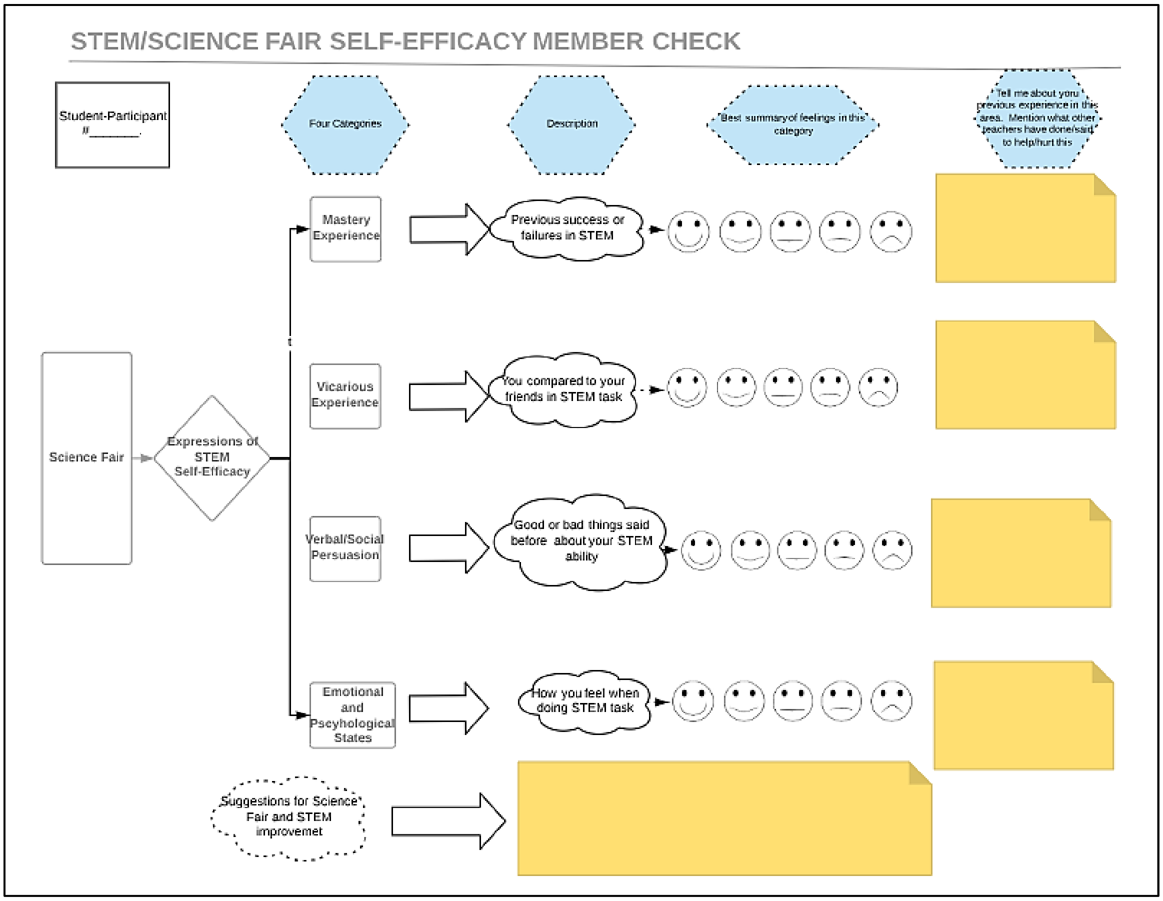

Figure 4.2. Student concept map.

were first time participants. At the end of the Science Fair project, student-participants completed the posttest (see Table 4.3).

I analyzed data based upon students who were willing to retake the posttest survey. I explained to the students again that taking the posttest was voluntary. Thirty-three students participated in the posttest, which I created in a Google Sheet and shared with students, to elicit more feedback.

When I compared the student responses, there were only five that improved in value from pretest to posttest, compared to nineteen responses that decreased. These changes were insightful as to interventions I might initiate to improve self-efficacy values. The largest decrease occurred with the response to “I am able to stay calm when presenting my Science Fair project," which dropped 10.93%. The second largest drop was with "I can get my science teacher to help when needed during the Science Fair Process" (9.17%). The third largest drop was in the response to "I am confident in presenting my Science Fair project," which dropped by 9.13% (see Table 4.3). I believe that this information will allow me to create interventions and improvements, which I can implement before the Science Fair, to increase student self-efficacy. To measure the effectiveness of various interventions, I will conduct follow up data collection, as outlined by the iterative and cyclical nature of action research.

There was an increase of 9.79% in student response to the statement, "I feel confident in my ability to debate my Science Fair project with someone who disagrees with me." The statement "I feel confident I can complete a Science Fair investigation of high quality" had a 3.72% response increase. The statement, "Science Fairs offer me an ability to make new friends" also showed a 3.72% improvement in student response (see Table 4.3).

The questions covered three domains—social, academic, and emotional. In the social and academic question categories, there was a decrease of 0.84% and 3.27%, respectively. In the emotional category, the values decreased by 5.99% (see Table 4.4.)

The data shows that there are many improvements I can make to the current Science Fair preparation process. The p-value ($p<0.05$) indicates that the change in responses upon completion of the Science Fair project were statistically significant, as shown in Table 4.5. As Mertler (2014) explained, the means of the groups are calculated and compared to see if they are statistically significant, with an alpha level set at 0.05 in educational research studies (see Tables 4.5 and 4.6).

Table 4.3

Changes in Student Survey Responses Before and After Science Fair

Question #	Likert Scale Averages Before Science Fair Preparation	Likert Scale Averages After Science Fair Preparation	Change in Student Response as Class Average per Question	Change Per Question (Rounded)
1	4.318181818	4.366666667	0.0484848489999994	+1.11%
2	3.977272727	4.366666667	0.38939394	+9.79%
3	4.704545455	4.566666667	-0.137878788	-3.02%
4	4.25	3.966666667	-0.283333333	-7.14%
5	3.909090909	3.833333333	-0.075757576	-1.98%
6	4.5	4.433333333	-0.0666666669999998	-1.50%
7	4.045454545	4.1	0.0545454549999995	+1.33%
8	4.045454545	3.833333333	-0.212121212	-5.24%
9	4	3.633333333	-0.366666667	-9.17%
10	3.977272727	3.75862069	-0.218652037	-5.50%
11	4.386363636	4.4	0.0136363640000008	+0.31%
12	4.295454545	4.266666667	-0.0287878780000002	-0.67%
13	4.431818182	4.2	-0.231818182	-5.23%
14	4.113636364	4.266666667	0.153030303	+3.72%
15	4.159090909	4	-0.159090909	-3.83%
16	3.818181818	3.571428571	-0.246753247	-6.46%
17	3.636363636	3.333333333	-0.303030303	-8.33%
18	3.886363636	3.461538462	-0.424825174	-10.93%
19	3.5	3.5	0	0%
20	4.181818182	3.8	-0.381818182	-9.13%
21	3.681818182	3.433333333	-0.248484849	-6.75%
22	4.136363636	3.9	-0.236363636	-5.71
23	4.227272727	4	-0.227272727	-5.38%
24	3.840909091	3.8	-0.0409090910000001	-1.07%

Table 4.4

Category Averages and Percentage Change

Major Reporting Category	Pretest Averages	Posttest Averages	Change%
Social Scores	33.75	33.46666667	-0.84%
Academic Scores	33.18181818	32.09671593	-3.27%
Emotional Scores	31.09090909	29.22820513	-5.99%

Economically disadvantaged population data. Data from the economically disadvantaged population (n=12) showed improvements in thirteen of the survey responses and eleven decreases. This was a better performance measure than the class-wide sample, which had only five increases within the data set. Also, negative metrics were less frequent, with 11 decreases versus 19 in the main dataset. Within the economically disadvantaged students, there was an increase of 14.67% when responding to the statement "I can solve disagreements on best approaches towards Science Fair projects." The statements with the second and third largest response increases were "I feel confident helping others improve their Science Fair project" (7.23%) and "Science fairs can allow me to have fun with my classmates," (7.23%). (See Table 4.7.)

Some decreases occurred in the posttest as well. The largest decrease was 12% when responding to the statement "I am able to give a 'pep-talk' to improve my feelings before a Science Fair presentation." The next two lowest scores both had a decrease of 8.70% in response to "I am able to stay calm when presenting my Science Fair project" and "It is easy to improve my attitude if something goes wrong with my Science Fair project" (see Table 4.7).

Students in this population also showed an increase in academic self-efficacy (5.81%), but a decrease in social self-efficacy (0.61%) and emotional self-efficacy (4.79%), upon completion of their Science Fair projects (see Table 4.8 and Figure 4.1). Despite these findings, the p-value was over an alpha of 0.05 (see Figure 4.3 and Table 4.9). As described by Mertler (2014), the p-value greater than alpha (0.05) suggests that the differences are not statistically significant. Thus, the decreases are more likely due to chance than the variables tested by the experiment.

Table 4.5

t-Test of Individual Responses to Questions on Likert Scale Survey (Pre and Posttest).

t-Test: Paired Two Sample for Means. Per Question Average on Likert Survey.

	Variable 1	Variable 2
Mean	4.084280303	3.949649488
Variance	0.08140851452	0.1259869896
Observations	24	24
Pearson Correlation	0.8496188132	
Hypothesized Mean Difference	0	
df	23	
t Stat	3.510101998	
P(T<=t) one-tail	0.0009405769446	
t Critical one-tail	1.71387148	
P(T<=t) two-tail	0.001881153889	
t Critical two-tail	2.068657599	

Note. Chart created with XLMiner Analysis ToolPak, through Google Sheets.

Table 4.6

t-Test for Reporting Categories

t-Test:Two Sample Assuming Equal Variances

	Variable 1	Variable 2
Mean	32.67424242	31.59719591
Variance	1.960915978	4.678279244
Observations	3	3
Pooled Variance	3.319597611	
Hypothesized Mean	0	
df	4	
t Stat	0.7239980008	
P(T<=t) one-tail	0.2545720463	
t Critical one-tail	2.131846782	
P(T<=t) two-tail	0.5091440926	
t Critical two-tail	2.776445098	

Note. Chart created with XLMiner Analysis ToolPak, through Google Sheets.

Qualitative Data

Pre-science fair semi-structured interviews. I selected six students for semi-structured interviews: students with the two highest scores, the two lowest scores, and two students from the economically disadvantaged population. The interview results were insightful and enlightened areas for future improvement within my curriculum, to build student efficacy. Student expressions ranged greatly for coding of the interviews. Students mentioned two major themes, mastery and vicarious experience within the academic and social domain, as a major source of generating efficacy in the past. Vicarious experiences, by relating to associated task/careers/courses, served as a frequent node during the interviews. Students often expressed that they enrolled in the Science Fair process to better prepare for future careers. Interestingly, students expressed that they had high initial STEM self-efficacy, which probably encouraged them to enroll in the class. Based upon these interviews, the association of STEM and Science Fairs to vicarious fields/topics along with past mastery were the most commonly expressed thematic codes. Interestingly, the students from the economically disadvantaged population mentioned only a "slight" worry about not having the money to go to college. One student mentioned that they "should have enough money" to go to college and the other that, "I don't think money will be a problem" for going to college. I found these expressions intriguing, as I did not ask students any questions regarding economic background.

Post-science fair semi-structured interviews. At the conclusion of the Science Fair process, I once again conducted semi-structured interviews regarding students' insight into the process, which will help formulate the action plan set out in Chapter Five.

Table 4.7

Economically Disadvantaged Average Response and Percent Change

Pretest Averages	Posttest Averages	Change %
4.5	4.7	4.44%%
4.166666667	4.3	3.20%
4.166666667	4.8	2.86%
4.25	4.5	5.88%
3.916666667	4.2	7.23%
4.5	4.8	6.67%
4.083333333	4.2	2.86%
3.75	4.3	14.67%
4	4.2	5.00%
4.25	4.444444444	4.58%
4.583333333	4.4	-4%
4.416666667	4.2	-4.91%
4.333333333	4.3	-0.77%
4.166666667	4.3	3.20%
4.166666667	3.9	-6.40%
3.833333333	3.8	-0.87%
3.833333333	3.5	-8.70%
3.833333333	3.5	-8.70%
3.166666667	3.1	-2.11%
4	3.7	-7.50%
3.75	3.3	-12%
4	3.8	-5%
4	4.1	2.50%
3.666666667	3.8	3.64%

Table 4.8

Category Averages of Economically Disadvantaged Students from Pretest and Posttest

Major Reporting Category (ED Students)	Pretest Averages	Posttest Averages	Change%
Social Scores	33.83333333	35.8	5.81%
Academic Scores	33.75	33.54444444	-0.61%
Emotional Scores	30.25	28.8	-4.79%

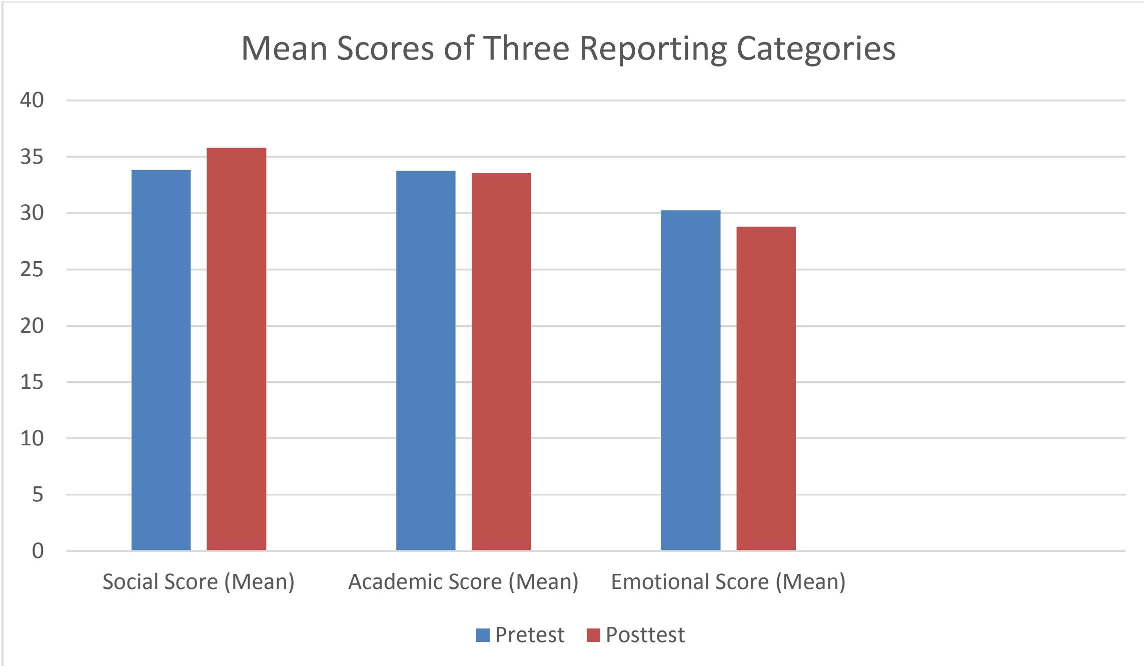

Figure 4.3. Category averages of economically disadvantaged students from pretest and posttest.

As we were now seven weeks into school, students were talking a lot more about vicarious and mastery experiences, or lack thereof, which they were experiencing. Vince provided me with particularly interesting feedback. Vince initially ranked his STEM skills a 9, which he reduced to an "8 or 9." He then said that his overall science skills were a 5 or 6. He explained that it depended on what he was doing and mentioned that he still had not passed his state mandated Biology exam. He told me that he was really only good at "like 5 things." I believe that this lack of mastery was having a negative impact upon Vince's science self-efficacy. When I asked him if he thought the Science Fair had helped him, he stated that he "deals with engineers all the time, so I don't have any problem in engineering." To me, this showed that Vince placed a value on vicarious experiences.

Table 4.9

t-Test for Pretest and Posttest Means for Economically Disadvantaged Data Set

t-Test: Paired Two Sample for Means for Economically Disadvantaged

	Variable 1	Variable 2
Mean	4.076388889	4.089351852
Variance	0.1158917069	0.2059095992
Observations	24	24
Pearson Correlation	0.8365660559	
Hypothesized Mean	0	
df	23	
t Stat	-0.2523301761	
P(T<=t) one-tail	0.4015135821	
t Critical one-tail	1.71387148	
P(T<=t) two-tail	0.8030271642	
t Critical two-tail	2.068657599	

After completing the science fair projects, many students mentioned their concerns for components that were involved in a Science Fair and in an upcoming competition. Patrick explained that public speaking would be an area for concern within STEM, but emphasized that it wasn't "that big of a concern." He said that "advanced math" could limit his ability to pursue STEM careers. He also mentioned that the Science Fair had helped him in his Environmental Science course, because he was able to use the scientific method that he learned in Science Fair. Isabelle also mentioned that if something stopped her pursuit of a STEM career it would be mathematics, like the ones used to do the tables, charts, and statistics for the data analysis. Sally, who had one of the lowest efficacy scores, mentioned seven nodes of vicarious efficacy. These strong connections to purpose within her project, gave her a more positive outlook on the process.

Interestingly, from the pre to the posttest, there was a drastic variance of effectiveness, based upon coding in the semi-structured interviews. In summary, the semi-structured interviews involved 17 nodes of mastery experiences versus 14 nodes in the pretest. Most impressively was the increase in vicarious experiences. In the posttest, students mentioned 34 nodes of vicarious experiences versus 14 in the pretest. The posttest also had 9 nodes for social/verbal expressions versus 7 in the pretest. Finally, there were 16 emotional nodes in the posttest versus 14 in the pretest.

Observational field notes. I kept observational field notes on students' actions and behaviors, which gave me valuable insight into how I could improve the Science Fair process to help students. For example, within mastery experience, Francine (all names are pseudonyms) said, "I don't know if I can do that, it looks too hard." Initially, many students expressed excitement in the process itself. Jessie stated, "I could do this, it is a great idea" followed by "this is so neat." And David said, "I didn't know I could do a Science Fair on video games. I didn't know that classified as science. This is so cool." These initial comments aligned strongly to the emotional and psychosocial states. Dominic and Francine stated negative expressions in this domain. Dominic said, "I'm so frustrated. Do you have an idea for me? What can I do? Like, I am lost." Denis demonstrated a vicarious experience when he said, "I want a STEM project, like all the other kids." Likewise, Jacee turned to a friend (Paul), who participated in previous years and said, "Help me come up with an idea." This student (Paul) showed verbal/social persuasion by stating, "I like that idea. It's neat." As I circled the students, I noticed that one of the students was noticeably frustrated. When I went over to him, he said, "I can't download Android Studio without permission from tech. No joke, the speed is a thousand times faster than my internet at home." These conversations helped me refine the concept map and initiate improvements within the Science Fair process.

Concept map. I created a concept map to develop consistencies in my data interpretations. This map helped polyangulate findings, while eliciting more details from students for improving and demystifying the Science Fair process. I encouraged students to participate in adding to the concept map by identifying the relationships between STEM and Science Fair self-efficacy. With this assignment, I asked students to reflect upon their previous experiences and about how the completion of a Science Fair project might influence their beliefs regarding STEM opportunities. The concept maps served as another methodology for evaluating student responses and helped polyangulate my findings. Through the completion of concept maps, students recalled self-efficacy influencers within each category.

Expressions of the mastery domain varied greatly between students. Evan, Betty, Isabelle, Regan, Sally, Tommy, and Ester talked about previous Science Fair performances within the mastery experience. Participant Betty said that her mastery experience was aligned to her previous qualifications as a Broadcom MASTER® finalist when she was in eighth grade (a prestigious national science and engineering competition in which only two students were selected out of over 1,000), in addition to receiving first place at the regional competition. Evan, Isabelle, Regan, Sally, Tommy, Ester, and Kelly mentioned previous finishes at state competitions and winning scholarships at previous Science Fairs as forces that shaped their mastery experience. Beth, Doug, Ethyl, Francine, Mike, Regan, and Betsy related their mastery in Science Fair/STEM to their levels of success in other school science courses. As Ester explained, “Science comes easy to me, and it is always an easy A.”

Vicarious experiences had the most mentions in the semi-structured interviews. Within the vicarious aspect of efficacy, Isabelle explained that it was her science teacher’s support that encouraged her. David, Ethyl, Francine, Henry, Isabelle, Lucy, and Sally compared their grades and achievements to other classmates to define their vicarious experiences. Interestingly, Evan identified that “others were able to test in one day,” which was a comparison this individual used and valued.

Verbal and Social persuasion was an area that did not elicit much response, but nonetheless provided interesting perspectives into self-efficacy. David, Denise, Ethyl, Henry, Ester, and Jacee felt that positive teacher comments influenced their beliefs about their abilities in STEM fields. Mike said that he was “persuaded” by his sister to pursue honors courses. And Regen, Tommy, and Sophie said that comments from judges positively influenced their self-efficacy.

Lastly, Doug, Isabelle, Regan, Tommy, Ester, Kelly, and Sammy associated the emotional and psychological states to their “confidence.” David, Francine, and Regan mentioned the need to have “fun” in classes, while Lucy explained that she sometimes “got bored.” Ethyl explained that STEM/Science Fair “comes easily.” Denise explained that he felt stressed about STEM/Science Fair when he did not receive affirmation that he was “doing it right.” And Sally explained that it “makes me anxious.” Student responses helped further define influencers upon self-efficacy (Figure 4.4), which I can use to improve the Science Fair process at Highland.

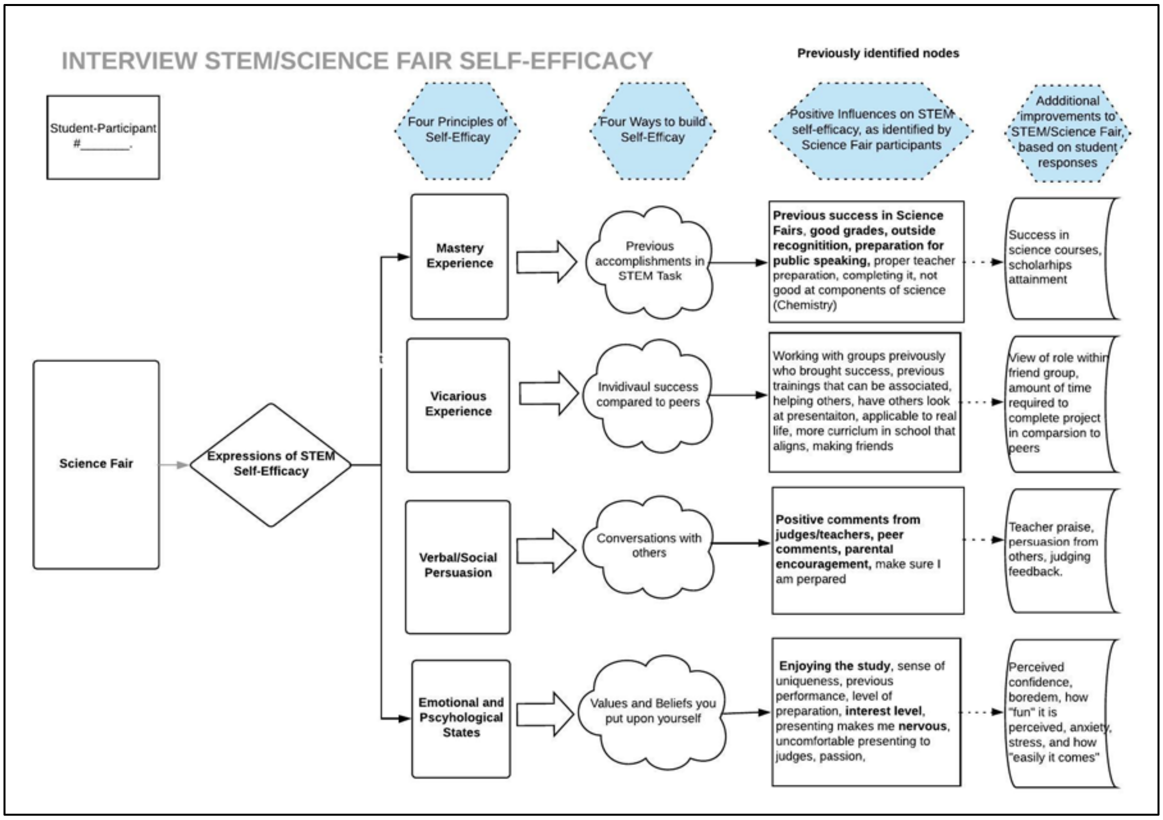

Figure 4.4. Refined concept map.

Answering the Research Question

I designed this action research study to provide information for curriculum improvement to answer the research question: "What effects did the preparation of a Science Fair have on my high school students' feelings of STEM self-efficacy?"

I also investigated the sub-question: "Were there any differences in the response patterns between students from different economic backgrounds?"

This research study investigated the social, emotional, and academic domains for learning, as defined by expressions of self-efficacy from mastery experience, vicarious experience, verbal/social persuasion, and emotional/psychological states. Specifically, I wanted to know (a) how my existing practices (or lack thereof) influenced my students' feelings of STEM self-efficacy, (b) what role economic status played in student's feelings of STEM self-efficacy through the Science Fair experience, and (c) how I could improve my pedagogy and curriculum to help all of my students.

Limitations and Errors

It is important to acknowledge possible influences that may have affected the study, in progression from pretest to posttest. First, I gave the pretest within the first week of school, which meant students were feeling the excitement of a new year. Secondly, students were adding other courses during this time (high school chorus, forensics, and vocational/technical courses), which meant they had to juggle their schedules to accommodate those activities. In keeping with my philosophy, I told these latter students that if they thought that they could balance such a schedule, then we could change the days and frequency in which we met as a class. As a result, some students received less guidance and less consistent content delivery.

I gave the posttest after students completed a competition-ready Science Fair project. Many of these students had just completed a very busy class period, immediately before taking the test. This may have skewed the emotional/psychological values. Science Fair projects also varied greatly among students, in terms of difficulty and relevance. Many times, the more complex the project, the more I needed to be involved. This frustrated some students, when they could not get immediate feedback because I was working with another student. This may have resulted in varying levels of responses when the question was about a teacher, as indicated by the data. For example, some students chose not to answer such questions on the Likert scale, and left the responses blank.

Lastly, I acknowledge that the nature of the Science Fair course in the current structure may have been overwhelming for some students. This caused additional stress on students to plan, prepare, test, report, and turn in the essential forms, with less than desired teacher guidance. During this process, it was also important not to express my own frustrations over my own course load, which could have negatively influenced my students' self-efficacy.

New Possibilities

I must acknowledge that, prior to writing this dissertation, I already believed that the Science Fair provided a great opportunity for all students in my local setting. The honest feedback from students will lead to structural improvements within my Science Fair approach, which I outline in an action plan in Chapter Five. The prior Science Fair format focused exclusively upon the cognitive domain and on judging rubrics. I believe the process requires a more holistic approach, in order to improve the curriculum and to demystify the Science Fair experience so it is more inclusive of students from all backgrounds. Using the inquiry-based learning practices, such as those outlined by the Science Fair, can improve attitudes towards science processes (Buxton, 2006).

As outlined by Bandura's (2001) social cognitive theory, psychological mechanisms produce behavioral reactions. These psychological mechanisms, such as self-efficacy, may ultimately influence career decisions (Dawes, Horan, & Hackett, 2000). Monitoring students' self-efficacy and intervening when negative expressions or feelings emerge may provide opportunities to build self-efficacy. This response to expression is at the heart of action research.

Action research is a reflective practice that is reciprocal, iterative, and cyclical in nature and data collection is the starting point for continual improvement within the current structure of Science Fairs at Highland School District. It is my ongoing goal as a teacher-researcher to improve student self-efficacy, as it influences how students set goals and ultimately predicts their lifetime outcomes (Usher and Pajares, 2009).

Conclusion

In this chapter, I discussed how I collected and analyzed data in an attempt to find a possible relationship between Science Fair preparation and student self-efficacy. I then presented my findings and implications. I collected data through pre and posttest Likert scale surveys, semi-structured interviews, informal interviews, teacher journal entries, observational field notes, and concept maps. I summarized data in a concept map, which allowed me to be more objective and seek further input from students, by emphasizing the reciprocity nature of the action research paradigm. In addition to the main research question, I investigated if there were there any differences in the response patterns between students from different economic backgrounds.

Data from the pre and posttest showed that the emotional domain had the lowest average score. In the class-wide sample, the cumulative average pretest score of all categories showed a 3.29% decrease when accounting for all domains. In the economically disadvantaged populations, there was a 0.32% increase across a cumulative average of all domains. For the social domain, there was a 0.84% decrease class-wide versus a 5.81% increase among the economically disadvantaged population. In the academic domain, there was a 3.27% decrease class-wide versus a 3.61% decrease among the economically disadvantaged population. Lastly, emotional scores dropped

5.99% class-wide versus a 4.79% decrease among the economically disadvantaged population.

Prior to this study, I believed that my Science Fair process was well refined and was a positive experience for all involved. However, I now realize that I had never looked beyond the academic domain. Moving forward, I will be using a more holistic approach to evaluate the process. This study indicates that there are many improvements needed in each domain to improve the Science Fair process. To do this, I will use the responses from the survey, in conjunction with the semi-structured interviews, to improve my curriculum and pedagogy, to better address the needs of learners. Using this process to assess self-efficacy and apply intervention through the four areas of efficacy creation is critical to improving the Science Fair process. This dissertation serves as a starting point for evaluating and improving curriculum practices locally and, in the future, on a larger scale. Ultimately, I will create a process to evaluate all three domains and use it to improve the educational experience and the lives of the students in my care. In this way, I hope to demystify the Science Fair experience and make it accessible to all students.

In Chapter Five, I outline an action plan, with the goal of improving student self-efficacy within my school setting, both inside and outside the Science Fair curriculum.

Chapter Five: Summary, Conclusions, and Action Plan

Introduction

The present study measured the influence of a Science Fair preparation curriculum on 44 high school students' feelings of STEM self-efficacy. Chapter Five provides a summary of the study, an overview of key questions, details the role of the action researcher, recommends an action plan, suggests goals for facilitating educational change, and proposes areas for future research.

Summary

I created this action research study because it was unclear to me whether my Science Fair curriculum and pedagogy had an impact on my student's feelings of self-efficacy. As a science teacher, I wanted to know (a) how my existing practices (or lack thereof) influenced my students' feelings of STEM self-efficacy, (b) what role economic status played in student's feelings of STEM self-efficacy through the Science Fair experience, and (c) how I could improve my pedagogy and curriculum to help all of my students. My participants were 44 high school students at Highland High School in a rural town in Pennsylvania; the study took place in my classroom. Out of the 44 students, twelve were classified as economically disadvantaged.

I wanted to know what effects the preparation for a Science Fair had on my high school students' feelings of STEM self-efficacy. And within this question, if there were differences in STEM self-efficacy between students of different economic backgrounds. The results of this study indicated that the Science Fair preparation curriculum was ineffective in generating self-efficacy. In the class-wide sample, the cumulative average pretest score of all categories showed a 3.29% decrease when accounting for all domains. In the economically disadvantaged populations, there was a 0.32% increase across a cumulative average of all domains. For the social domain, there was a 0.84% decrease across the entire population, from an average of 33.75 on the pretest and 33.47 on the posttest, versus a 5.81% increase among the economically disadvantaged population, in which the social average increased from 33.83 on the pretest to 35.8 on the posttest. In the academic domain, the average score for the class-wide population decreased 3.27%, from 33.18 to 32.10. In the economically disadvantaged population, the score decreased 3.61%, from 33.75 to 33.54. This data is helpful, as it provides a platform for me to improve the Science Fair preparation process for my students. Lastly, emotional scores dropped 5.99% among the entire population, from 31.1 to 29.23. Emotional scores in the economically disadvantaged populations dropped from 30.25 to 28.8, a 4.79% decrease (see Tables 5.1 and 5.2).

Table 5.1

Category Averages from Pretest and Posttest

Major Reporting Category	Pretest Averages	Posttest Averages
Social Scores	33.75	33.46666667
Academic Scores	33.18181818	32.09671593
Emotional Scores	31.09090909	29.22820513

As outlined in the MVPx2 model (Reinhart et al., 2018), in order to improve their self-efficacy and to access the affective domain, the data generated indicates that students need (a) exemplary models to illustrate high-level expectations (mastery experience), (b) observance of others who successfully complete task (vicarious experience), (c) reinforcement and guidance and support areas of expressed weakness (verbal/social persuasion), and (d) to foster a creating a positive and constructive climate.

Table 5.2

Category Averages of Economically Disadvantaged Students from Pretest and Posttest

Major Reporting Category (ED Students)	Pretest Averages	Posttest Averages
Social Scores	33.83333333	35.8
Academic Scores	33.75	33.54444444
Emotional Scores	30.25	28.8

This is in accordance with Lord and Orkwiszewski (2006), who stated that inquiry-based activities increase academic performance, improve performance outcomes, and generate more positive perceptions when compared to students in traditional courses. Buxton concurred, finding that creating inquiry activities, which are grounded in inquiry-based learning, improves teaching practices and helps students develop their beliefs about the scientific process (Buxton, 2006). And Heslin and Klehe (2006), when discussing self-efficacy, described it as the most powerful motivational predictor of performance on almost every undertaking.

Based on these findings, I developed an action plan to improve and generate self-efficacy in learners within the curriculum and pedagogy at Highland. These professional development activities focused on the following ideas. First, raise awareness of self-efficacy in the science department and across cross-curricular subjects to improve curriculum and pedagogy. Second, encourage the use of self-efficacy as a metric within instructional practices, while collecting beneficial strategies and approaches. Third, create a library of these strategies for sharing and collaboration to build a more holistic learning community. I will use the action plan to implement curricular decisions to monitor and improve efficacy values during the learning process. Specifically, I will perform further case studies on students from economically disadvantaged populations for analysis and publication in academic journals.

The action plan will enable me to share this study through localized professional development options, professional organizations, and eventually, through academic publication. I will meet with fellow science teachers to present this information on May 3, 2019 during a scheduled in-service day. I will present the data via a PowerPoint demonstration, followed by group discussion and reflection. I will use suggestions, comments, and ideas to prepare and improve the action plan (see table 5.3 under "Action Plan"), which will begin in August of the 2019–2020 school year.

The curriculum theory of social meliorism is that education is a tool to reform society and to create change for the better, and that curriculum should be reflective of a new vision for society (Kim, 2018). Following this concept, I will use this action plan to better serve the traditionally marginalized, economically disadvantaged student population in my school. I will actively encourage those students who are classified as economically disadvantaged by the Pennsylvania Department of Education (Pennsylvania Department of Education, 2016) to enroll in the Science Fair course. This is the same reason I applied for the Advocate Grant Program in January 2019 through the Society for Science in the Public. I submitted a plan for this grant to increase the enrollment of economically disadvantaged students by a minimum of 30% for the 2019–2020 school year. It is my goal to increase enrollment in the Science Fair from 12 economically disadvantaged individuals this year (2018–2019) to a minimum of 17 for the 2019–2020 school year.

Action Researcher Positionality

The present action research took place within my own school, Highland High School, which meant I participated actively in the research as an insider. The year of the study (2018) was my 14th year as a teacher, my 10th year at Highland, and my fourth year serving as adviser to Highland's Science Fair competition. This familiarity within the employment setting allowed me to establish relationships and promote mutual respect within the school among the administrative team and community. It also facilitated the creation of an action plan designed to enable other teachers to negotiate Science Fair preparation.

As an insider, I had regularly scheduled science courses and I was responsible for the construction, delivery, and evaluation of the curriculum for Science Fair preparation. As an outsider, I was as objective as possible with data collection that included semi-structured interviews, informal interviews, teacher journal entries, observational field notes, and concept maps. I concluded that a Science Fair course should be required for all incoming freshman students.

At the time of the study, I had served for four years as both the teacher and advisor for the Science Fair course. As such, I had a familiarity and comfort with the curriculum and pedagogy. However, I realized that some students, particularly those who were classified as economically disadvantaged, did not self-identify as "Science Fair material." As an insider, through the Science Fair process, I had witnessed the transformative power that competitive Science Fairs have on historically marginalized populations. In my case, the students had been classified as economically disadvantaged and many were the first in their families to go to college. I had previously taught many of these students, as I serve as a sixth-grade science teacher at the Middle School in the District. Once of my goals was to increase access and equity for these students, both to encourage participation in the Science Fair, and because the growing STEM fields were increasingly focused on diversity among STEM majors at technical and four-year post-secondary institutions.

The position of insider allowed me to collect data and maintain an ongoing dialogue with participants. During the study, before each data collection cycle, I reinforced with students the optional nature of the study. I believe this conversation resulted in some students choosing to dedicate their time to other tasks versus the follow up data collection methods. Specifically, 33 out of the 44 students decided to take the posttest, while two interview participants elected not to interview again. Students expressed remorse and stated that they were too busy or felt stressed about other coursework. These issues were not present during the pretest and initial interviews, as I did these at the beginning of the school year.

As an outsider, I initially felt that the difficulties I described were a hindrance to my study, but soon found that they actually helped develop strategies for improvement in the Science Fair preparation process. As Mills (as cited in Mertler, 2014) explained, after learning from the study, we must identify the next steps of our professional practice (p. 211).

Key Questions

The following key questions arose during the study, which helped define the action plan and generated ideas for future improvement within curriculum and pedagogy:

1. How can teachers at Highland improve the Science Fair process, to increase economically disadvantaged high school students' feelings of STEM self-efficacy?;
2. How can improved STEM self-efficacy increase equality in all subject areas to ensure access for students from all economic backgrounds?
3. How can we implement a more holistic STEM curriculum, through the integration between the arts and science, to improve Science Fair preparation?
4. How can we leverage these findings to recruit more economically disadvantaged students and students from other marginalized groups into advanced STEM coursework and careers?

Developing the Action Plan

On November 2, 2018, I attended the Pennsylvania Junior Academy of Science (PJAS) meeting in an undisclosed location. As we discussed ways of improving the Science Fair's enrollment and methodology, a PJAS adviser made a statement that resonated with the purpose of the present study:

> Participation in Science Fairs is more important than ever for our area. We need to increase both enrollment and exposure of this program to our kids. Providing these Science Fairs gives a connection to STEM and must be emphasized. For many of our kids, this will be their only exposure to STEM fields. We need to figure out how to increase enrollment because I am tired of seeing kids viewing

their career opportunities as retail or restaurant businesses. This program is a great opportunity for exposure for our most at risk students. (D. Bryson, personal communication, November 8, 2018)

Action research, unlike traditional research, is cyclical and iterative in nature and is used as a critical analysis or justification of one's teaching practice (Mertler, 2014). My action plan relies heavily upon professional development opportunities, by building stakeholders' exposure to the construct of self-efficacy and valuing their input and feedback for curricular improvement. According to Dana and Yendol–Hoppey (2014), teacher inquiry fosters leadership through experimentation, investigation, and collaboration of motivational strategies to positively influence deeper engagement within learning. Sharing my inquiry, findings, and hypothesized improvements provides the opportunity for a reciprocal, iterative, and cyclical action plan. It generates future goals for my practice and informs my conversation with my science department colleagues, other subject areas colleagues, and outside professional organizations. It helps us collectively develop strategies to raise awareness and improve students' self-efficacy. Systematic steps of developing, planning, performing, and reflecting will generate consideration for improvement, through collaboration and reflection upon the study (Mertler, 2014). By developing and sharing future studies and methodologies, I hope to build a community to lead improvement within schools. Monitoring student expressions throughout the process of learning may provide interventions to improve expressions of self-efficacy.

Knowing the following helped me formulate the action plan:

1. Self-efficacy varies greatly within individuals.

2. Self-efficacy values have a strong connection to past successes.
3. Teacher personality and interactions with students can influence students' self-efficacy.
4. Teachers can manipulate classroom climate and expectations can be to improve self-efficacy.
5. Collaboration, mentorship, and comparison with peers strongly influence self-efficacy in students.
6. Because self-efficacy is complex, teachers may need to develop interventions to improve areas that are lacking.
7. Monitoring self-efficacy provides a more holistic education that is not dependent solely upon student achievement and standardized testing.

The Action Plan

The purpose of this action plan is to:

- address local-level problems with immediate solutions through raised awareness and collaboration (Mertler, 2017); and
- involve a variety of professionals in implementing and eliciting feedback to develop ideas and resources for addressing self-efficacy in learners.

Accordingly, this action plan outlines professional development initiatives that are reciprocal and collaborative. I hope that teachers will use the plan to demystify STEM for all students who participate in the Science Fair at Highland. I believe that, through critical analysis of teaching practices, teachers can help students improve self-efficacy through the reciprocal, cyclical, and iterative methodology (Mertler, 2014).

Mills (as cited by Mertler, 2014) suggested that an action plan should include charts that delineate, in concise form, the components of the study in a “Steps to Action Chart” (p. 211). The chart I created outlines the recommended action, the required team members, the supports needed, an estimated timeline, and the resources necessary to implement the plan (see Table 5.1). I designed the action plan to be fluid so teachers can adjust it as new discoveries and opportunities arise.

Phase One: Share Findings

Share findings with science department colleagues to encourage change.

Action research plans are implemented in educational settings to help facilitate change (Mertler, 2014). Accordingly, I will share the findings of this action research with fellow science educators at department meetings in the fall of 2019. I will present the plan as a PowerPoint presentation, reviewing major aspects of this dissertation and my ideas for improvements within the science curriculum. As Mertler (2014) explained, it is imperative that teacher-researchers share results of their action research to bridge the gap between theory and research and actual practice. I hope to encourage my Science Department colleagues to participate in monitoring and sharing interventions, to foster student self-efficacy. This component requires my colleagues to value self-efficacy as a critical component of curriculum and pedagogy.

The student-participants in this study revealed the following expressions of self-efficacy through semi-structured interviews. I have organized the expressions based on Bandura’s (1997) principles of self-efficacy. This feedback, which I member checked using student concept maps, might help lead to possible strategies for improving self-efficacy.

Table 5.3

Action Plan for Collaboration of Best Practices to Improve Self-Efficacy Towards STEM Learning.

Recommended Action	Who is responsible for action?	Who needs to be consulted/ informed of action plan	Who is respons-ible for monitor-ing/collecting data?	Timeline	Resources
I will share findings through professional development within science department.	Individual teacher-researcher	Principal and fellow science teachers, grades 6-12	Science teachers	1x2 hour meeting for training (May 2019). 2x2 hour follow up meetings for preparation of data collection and sharing of data collection. (August 2019) and follow-up 1x3 hour (November 2019)	Power Point presen tation and sample self-efficacy survey
I will present at district-wide in-services, focusing on all subject area educators in evaluating and improving self-efficacy of participants. Establish self-efficacy as a metric option for differen-tiated super-vision projects and share findings.	Science teachers and other teachers who elect to use self-efficacy data collection	Superinten-dent, Principal, and voluntary subject matter teachers	Individual teachers who choose to evaluate curriculum choices and relation-ship to efficacy	Presentation 3x1 hour presentation. Initial plan: assistance (1 hour); mid-point review in January (1 hour); finalization in May (1 hour). Total time: One calendar school year	Teacher; PowerPoint; teacher-selected resources; self-efficacy survey; computers, with Google Classroom and Google Forms for evaluating and sharing findings

I will share at professional development in local setting and at professional science conferences (PJAS and Society for Science and the Public) as a cyclical and iterative process for improvement. Findings will be used to identify and improve Science Fair/STEM preparation to recruit individuals from marginalized backgrounds.	Science teachers from various school districts, Science organizations	PA Junior Academy of Science (PJAS) Board	Individual teachers who voluntarily participate	Initial in-service (1x2 hour session); PJAS meeting (1x4 hour session); PJAS regional follow up meeting (1x4 hour); presentation at Society for Science and Public (1x1 hour); and Pennsylvania Science Teacher's Association (1x1 hour); follow-up correspondence (continuous)	PowerPoint presentation, Google Forms, Edmodo group for collabora tion and conversa tion, initial webpage develop ment for collabora tive sharing
I will compile strategies on improving self-efficacy to improve equality by building a laboratory of strategies from all stakeholders for publication to reach a larger audience.	Researcher	District Principals, department heads, teachers who voluntarily enroll, and outside profession-als	Educators who voluntarily enroll to follow initiative	Continuous	Google Drive for shared collabora-tion of resources, Edmodo page for sharing findings through net-working, future develop-ment of collabora tive website; profession-al journal publication submission

- *Principle: Mastery Experience*

  Expressions: Previous success in science. Previous success in science competitions/fairs. Trying to limit viewing things as failures, but rather as area for growth. Proper structure to allow for success along the way. Mastering the base of knowledge needed to acquire new knowledge.

- *Principle*: *Vicarious Experience*

  Expressions: Working with groups. Previous success with groups. Associated competitions/trainings that student-participants view as related. Have others review and provide feedback. Make applicable to real life. Make curriculum align to outcome of project. Make friends in process.

- *Principle: Social/Verbal Persuasion*

  Expressions: Positive comments from teachers. Positive comments from judges. Parental encouragement. Verification of being well prepared.

- *Principle: Emotional/Psychological State*

  Expressions: Enjoyment of the study. Sense of uniqueness. Adding value. Feelings of preparedness. Being interested in topic. Nervous of public presentations. Uncomfortable being evaluated. Driven by passion as a project.

Phase Two: Present at District-Wide In-Services.

Focus on all subject-area educators in evaluating and improving student self-efficacy. Establish self-efficacy as a metric option for differentiated supervision projects and share findings.

Once a year (typically in October), Highland creates an "Education Camp," where teachers can present on topics of interest they would like to share for the betterment of the professional staff. Teachers who do not present enroll in sessions for their professional development opportunity. For my presentation, I will use the findings of the present study to explain self-efficacy, influencers, and value, and to outline initiatives to create cross-curricular partnerships. I will present using PowerPoint, elicit feedback through Google Forms, and suggest collective ideas for improvement in a Google Classroom for individuals who wish to develop this initiative. It is my hope that, during the 2019–2020 school year, Principals will permit self-efficacy as a platform for differentiated supervision projects for these teachers.

I believe that this action research study will open opportunities to collaborate more extensively with other educators, discuss common problems and solutions, and improve the holistic education process within my local setting. As Johnson (cited in Mertler, 2014) explained, there is likely no one more interested in your research than your colleagues; this helps promote professional discussion and facilitates growth in the teaching profession.

Phase Three: Share as Professional Development

Share findings locally and at professional conferences as part of a cyclical and iterative improvement process. Leverage findings to identify and improve Science Fair/STEM preparation to recruit individuals from economically disadvantaged backgrounds.

In addition to the action plan that I will share locally with my professional colleagues, from October through March 2019–2020, I will present to a larger collection of science and STEM educators. I will develop an improved plan for professional development regarding self-efficacy and share it with the following groups, to elicit additional suggestions:

- Pennsylvania Junior Academy of Science (Region Six Board: October/November 2019)
- Pennsylvania Science Teachers Association (November/December/ January 2019–2020)
- Presentation at Society for Science in the Public (October 2019)

Sharing research studies allows for further insight and helps refine a more accurate representation of the findings (Mertler, 2014). Further, action research involves teachers “gathering information about how their particular schools operate, how they teach, and how their students learn" (Mertler, 2017, p. 4). Thus, not only will present and share my findings with these groups, I will gather input, suggestions, and research from them to improve the practice I currently use.

Phase Four: Compile strategies on improving self-efficacy

Publish in academic journals. Build a laboratory of strategies from all stakeholders and use this to reach a wider audience via publication. Use journal publication as a tool to promote science/STEM self-efficacy, access and equality for all students.

It is my goal to promote student self-efficacy by advancing this action plan to publishing in academic journals. It is my hope that this will lead to a wider dissemination of information to promote student STEM/science self-efficacy, resulting in larger collaboration and further initiatives, and ultimately, access and equality for all students. Achieving this goal will include creating advocates in cross-curricular areas, including professional science organizations, and gathering and sharing findings with local and larger audiences. As Mertler (2014) stated, it is important to establish a collaborative environment, made of professionals with common goals, who focus on continuous improvement towards a collective inquiry.

As this process continues, I plan to present the findings of this action research study, accumulate strategies, follow up with more case studies, and submit content to professional journals for publication. I believe that the information gathered in each phase of the action plan will help refine improvements. As I implement the action plan, I will collect data to answer questions about how the participants feel about the action plan, to assess students' feelings and identified needs, in order to complete a high level of inquiry-based curriculum and pedagogy. I will continue to do so throughout the process and will revise the action plan accordingly.

Facilitating Educational Change

A critical component of an educator's job is the ability to evaluate and improve upon one's own professional practice; this was my goal during this study and is at the heart of my action plan, moving forward. This action research project required me to focus upon the affective domain of the learner versus the traditional cognitive metrics. This provided valuable insight for improving curriculum and instruction with regard to student self-efficacy towards STEM. Using the evidence of this study to justify decisions towards curriculum and pedagogy (Dana & Yendol-Hoppey, 2014) allows for more effective practice and accountability within schools (Mertler, 2014). This is outlined in my action plan for Highland High School.

One of my goals is to use the findings from this study to appeal to and recruit traditionally marginalized individuals for the Science Fair. If curriculum is designed to generate self-efficacy towards the Science Fair and accompanying STEM fields, it will provide more opportunity and access for economically disadvantaged students at Highland. Creating case studies of these students may provide a better understanding and consideration of their self-efficacy. These case studies and findings can also help me secure grants to give disadvantaged students access to science fair competitions. I have already applied for the *STEM Research Grant* (applied November 2018) and the *Advocate Grant Program* (applied January 2019) from the Society for Science and the Public for the 2019–2020 school year. Both grants are designated to recruit individuals from historically marginalized populations, so they can participate in science fair competitions. These grants can be used to purchase equipment, provide financial assistance for materials, and fund travel to competitions for schools to compete in science fairs (Society, n.d.-c). These grants, if acquired, can provide resources and finance equipment and projects for the 2019–2020 school year.

Conducting the educational changes I've outlined in the action plan for Highland comes with challenges. First, the plan will result in a higher student to teacher ratio, which will increase the teachers' need for guidance. Second, the Science Fair course takes place during an activity period, when many students are involved in other activities. Third, the plan will require more money for supplies and transportation, which I have requested in my 2019–2020 budget. As the action plan develops, I can use my colleague's suggestions to address these challenges.

For the action plan to succeed, it is important to create a culture of learning and a culture of learners in my Science Fair classroom. To do this, I will create a place where my students can succeed, where they feel heard and can communicate with me when they need to, where they receive constructive feedback, and ultimately, I hope to increase their Science Fair and STEM self-efficacy.

I believe that using an online platform, such as Google Classroom to supplement classroom instruction, will allow additional, effective communication between me and my students and will provide more flexibility with scheduling, meaning I can accommodate a larger number of students. This hybrid model of instruction is preferable because I can adjust it to meet the needs of a larger number of students. To further create a culture of learning while the action plan unfolds, I will institute the MVPx2 (Reinhardt, Fail, & Millam, 2018) for the new hybrid online/classroom instruction model. I suggest this model to help address challenges such as scheduling, teacher access, and ease of communication, and to foster self-efficacy development within the learning community. The MVPx2 is model for online instruction and self-efficacy that incorporates Bandura's mastery (M) experience, vicarious (V) experience, social persuasion, and physiological cues (Px2).

I will further assist my students by modeling all four of Bandura's principles of self-efficacy. Exemplary models that illustrate high-level expectations can improve self-efficacy through mastery experience. The connection between these models and their link to real-world experiences is important, as students must connect to previous mastery in areas they are familiar with in relationship to their given task. For Science Fair preparation, I will share an example of an exemplary model's format with the students, to provide familiarity. As students progress through the Science Fair, I will supply timely and appropriate feedback and encourage them to advance (Reinhardt et al., 2018).

Improving vicarious experience relies upon observing other students succeeding at a task, observing similarities with them, and desiring the same success, thus building self-efficacy towards one's own abilities (Bandura, 1982; 1997). Publically posting models of classmates and emphasizing positive attributes helps increase vicarious experience. Teachers who point out deficiencies in a student's work should be careful to do so in an objective manor, with specific models to provide a framework for remediation (Reinhardt et al., 2018). Providing learners with high level and distinguished models (not to be copied) can be used to generate a "library" for assistance and build vicarious efficacy. When students submit assignments that miss expectations, feedback should clearly communicate the shortcomings and provide clear solutions for moving forward (Reinhardt et al., 2018).

Verbal/Social persuasion can be improved through various methods. First, it is critical to assure students that they can succeed and to reinforce that they have the guidance and support of the instructor (Reinhardt et al., 2018). Using positively crafted responses, teachers can reinforce the ability of the learner, improve the likelihood of success, and generate self-efficacy. Using positive comments and providing specific areas for improvement within graded feedback helps model and motivate students to pull from their strengths to improve weaknesses (Reinhardt et al., 2018). This process also helps the learner build an understanding and appreciation for constructive criticism.

Finally, improving the emotional/psychological state requires a nurturing culture that reinforces a can-do attitude and makes an effort to reduce a learner's stress and anxiety(Reinhardt et al., 2018). "The instructor can maintain a positive, productive approach by genuinely praising student comments, offering thoughtful guidance when necessary, and carefully redirecting students when they begin to veer off track" (Reinhardt et al., 2018, p. 25). By focusing upon a positive climate and constructive interactions, instructors can directly influence self-efficacy.

Teachers can and should foster a student's search for new discovery and meaning within an environment of collaboration and connectivity (Reinhardt et al., 2018). Google Classroom may help with this in my classroom, by providing more frequent connectivity and more familiar platform for interactions for students. In addition, I will develop online seminars and help sessions. By reinforcing my students' ability to succeed, I will use these sessions to foster my students' success and help them overcome obstacles. Through the above, I will facilitate a culture of learning and learners in my Science Fair classroom.

Summary of Research Findings

Forty-four student-participants in grades 9–12 participated in the present study. These students voluntarily enrolled in an independent research class, where the preparation and participation in a Science Fair competition was the cumulating activity. This action research study measured the student-participants' evaluations of their self-efficacy before and after composing their Science Fair projects. Self-efficacy involves a reciprocal relationship between personal, environmental, and behavioral domains (Bandura, 1997) and significantly influences problem-solving skills and efficiency in completing tasks (Hoffman & Spatariu, 2007). It also serves as a foundation for academic achievement and motivation (Bandura, 1997) and is linked to assessments on ability and future career decisions (Patrick, Care, & Ainley, 2011).

Research Finding One: Metacognition and STEM

The current process for preparing Science Fair participants at Highland may be effective for competitions but more metacognitive consideration is needed to generate STEM self-efficacy.

The process for preparing Highland students for the Science Fair process focused exclusively on the following ten steps. Students, as outlined by Wilson, Cordry, and Uline's (2004), and in alignment with the scientific method, were to:

1. outline their problem,
2. choose variables,
3. create hypothesis,
4. explain variable manipulation,
5. explain results,
6. keep a logbook,
7. evaluate data,
8. create charts/graphs,
9. determine conclusions, and
10. decide about future studies.

The present study involved these steps in addition to an alternative to the current process to see if more students might become interested in STEM and Science Fair, as some were found lacking in STEM and Science Fair preparation and were not self-identifying as "STEM material." One initiative, created by the District and me, involves reaching out to these students. Other critical components of the Science Fair process includes inquiry-based skills, teamwork, data collection, analyzing, research, concluding research (Sumrall & Schillenger, 2004), and fostering an interest in science (Bellipanni & Lilly, 1999).

Bandura (1997) argued that the foundation for success lay in a learner's underlying thought process that activates skills and knowledge. Gathering initial insight into this process via Likert scale surveys indicated decreases within every major reporting category from the beginning to the completion of the Science Fair preparation process. As an entire population, student scores decreased by 0.84% for social, 3.27% for academic, and 5.99% for emotional.

Table 5.4

Percentage Change from Pretest to Posttest

Major Reporting Category	Change %
Social Scores	-0.84%
Academic Scores	-3.27%
Emotional Scores	-5.99%

The limited participants do not provide statistical significance to the p-value, which was less than 0.05.

Evaluating curriculum not only for achievement but also for metacognitive processes is essential for holistic improvement. Metacognitive strategies have revealed a clear relationship between self-efficacy levels and an ability to successfully perform desired outcomes (Hoffamn & Spatariu, 2008). According to Pintrich and DeGroot (1990), "self-regulated learning includes students' metacognitive strategies for planning, monitoring, and modifying their cognition." Further, "different aspects of the expectancy components have been linked to students' metacognition, use more cognitive strategies, and are more likely to persist at a task" (Pintrich & DeGroot, 1990, p. 34).

Research Finding Two: Self-Efficacy in Economically Disadvantaged STEM Students

The process of creating curriculum that values and generates efficacy could help economically disadvantaged and other traditionally marginalized students.

Data from the present study shows that there are direct improvements that can be applied to the current Science Fair preparation process; however, larger scale strategies in both the Science Fair process and in cross-curricular areas are needed to be effective at generated self-efficacy among the Highland students in STEM.

This is where involving more stakeholders in the action plan can help formulate a more holistic and effective methodology of improving self-efficacy in learners. As Zimmerman (2000) explained, conceptualizing self-concept as a hierarchical construct, within a global apex of self-hierarchy, may present important self-reflective questions. Self-efficacy and outcome expectations play a larger role because they depend largely upon perceived self-efficacy of one's own judgements to execute and attain goals (Zimmerman, 2000). I hypothesize that, if students can increase self-efficacy through the Science Fair preparation process, it can help improve generational sentiments found in low-income students, which arise from boredom, anxiety, confusion, and frustration (Basu & Barton, 2007). I further believe that working through curriculum and pedagogy to proactively address frustrations due to economic inequality, may assist in developing skills to self-organize, self-regulate, and self-reflect to better support a sense of human agency (Bandura 2006). If the curriculum is designed to generate efficacy, an individual may better generate human agency and better influence his/her functioning and life circumstances (Bandura, 2006, p. 164).

Among economically disadvantaged students (n=12), there was an increase in social scores of 5.81%; academic scores decreased by 61% and emotional scores decreased by 4.79%.

Table 5.5

Percentage Change from Pretest to Posttest for Economically Disadvantaged Students

Major Reporting Category (ED Students)	Change %
Social Scores	5.81%
Academic Scores	-0.61%
Emotional Scores	-4.79%

Barton (2001) explained that economic inequalities lead to lower student achievement, less resources, decreased expectations, and an overall negative learning environment. I believe that science fairs provide a unique opportunity to improve STEM self-efficacy for economically disadvantaged students and to provide access to higher level STEM courses and careers. In a study of junior high school students by Wiederkehr et al. (2015), self-efficacy served as a mediator between socioeconomic disadvantages and anticipated performance; I theorize that similarities may apply to my students. As Bandura (2012) stated, building personal agency, in combination with other sociostructural influences, increases performance towards goals that an individual believes are important.

I will connect my findings from this study to initiatives at Highland to lead educational change, by analyzing self-efficacy in relationship to the Science Fair and STEM education. This action research study adds to the breadth of knowledge within this area, with intentions of exploring further case studies to better understand more effective practices in curriculum and pedagogy. Exploring this relationship, as a part of my action plan, provides a platform to pursue grant opportunities so that all students have access to the Science Fair, science fair competitions, and STEM opportunities. I believe that, upon the completion of the action plan, I will better understand how to best foster my students' efficacious attitudes towards STEM classwork and careers, how to provide supports for economically disadvantaged students, and the best way to ensure access and equality so that all students might succeed.

Research Finding Three: Science Fair as Authentic Science

Science Fairs are a unique way to expose students to authentic science, which allows students to serve in the role of scientist within an inquiry-based framework.

Researchers believe that authentic science activities, like those displayed within the Science Fair, can influence students' attitudes towards learning science and help shape their perceptions of who can and cannot become scientists (Buxton, 2006; Chinn & Malhotra, 2002; Sadler et al., 2010). According to Grote (2005), "Science fairs promote enthusiasm about science, give students experience in communication skills, and give [students] the opportunity to interact with other students [who are] interested in science" (p. 274). Generating this interest in STEM may lead to a STEM-related career (Hiller & Kitsantas, 2015, 2013). This is done by modeling exemplary models (mastery experience), observing others who successfully complete task (vicarious experience), giving positive support and encouragement (verbal/social persuasion) within a positive and constructive climate and addressing perceived weaknesses (emotional/psychological state) in an effort to improve self-efficacy by accessing the affective domain within STEM (Reinhart et al., 2018).

As Schmidt and Kelter (2017) explained, science fairs may play a major role in generating interest and promoting the skills needed to succeed in STEM related fields. Science fairs have become a common educational practice within U.S. science education (Schmidt & Kelter, 2017). Depending upon the professional, the objectives range from curriculum requirements to optional competitions to an exploratory method of learning the scientific method and developing a positive attitude and interest towards STEM topics (Abernathy & Vineyard, 2001; Bellipanni & Lilly, 1999; Basu & Barton, 2007, Bruce & Bruce, 2000; Schmidt & Kelter, 2017).

Research Finding Four: Peer-Modeling and Self-efficacy in STEM

Out of Bandura's four criteria for self-efficacy, the most commonly expressed was vicarious experience.

The Science Fair process indicated an increase of 14 to 34 nodes of expression from the beginning to the end of the process among Highland students in the fall of 2018. I hypothesize that this could be a result of employing methods and equipment used in advanced coursework and STEM careers. To assist with procedures and data collection, I permitted students to work collaboratively with their peers in data collection and analysis. Traditionally, this has been the procedure, in order to establish a mentorship mentality within the program between student scientists. Reflecting upon this study, as the participant increasingly identifies similarities between him/herself and the desired model, there is a corresponding increase in desired success (Bandura, 1997). By modeling the goals and behaviors of peers, students have the ability to boost their self-efficacy through the observance of others who successfully complete tasks (Reinhart et al., 2018). Further, according to Britner and Pajares (2006), vicarious experiences that are exploratory and adaptive build the sense of science self-efficacy that strongly correlates to my design for this action research study. In a vicarious experience, an observer models a desired behavior within a domain to instill confidence within the individual, by identifying similarities between him/herself, which correspond to an increased level of desired success (Bandura, 1997). Using vicarious modeling/experiences, by modeling the goals and behaviors of peers, students are able to boost their self-efficacy by comparing themselves to those of similar characteristics or abilities (Reinhart et al., 2018). In addition, Schmidt and Kelter (2017) hypothesized that working in partners or in small groups may increase science inquiry and foster positive attitudes towards STEM fields. Lastly, vicarious experiences and modeling, when adaptive and exploratory, can build science self-efficacy (Britner & Pajares, 2006). All of these apply to Science Fair preparation.

Suggestions for Future Research

This action research study investigated the impact of Science Fair preparation upon feelings of self-efficacy in STEM. Following Mertler (2017), initial findings were designed for direct application to improve curriculum and pedagogy, by addressing a local-level problem in pursuit of immediate solution. Future research is focused on the following areas: (a) increase the trustworthiness of the data by incorporating more stakeholders; (b) develop strategies to increase self-efficacy in curriculum; (c) evaluate how Science Fair competition influences learners' self-efficacy; and (d) conduct case studies within economically disadvantaged groups, to improve equity and access for students from traditionally marginalized backgrounds.

Future studies that improve the trustworthiness of the data, by incorporating more stakeholders, would help better this study. Enrolling other Science Fair participants and educators from other schools may improve both the quality and synthesis of data collected. As indicators of efficacy emerge, an in-depth analysis could be conducted to share findings with fellow educators. Teacher leaders open their doors to collaborate with others, while sharing approaches to various learning situations (Dana & Yendol-Hoppey, 2014).

Creating a pedagogy and curriculum to address and monitor self-efficacy and to improve the learning environmental for all is another future initiative. Starting with surveys as a form of a needs assessment, I believe students may provide insight to individualized need-based instruction towards building STEM self-efficacy. From these need-based surveys, future teacher-researchers can facilitate interventions and monitor subsequent changes within student self-efficacy. I believe that improving the STEM and Science Fair experience, in regard to self-efficacy, can create more positive learning environments that may improve marginalized students' access to advanced level coursework and careers. This may raise awareness towards the impact of teachers' curriculum and pedagogy on self-efficacy for their own students. In sum, I hope to expand self-efficacy in case studies to promote a more holistic development of economically disadvantaged STEM students by leading future research at Highland.

I also suggest expanding this study to evaluate how competition influences students' self-efficacy values. As evidenced in student responses and study data, students expressed concerns regarding their preparedness and proficiency in skills needed to present their project and findings. Some were uncomfortable with presenting in public or of being evaluated by judges. Monitoring efficacy would allow teachers to apply interventions before competition.

Lastly, future initiatives will involve improving equity and access for economically disadvantaged students through improvements, using case studies. In conducting case studies, I believe that immediate interventions can be applied to improve self-efficacy in these marginalized groups. Following these students in a case study format will help improve equity and access in the Science Fair with regard to the student population. I will do this by following the student-participants from start to finish and gathering perceptions of feelings about their Science Fair experience and documenting it through the entire process. This data will be the focus of a future study and the data I will use the data to improve my own curriculum and pedagogy. This iterative and cyclical approach will allow me to establish myself as a curriculum leader, and to lead initiatives to improve teacher practice within my current educational setting. The findings of these case studies may lead to further studies, journal publications, and/or grant opportunities.

My goal in this study was to identify how the current implication of curriculum of the Science Fair influences student self-efficacy, while hypothesizing about strategies to improve all students' efficacy towards STEM fields at Highland High School. The aforementioned ideas for future research will allow professionals within a school setting to enhance their professional practices (Mertler, 2014). I hope to serve as an agent of change for the future direction of how students are taught at Highland and on a larger scale. It is my goal that self-efficacy becomes something, regardless of the subject matter, that is continually improved upon. I aim to create a repository of strategies, across multiple subject areas, to generate self-efficacy in learners. Through findings and input from other professionals, it is my hope to publish work in academic journals to raise awareness and acquire more stakeholders for improving strategies for addressing efficacy in learners. I believe that efficacy should be a component of science curriculum evaluation. In addition, I believe that the desire for a more effective science education should serve as a guiding foundation as a long-term goal for science education (Türer & Kunt, 2015).

Conclusion

The purpose of this study was to explore how a popular curriculum staple, the Science Fair preparation process, affected high school students' feelings of self-efficacy. I also wanted to know if there were any differences in science and STEM self-efficacy based on economic background.

Self-efficacy serves as a basis of human motivation, which is defined by what students believe is and is not true (Blackwell & Pinder, 2014). This belief in their own ability to complete tasks is critical for students to achieve equity and accessibility to advanced coursework and post-secondary schooling and careers.

For the study, I used a quantitative survey as my primary data set, which I polyangulated through observational field notes and student interviews, to refine student expressions. I administered the surveys pre and posttest and conducted semi-structured posttest interviews. Forty-four students contributed to the initial survey with thirty-three completing the posttest. Even though some participants decided not to complete their posttest, they still provided valuable insight towards improving self-efficacy in future learners. Each student-participant followed a guided format to create a presentation of their Science Fair project. Student-participants used an eight-week timeframe to compose a project, collect data, and compose a competition ready project. When the project was completed, but before competition, I returned to assess students' expressions of self-efficacy with a posttest, semi-structured interviews, informal interviews, teacher journal entries, observational field notes, and concept maps. Descriptive statistics, as outlined by Mertler (2014, p. 11), allowed me to summarize, organize, and simplify the dataset for mean, median, mode, range, standard deviation, and correlation between all scores. I used a holistic approach towards data collection and systematic observation to gain knowledge regarding the students' self-efficacy feelings about Science Fair preparation (Mertler, 204, p.11). All three category averages—social, academic, and emotional—showed decreases from pretest to posttest across the mean of the entire population. Class-wide, there was a decrease of 3.19%. The social self-efficacy survey pretest score was 33.75 and posttest averaged a 33.47, which resulted in a -0.84% decrease. The academic scores in the pretest were 33.18 and posttest was 32.10 for the entire population, which indicated a decrease of by -3.27%. Lastly, emotional self-efficacy scores dropped from 31.1 to 29.23 in entire population, which indicated a 5.99% decrease.

For the economically disadvantaged population, there was an average overall increase of 0.25%. The social self-efficacy pretest average was 33.83 and posttest was 35.8, an increase of 5.81%. The academic self-efficacy scores decreased by 0.61%, from 33.75 to 33.54, and emotional scores decreased 4.79%, from 30.25 to 28.8. It is worth noting that this data (n=12) demonstrated a p-value of greater than 0.05, which indicates that the responses may be outside of the independent variables tested. This indicates that the results are not statistically significant.

In this study, I sought to better understand my students' expressions of STEM self-efficacy after completing a Science Fair project. The findings indicated that, despite my students' current success in Science Fair competitions, the current Science Fair process needs improvement for generating STEM self-efficacy. Although this was personally humbling, aligning with Mertler (2014), I now seek a greater understanding of a situation where an instructional method is lacking effectiveness.

Prior to the inquiry laid forth in this dissertation, I believed that the Science Fair process was well refined and provided a positive experience for all learners. Previous evaluations focused solely on the academic domain, which was often measured based upon scientific merit and performance competitions, with no value being attributed to the affective domain. Addressing the affective domain—particularly self-efficacy—is one way to decrease the marginalization of economically disadvantaged students (Reis et al., 2005). Thus, using and improving this process to assess self-efficacy and apply interventions may increase accessibility to Science Fair opportunities for historically marginalized populations.

Semi-structured interviews showed the importance of vicarious experience and its connection to efficacy generation. In conducting interviews, nodes increased from 14 to 34 from the Science Fair preparation process. In the other categories of self-efficacy creation, only marginal changes were expressed. Nodes connected to emotional self-efficacy increased from 14 to 16, social/verbal self-efficacy increased from 7 to 9, and mastery increased from 14 to 17. Insights such as these allow for interventions to be hypothesized, implemented, and monitored for effectiveness.

Moving forward, I will be using a more holistic approach to evaluate the Science Fair process. The purpose of my action plan is to (a) address local-level problems with immediate solutions through raised awareness and collaboration (Mertler, 2017); and (b) involve a variety of professionals in implementing and eliciting feedback to develop ideas and resources for addressing self-efficacy in learners. The ultimate goal of the plan is to improve my professional practice towards Science Fair preparation, to improve the experience for all students.

Part of improving the lives of all students is sharing this process and collaborating with others. It is my hope that the action plan inspires teachers at Highland to collaborate and reflect upon their own curriculum and pedagogy. As Huang (2015) explained, lessons that build efficacy are the most critical components of student success. Providing a process that evaluates self-efficacy and develops strategies to improve educational facilitation, will improve the lives of all students. Understanding efficacy creation is essential to improving the lives of students. Research shows that individuals possessing the same cognitive ability may differ on achievement measures based upon self-efficacy beliefs (Zimmerman, 1995). According to Morales (2014), within a student's disposition, self-efficacy is the most important quality to develop.

Improving self-efficacy experience within the Science Fair may help demystify the experience for individuals from all backgrounds. Self-efficacy researchers believe that if students are able to persevere to overcome difficult task and situations in science activities, it is an indicator of the ultimate testament for success in science (Britner & Pajares, 2006). I believe that refining the Science Fair process may allow teachers to better engage students from marginalized backgrounds, while promoting equality and improving access to higher-level STEM courses and careers.

I will also use the findings of this study to formulate professional development plans focused on self-efficacy generation in a cyclical, iterative, and reciprocal methodology. I will share these professional development plans locally at Highland in addition to pursuing publication in academic journals in the future.

This study indicates that there are many improvements needed in each domain to improve the Science Fair process. This dissertation and action plan serve as a starting point to improve curriculum locally while framing expansion as a future goal. Using multiple measures and observations (Trochim, 2002 as cited in Mertler, 2014, p.11) gave me a more holistic picture of the Science Fair preparation process. This wide variety of data allowed me to reflect upon the inherent biases as the science teacher and Science Fair adviser through multiple measures and observations (Trochim, 2002 as cited in Mertler, 2014, p.11). This has allowed me to develop greater confidence as I move forward to create opportunities for students who are living in economically disadvantaged situations and may not have realized they are STEM material and that they can have access to higher-level STEM courses and careers.

I will share this study with fellow professionals to develop strategies aimed at improving self-efficacy within students across various disciplines. Improving curriculum at Highland through self-efficacy may improve achievement (Zimmerman, 1995) while shaping goals and life outlook (Usher and Pajares, 20098) for all students.

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Appendix A: High School-Grade Science Fair Project, Class Survey

Social Self-Efficacy (Adapted from Muris, 2001; Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011)

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Science fair offers me an ability to make new friends.	1	2	3	4	5
I feel confident in my ability to debate my science fair project with someone who disagrees with me.	1	2	3	4	5
Science fair allows me to meet new people.	1	2	3	4	5
Science fair allows me to work with other classmates.	1	2	3	4	5
I feel confident helping others improve their science fair project.	1	2	3	4	5
Science fair allows me to have fun with my classmates.	1	2	3	4	5
Science fairs can provide me lasting friendships	1	2	3	4	5
I can solve disagreements on best approaches towards science fair projects.	1	2	3	4	5

Academic (Adapted from Muris, 2001; Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011)

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
I can get my science teacher to help when needed during the science fair process.	1	2	3	4	5
I can do the math required within a science fair project.	1	2	3	4	5
I can prepare a science fair project, according to the steps of the scientific method.	1	2	3	4	5
Overall, I am good at science.	1	2	3	4	5
A science fair is useful to my future	1	2	3	4	5
I feel confident I can complete a science fair investigation of high quality.	1	2	3	4	5
I will be able to present my findings in a confident way.	1	2	3	4	5
I believe my project deserves first place or scholarship.	1	2	3	4	5

Emotional (Adapted from Muris, 2001; Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011)

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
It is easy to improve my attitude if something goes wrong with my science fair project.	1	2	3	4	5
I am able to stay calm when presenting my science fair project.	1	2	3	4	5
I have the ability to control how nervous I am when presenting my project.	1	2	3	4	5
I am confident in presenting my science fair project.	1	2	3	4	5
I am able to give a "pep-talk" to improve my feelings before a science fair presentation.	1	2	3	4	5
I can tell my friend if I am struggling to stay calm for science fair presentations.	1	2	3	4	5
I am able to succeed in hiding negative thoughts during my presentation.	1	2	3	4	5
I am able to ignore possible bad things that may happen during my presentation.	1	2	3	4	5

Appendix B: High School-Grade Science Fair Project, Interview Questions

Possible Open-Ended Questions

1. What could make things better?
2. On a scale from 1 to 10, how well do you understand the information in science class? Why do you give it that number?
3. In your survey, you expressed [X]. Tell me more about that.
4. Do you feel Science Fairs are important in relation to a STEM career or future courses? Why/Why not?
5. You said you do not feel comfortable with [X]. Why?
    a. How can I help you improve that area?
6. Do you think science fair is important part of preparing for a STEM career? Why/Why not?
7. Overall, do you feel you are good at STEM? What areas do you struggle with? Tell me why you feel this way.
8. Do you think you will pursue a STEM related career? Why /Why not?
9. Do you feel Science Fairs helps prepare you to be successful in higher level STEM courses? If so, how? If not, why?
10. What do you think teachers could do to help you better prepare for STEM fields/courses/majors?
11. Is there anything else you want to say?

Appendix C: Data Collection Checklist

Data Collection Method	Data Collection Dates													
Self-efficacy rating scale														
Student Interview														
Observational Field Notes														
Student Interview														
Self-efficacy rating scale														

Appendix D: Guardian/Parent Consent Form

Date________________

Dear Parent or Guardian,

The Cambria Heights School District periodically asks students to participate in surveys, test, and questionnaires to gather information about various topics pertaining to curriculum. During the school year, I will be implementing a survey and interview to gather information about the impact of science fair projects upon your child's motivation and self-efficacy. This is a very important survey, which will help me promote better classroom pedagogy towards students learning science. I will use his information in my dissertation in practice for my doctoral degree at the University of South Carolina. Your agreement and your child's participation in the survey and interview are completely voluntary. Please read the following information about the study and sign the form below:

Survey Content

The survey and interview gathers information about how science fair projects influence your child's science motivation and self-efficacy (belief in their ability to perform tasks).

Participation is Voluntary

Your child does not have to take the survey (or be interviewed). Students who participate only have to answer the questions they want to answer and may stop talking at any time without any penalty. The interview is designed to see how their motivation and feelings of reaching science goals changes from the beginning to completion of the science fair.

It is Anonymous and Confidential

The survey and interview will be kept confidential (not seen by others) and anonymous (no names and the survey will be coded- Students cannot be identified)

Benefit of the Study

The survey and interview will help teachers plan and/or learn more about how to design activities to improve the classroom practice of the science teacher. Findings will be later shared with staff, to better design lessons that build students motivation and self-efficacy.

Potential Risks

There are no known risks or physical harm to your child. Your child will not have to answer any questions unless s/he wants to.

Survey Review

Beginning _____________, a copy of the survey will be available by contacting Mr. Wharton at 814-674-6290 or nwharton@chsd1.org.

For Further Information

Please call Mr. Wharton at 814-674-6290 or nwharton@chsd1.org.

Please see next page for consent form.

Parent/Guardian Consent Form for Science Fair Project

If you do NOT WANT your child to participate in the project, please complete the following and return the signed form to me by the date below.

I DO NOT want my child: to participate in the project.

Please print name of child: ____

Please sign name: ____

Please print name: ____

Date of signature: __________________________

If you DO WANT your child to participate in the project, please complete the following and return to me by the date below.

I DO WANT my child to participate in the project:

Please print name of child: ____

Please sign name: ____

Please print name: ____

Date of signature: __________________________

Please return this form to me no later than ________________________.

Thank you.