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Administrators' perceptions of STEM education and their influence on classroom practices in Louisiana schools

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ADMINISTRATORS' PERCEPTIONS OF STEM EDUCATION AND THEIR INFLUENCE ON CLASSROOM PRACTICES IN LOUISIANA SCHOOLS

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ABSTRACT

The purpose of this study was to examine administrators' understandings and perceptions of STEM education and their influence on classroom practices. Due to the well-documented need throughout decades of literature for quality STEM programming in the nation's schools, the knowledge gained in this study was valuable because of the potential impact administrators' perceptions and understandings can have on program implementation. This study focused on the implementation of Project Lead the Way (PLTW) STEM programs.

In this mixed-methods investigation, quantitative and qualitative data were gathered through the use of surveys and interviews. The study participants were administrators of schools utilizing at least one PLTW curricula. The data collection and analysis were guided by the following research questions:

1. How do administrators of schools in Louisiana implementing a PLTW curriculum define STEM education?
2. How do administrators of schools in Louisiana implementing a PLTW curriculum perceive STEM education?
3. What evidence exists to indicate administrators' understandings and perceptions of STEM education impact program implementation and classroom practices?

The study revealed that there is not a universally understood definition of STEM education. Similarly, there is a wide range in variation of perceptions regarding STEM education. The study also found that not all administrators feel prepared to oversee the implementation of STEM programming, as STEM education does require some unique administrative thinking and actions. There was some evidence that administrators' understandings and perceptions of STEM education can impact program implementation and classroom practices.

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DEDICATION

This dissertation is dedicated to several people without whom I could not have completed the process. First, to my husband, Todd, and my two children, Ella and John Kirklin, I will be forever grateful for your love, patience, and understanding over the past four years. Second, to my parents, Dave and Annette Fortuna, and in-laws, Becky and Kirk Davis, your support and constant willingness to help pick up my slack as I made my way through this journey was truly amazing. Lastly, to my other family and friends who were always there to encourage and support me, thank you. I love you all very much and am blessed to have you in my life.

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CHAPTER 1

INTRODUCTION

The term "STEM" (an acronym for Science, Technology, Engineering, and Mathematics) was created by the National Science Foundation nearly 15 years ago and since then has become a "buzz word" in education across the United States (Dugger, n.d.). Educational leaders in schools throughout the country are creating and implementing instructional plans to promote effective teaching and learning of STEM content. The integration of STEM disciplines in elementary, middle, and high school settings presents new challenges for both students and educators that must be specifically addressed (Nathan et al., 2013). These challenges must be met and the educational focus on STEM must remain steady so students can be prepared for the modern, technology-driven society and the significant number of rapidly expanding career options in STEM-related fields (Sanders, 2009).

The increased interest in this area is the result of an urgency surrounding the STEM education movement due to reports documenting the declining position of the United States as one of the leaders in STEM-focused industries and innovations (National Academies Committee on Science, Engineering, and Public Policy [COSEPUS], 2006, 2011). There is a common belief that a critical component of the nation's ability to maintain its status as a world economic leader is a strong educational system that helps students develop the foundational knowledge and skills needed for STEM careers

(COSEPUS, 2006, 2011; National Commission on Excellence in Education, 1983). Building this strong educational system requires improvements in programming for both K-12 and post-secondary settings (COSEPUS, 2006, 2011; National Science Board, 2003).

One organization that has developed multiple instructional programs to specifically address STEM education needs in the United States is Project Lead the Way (PLTW) (PLTW, 2014b). Originally based in New York, over the past 17 years PLTW has created curricula and trained teachers in the content areas of engineering, biomedical sciences, and computer science (PLTW, 2014b). Their various programs target elementary, middle, and high school settings (PLTW, 2014b). As of the 2014-2015 academic year, there are more than 5,000 schools throughout the country implementing at least one PLTW curriculum, making it one of the most widely-used STEM programming options nation-wide (Nathan et al., 2010; PLTW, 2014a).

The success of any initiative in education at the district or school level, STEM or otherwise, is heavily dependent on the quality and support of the individuals in leadership roles (Council of Chief State School Officers [CCSSO], 2008; Rogers, 2007). Effective leaders must continuously improve their understanding of instructional practices to support the successful implementation of productive programs in order to reach the demanded outcome of improved student achievement (CCSSO, 2008; Merrill & Daugherty, 2010). Quality school administrators establish the culture and organizational direction that affect how teachers and students perform (CCSSO, 2008). They must also assess and anticipate evolving trends, such as STEM, and adapt their leadership strategies accordingly (CCSSO, 2008). The impact of administrators through school culture development, which is shaped by their beliefs and perceptions, is particularly important because of its influence on school objectives, instructional practices, and students' expectations for mastering goals (Nathan, Tran, Atwood, Prevost, & Phelps, 2010).

Statement of the Problem

There is a need to gain knowledge and understanding of administrators' perceptions and practices regarding STEM education (Rogers, 2007). Acquiring this knowledge is valuable because of the potential impact they may have on students' educational experiences and learning outcomes. Although there is a large volume of research literature on effective educational leadership practices in general, there is not a great quantity of research specifically focused on leadership in relation to STEM education (Brown, Brown, Reardon, & Merrill, 2011). Given the well-documented need for high quality STEM programming in the nation's schools and the complex nature of the content, it seems prudent to examine school leadership in the context of STEM education. Educational leaders must have the appropriate knowledge to strengthen the STEM career pipeline (COSEPUS, 2006). The findings of this proposed research can be important for guiding future instructional leadership practices relevant to this rapidly growing focus area.

Purpose of the Study

The purpose of this study was to examine administrators' understandings and perceptions of STEM education and their influence on classroom practices. As the instructional leaders of their schools, principals and other administrators can play an essential role in improving STEM education (Scott, 2012). This study examined school leaders' understandings and perceptions regarding STEM education because of the influence they have on professional practices which impact how administrators manage program implementation and maintenance. The knowledge gained through this study revealed professional growth needs of educational leaders interested in building and sustaining quality STEM programming in their schools.

Research Questions

This study involved a mixed-methods investigation into the understandings and perceptions of Louisiana school leaders regarding STEM education. The combined research methods began with a quantitative, nonexperimental survey, followed by a qualitative interview approach. The research questions below were developed to guide the study.

1. How do administrators of schools in Louisiana implementing a Project Lead the Way (PLTW) curriculum define STEM education?
2. How do administrators of schools in Louisiana implementing a PLTW curriculum perceive STEM education?
3. What evidence exists to indicate administrators' understandings and perceptions of STEM education impact program implementation and classroom practices?

Theoretical/Conceptual Framework

For decades, there has been a well-documented need to improve education in the United States, particularly in the areas that prepare students for STEM-related career fields (COSEPUS, 2006; 2011; National Commission for Excellence in Education, 1983; National Science Board, 2003; 2010). By equipping students with the knowledge and skills necessary to be successful in these careers, educators give students increased odds for personal financial success because jobs in these areas are generally high-wage and are considered the industries with the greatest growth potential in the future (Committee on Highly Successful Schools or Programs for K-12 STEM Education, 2011). In addition to contributing to individuals' improved earning potential, adequately educating students for STEM careers is critical for the financial future of the United States as a nation because these industries are and will continue to be the engine of the country's economic growth (COSEPUS, 2006; 2011).

Given the significant role STEM education can play in the future of individuals and the nation, academic research in this area has increased in recent years (Brown, 2012). This area has been addressed in a variety of forms with somewhat unclear parameters. Many of the studies that have been performed are descriptive examinations of topics such as integrative classroom activities, program analysis, or content standards (Brown, 2012). Based on current literature, there is strong evidence that educators' understandings, beliefs, and perceptions play a vital role is decision making, academic action, instructional planning, course offerings to students, and implementing change initiatives (Diaz, Cox, & Adams, 2013; Nathan et al., 2010; National Science Board, 2010; Praisner, 2003).

Leadership plays an important role in any successful initiative (Brumley, 2012; Rogers, 2007). Administrators must set the goals and establish the sense of purpose within their organization as they work to address educational needs and emerging trends (CCSSO, 2008). The concept of principals as instructional leaders is of paramount importance as the fundamental reason schools exist is to ensure student learning (Brumley, 2012). This role requires that all principals must remain current with their understanding of content needs and effective classroom practices (Merrill & Daugherty, 2010). While they may not be content experts in all subjects, they are expected to examine and assess the impact of instructional programs in their schools (CCSSO, 2008). These concepts are particularly important for school administrators who commit to leading a school that engages students in quality STEM instruction which involves unique content needs and innovative classroom practices (Brown et al., 2011).

Examining school leaders' understandings and perceptions is valuable because understandings and perceptions can impact the implementation of initiatives such as STEM-focused education (National Science Board, 2010). There is evidence that perceptions can influence to whom schools offer engineering and technology content and to what degree (Diaz, Cox, & Adams, 2013). Beliefs of teachers, principals, and policy makers regarding the complexity of STEM content and the ability of students (based on ethnic, socioeconomic, and gender biases, as well as past academic performance) can shape the manner in which STEM education is offered in schools (National Science Board, 2010). Because understandings, beliefs, and perceptions of educators impact instructional planning, educational reform, and students' educational experiences, there is a genuine need to understand those beliefs and perceptions (Nathan et al., 2010).

The model of culture proposed by Trompenaars and Hampden-Turner (2000) provides a conceptual framework that supports this research. Trompenaars and Hampden-Turner describe cultures as having three layers. At the core of these layers are the basic assumptions held by the group about existence. These assumptions are a result of the group's "routine responses to the environment" (p. 24) in which it exists. The second, middle layer of culture includes the group's norms (which provide a shared feeling of what is right and wrong) and values (which are the basis for the definition of good and bad). Trompenaars and Hampden-Turner (2000) suggest that cultures have greater stability when their norms accurately reflect their values. According to this model, the outermost layer of culture includes the observable realities and specific products that act as symbols of the deeper levels of the culture.

This study sought to learn more about these cultural layers within school settings where specific STEM programming is being implemented by examining the understandings and perceptions of the instructional leaders. Examining STEM education leadership in this manner is relevant because of the influence school administrators can and should have on the culture of the institutions they serve (CCSSO, 2008). The initial online survey included questions that provided insights and indirect evidence of the core layer of assumptions the leaders possess about schooling and the existence of STEM education. The survey responses also supplied some preliminary data regarding the schools' norms and values of the second cultural layer and the instructional "products" in the classrooms. The follow-up interviews provided more in-depth knowledge and details of the norms, values, and explicit products and realities within the schools. The compilation and analysis of the survey and interview data provided valuable insights into administrators' understandings and perceptions regarding STEM education and how those impact the culture, norms, values, and, ultimately, instructional practices of the schools they lead.

Significance of Study

There are multiple examples of professional literature that discuss the need to strengthen the "STEM pipeline" in K-12 education (National Science Board, 2003;

Sanders, 2009; Sterns, Morgan, Capraro, & Capraro, 2012). This K-12 pipeline must be improved to adequately feed into the post-secondary system, which will further develop the knowledge and skills needed to prepare for STEM-related careers (Sanders, 2009). According to Nathan et al. (2010), to generate meaningful, long-term change in educational practices that positively impact the STEM pipeline, educators' beliefs, perceptions, and expectations need to be fully understood. This study proposes that examining school leaders' perceptions and understandings is particularly important because, as Rogers (2007) points out, the acceptance and implementation of instructional change initiatives are heavily influenced by building-level administrators. This research contributes to the body of research regarding specific leadership knowledge and practices that promote quality STEM education within the K-12 STEM pipeline.

The first phase of this study gathered information regarding how educational leaders in various schools throughout Louisiana understand and perceive STEM education through the use of an online survey instrument. The targeted leaders exhibited an interest in providing STEM programming for their students through the implementation of a PLTW curriculum. It is valuable to examine the level of understanding and perceptions of administrators about STEM education because of the previously referenced potential impact they may have on professional practices. The second phase of this study sought to gain a greater depth of knowledge regarding administrators' understandings and perceptions of STEM education through face-to-face or telephone follow-up interviews. These interviews, conducted with a representative sample of the survey respondents, allowed study participants to elaborate on survey responses.

The data gained from this research provides useful insights into how practicing school administrators define and perceive STEM education. Information from the survey responses and more in-depth interview answers reveals how administrators' perceptions influence their professional practices and how these practices impact STEM program implementation. The gathered data is also be valuable for identifying professional growth needs that should be addressed to promote more effective administrative support of STEM education initiatives.

Assumptions

The first phase of this study relied on school administrators completing a survey containing both open-ended and Likert-scaled responses. One assumption was that a sufficient number of the targeted administrators would be willing to complete the online survey once permission was granted for them to participate by their district superintendent. This assumption was based on the fact that these administrators have demonstrated a desire to strengthen the STEM pipeline at their school through the implementation of PLTW programming. The assumed survey return rate was 40–50%. The actual return rate was 58.33%.

A second assumption in this research was that the responding school leaders would provide honest answers that accurately reflect their perceptions of STEM education and the level of implementation at their school sites. This assumption of the respondents providing accurate self-reported answers applied to both the online survey responses and, for the selected participants, follow-up interview answers. Clarifying questions during the interview phase of the study were used to gain information to support this assumption.

Limitations

There were several limitations present in this study. First, the survey was completed on a voluntary basis by the respondents; therefore the return rate was somewhat unpredictable and the resulting sample size was small. Given the nature of the survey process, this study relied on self-reported data, which was an additional limitation. A third limitation was the geographic focus of the study. The survey was completed only by school administrators in a portion of the state of Louisiana. The restricted scope of the study participants limits the transferability of the study results.

Delimitations

There were several key parameters in this study. First, while there are multiple factors that impact STEM education and its effectiveness in a school setting, this study focused on the influence of the school administrator's understandings and perceptions. A second delimitation was that the survey was distributed only to administrators of schools in Louisiana that were implementing at least one PLTW curriculum. A third parameter related to the survey instrument. Some of the survey questions were presented in a Likert-scale format which limited how the participants could respond to those questions.

Definitions of Terms

Understanding the following terms is necessary to fully comprehend the content and implications of this research study. Therefore, to promote contextual understanding, the meaning of each is clarified below.

<u>Engineering</u>: Engineering is the use of scientific principles in creative ways to design, produce, build, and/or improve systems or devices that will sustain or enhance daily life experiences (National Society of Professional Engineers, 2014).

Innovation: Innovation involves being first to engage in cutting-edge research to gain new knowledge and leading the application of that knowledge to generate and introduce desired products and services. Innovation often requires the use of both revolutionary engineering and forward-thinking entrepreneurship (COSEPUS, 2011).

STEM Education: STEM instructional programs are those designed to strengthen and improve education in the areas of science, technology, engineering, or mathematics (STEM) at the elementary, secondary, post-secondary, graduate, and postgraduate levels (United States Department of Education, 2007).

STEM pipeline: STEM education in the elementary and secondary levels serves as the pipeline for students as they progress toward post-secondary STEM education. Within this STEM pipeline, students should engage in experiences that develop their interest in STEM-related areas of study and build the knowledge and skills necessary for success (Stearns et al., 2012).

Outline of the Study

This study is composed of five chapters. This introductory Chapter 1 has presented the need, research questions, theoretical framework, assumptions, limitations, and delimitations for the research. Chapter 2 offers a review of literature and research that is relevant to STEM education in general, specific instructional programming, and the role of educational leadership in its implementation. Chapter 3 describes the format of the study, research questions, population and sample, survey instrument, data collection, and data analysis methods. Chapter 4 details the data analysis and present findings, and Chapter 5 provides the summary, conclusions, and recommendations for practice and future research.

CHAPTER 2

REVIEW OF LITERATURE

A Historical Perspective of STEM Education

The history that has shaped the current state of STEM education in the United States covers multiple decades. As early as 1944, President Franklin Delano Roosevelt wrote to the head of the U.S. Office for Scientific Research and Development, Vannevar Bush, asking about effective programming that could be used to cultivate scientific aptitude among American students (National Science Board, 2010). Bush (1945) provided an answer to Roosevelt's inquiry when he wrote *Science–The Endless Frontier.* Although Bush did not use the STEM acronym, he did discuss the need for students to have specifically designed education and training that would promote scientific innovation. His report referred to the need to address the deficit of students pursuing higher education and careers in science and technology fields.

Just over a decade later, when the Soviet Union launched Sputnik in 1957, the United States took notice and an era of new technological and scientific developments followed (National Aeronautics and Space Administration, 2007). Throughout the country, there was a focused, coordinated effort to identify, recruit, and educate the best students to create the new generation of science and engineering innovators. During the decade following the launch of Sputnik, there was extraordinary progress made in scientific and technological discoveries and development. Unfortunately, the focus and enthusiasm for growth in the STEM areas decreased greatly during the 1970s and United States began to lose some of its competitive edge (National Science Board, 2010).

In 1983, the report *A Nation at Risk: The Imperative for Education Reform* (National Commission on Excellence in Education) highlighted the need for the United States to make adjustments to the nation's system of education. The report spoke of the country's risk of losing its status as an economic, intellectual, and innovative powerhouse. To support this claim, the report also offered a considerable list of risk indicators. This list referenced several STEM education related concerns, such as a 40 point decline in average SAT math scores between 1963 and 1980, a decline in science achievement scores for 17 year olds taking national assessments between 1969 and 1977, and a 72% increase in the number of remedial courses being taught at four-year public colleges between 1975 and 1980. *A Nation at Risk* made the argument that the educational system in America at that time was producing students who were functionally illiterate in science and technology in a world that was becoming more scientifically and technologically complex (National Commission on Excellence in Education, 1983).

Since the turn of the century, two reports produced by the National Academies Committee on Science, Engineering, and Public Policy (COSEPUS) again warned of the declining status of the United States in the areas of science and technology innovation. In the first report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (COSEPUS, 2006), the committee members expressed serious concern that the foundational building blocks in these disciplines, which are critical for the country to sustain economic leadership, were eroding while other countries around the world were gaining strength. This report also pointed out that because the

United States will likely not be able to compete with lower wage structures that exist globally, the country must compete by building better knowledge-based resources, especially in the areas of technology and science. Within the committee's four recommendations for the country to move forward, they specifically called for focused actions in K-12 education to target STEM disciplines.

The second report from COSEPUS, *Rising Above the Gathering Storm Revisited: Rapidly Approaching Category 5* (2011), offered a dismal status update on the progress the United States made since the release of the first report in 2006. The committee found evidence that the country's outlook to be an effective competitor in the global economy had worsened in the five years between the two reports. Because the country has decisively lost the ability to compete with nations that have lower labor cost structures, the report declared that the country must be able to supply scientists and engineers that can generate the next innovations in these fields. However, even with the country's growing population and the massive increase of knowledge in technology and science over the past ten years, the number of bachelor's degrees in the mathematics, science, and engineering from domestic universities has remained constant. According to the committee, this trend must be addressed because if the youth of the United States could match the performance of other, more promising countries, the national economic impact could be over one trillion dollars annually.

Recent Indicators Supporting the Need for STEM Education

There are some disturbing trends in higher education regarding STEM. Post-secondary institutions from across the nation have reported a decrease in the number of students pursuing engineering careers over several decades (National Science Board, 2010). Compounding the problem, students who are interested in earning degrees in engineering fields often lack the preparation required for the academic rigor of university-level coursework (Koehler, Faraclas, Giblin, Moss, & Kazerounian, 2013). This troubling issue is highlighted by the fact that one third of college students must take remedial coursework in one or more core subject areas (COSEPUS, 2011). There is research indicating some students with the potential to be high achievers are not ready to master advanced content because they were not adequately challenged by their earlier learning environments (National Science Board, 2010).

There are also some troubling trends that have been reported regarding the nation's workforce. The National Academies Committee on Highly Successful Schools or Programs for K-12 STEM Education (2011) reported many industry employers maintain that those applying for jobs do not possess the necessary skills in technology, mathematics, and problem solving to be successful. The committee supported this notion with the 2010 statistics indicating the demand for STEM educated employees was greater than the number of applicants with the appropriate training. This is noteworthy because there are significant national economic implications if the lack of qualified applicants for STEM job continues, considering that 80% of the careers with the greatest projected growth over the next ten years are in STEM-related fields (National Academies Committee on Highly Successful Schools or Programs for K-12 STEM Education, 2011). Given these facts, engaging students in STEM education promotes the United States' economic future. This engagement also has the potential to significantly impact the personal lives and prosperity of the students (Roberts, 2013).

Defining STEM Education

For the necessary progress to be made, it is important to have an understanding of what STEM is (Brown et al., 2011). STEM education can be defined as a meta-discipline requiring all teachers, particularly those in the disciplines of science, technology, engineering, and mathematics, to utilize an approach to teaching and learning where content is dynamic and integrated, not addressed as individual subjects (Merrill, 2009). Roberts (2013) proposed that the STEM content areas should be integrated in a manner where they are considered a "collective curriculum" (p. 22). Through an integration of the concepts of science, technology, engineering, and mathematics in K-12 classrooms STEM education seeks to allow students to develop stronger problem-solving, critical-thinking, adaptive-reasoning, and analytical skills (Brown et al., 2011; Koehler, et al., 2013; Tran & Nathan, 2010). A defining goal of STEM education is to produce intelligent students who possess the foundational knowledge, especially in science and mathematics, along with the dynamic problem-solving skills necessary to pursue and maintain a profession in a STEM-related field (Brown, Brown, & Merrill, 2012; Tran & Nathan, 2010).

Other common defining features of STEM education are the inclusion of collaboration with peers, project-based learning, and real-world application of knowledge (Ejiwale, 2012; Reid & Feldhaus, 2007; Stearns, Morgan, Capraro, & Capraro, 2012). In project-based learning experiences, students are expected to engage in authentic inquiry and utilize the design process to address real-world problems (Ejiwale, 2012). Working to solve these types of problems give students a context for internalizing their STEM content knowledge, which can support knowledge recall and transfer of learning to new situations and problems (Sanders, 2009). Students should be required to be aware of and appropriately utilize mathematic and scientific principles that apply to the problem they are working to solve in these project-based, collaborative learning activities (Nathan et al., 2013). In classrooms utilizing this signature style of STEM-focused teaching and learning, the education process is generally student centered rather than teacher centered, with the teacher acting more as a facilitator of learning than a distributor of information (Ejiwale, 2012).

Another aspect of STEM education that can be defined is the type of STEM-focused schools. The National Academies Committee on Highly Successful Schools or Programs for K-12 STEM Education (2011) identified three categories of schools. The first is selective STEM schools, which focus on one or more STEM discipline and use selective admissions criteria for students. The second type is inclusive STEM schools. These schools emphasize one or more of the STEM areas but do not use selective admissions requirements for students. The third type is schools and/or programs with career and technical education (CTE) that is STEM-focused. This type, generally in high school settings, includes programs within comprehensive schools, career academies, and CTE-focused high schools. CTE programs usually include traditional academic education that is framed within work-oriented and practical application experiences (Tran & Nathan, 2010).

Current Issues in STEM Research

Relevant literature frequently addresses the need to strengthen the K-12 "pipeline" to encourage the pursuit of STEM-related degrees after high school graduation (National Science Board, 2003; Reid & Feldhaus, 2007; Scott, 2012; Stearns et al., 2012).

Sanders (2009) reported that the STEM pipeline problem has resulted in a lower number of students entering STEM fields, especially students from traditionally underrepresented populations. Sanders acknowledged that some significant contributing factors to this pipeline problem include an insufficient number of qualified teachers, an inappropriate level of rigor in K-12 coursework, and issues with how current pre-college education is structured.

If there is to be a reverse to the growing pipeline problem, there must be a concerted effort to "cast a wide net" in order to recognize the STEM talent and potential in students from all demographic groups because high achievers exist in every geographic area and from all ethnic, racial, and socioeconomic groups (National Science Board, 2010). However, data indicate that students from lower income households have not been given sufficient opportunities to realize their academic potential, particularly in STEM areas (National Science Board, 2010). There is evidence that educators' knowledge of students' socioeconomic status can influence their beliefs about students' ability to successfully complete a pre-engineering curriculum (Nathan et al., 2010). These beliefs could lead to insufficient student exposure to challenging STEM content.

Enrollment in engineering programs at the post-secondary level generally lacks ethnic and gender diversity (Brophy, Klein, Portsmore, & Rogers, 2008). The need for more ethnic and racial diversity in STEM education is illustrated by the National Academies Committee on Highly Successful Schools or Programs for K-12 STEM Education (2011) reporting that "only 10 percent of all STEM doctorates are awarded to nonwhite, non-Asian students, although these groups now represent one-quarter of the U.S. population" (p. 4). In that same report, the committee highlighted the need to offer access to STEM coursework to students from underrepresented populations so they have the opportunity to develop the skills and knowledge necessary to pursue careers in the areas of predicted economic growth. According to Tsui (2007), there are multiple barriers that must be overcome to increase minority participation in STEM fields of study. These barriers can include cultural, structural, and institutional beliefs, policies, and practices.

Another challenge that must be addressed to improve the STEM pipeline in the United States requires identifying, training, and retaining a qualified K-12 teaching workforce in the STEM subject areas (National Science Board, 2003). Currently, many K-12 teachers do not have a strong enough understanding of engineering concepts and the applications of those concepts to have the in-depth discussions of relevant content necessary to effectively educate students and encourage them to pursue STEM careers (Brown, Brown, & Merrill, 2012; Pinnell, Rowly, Preiss, Blust, & Beach, 2013). Some contributing factors to the challenge of recruiting and retaining effective STEM teachers include demanding work environments, insufficient teacher training, the perceived low status of the teaching profession, inadequate financial compensation, and insufficient opportunities for professional advancement (National Science Board, 2003). This challenge is a cause for concern because quality K-12 instructors are a key component in the pathway needed to encourage students to pursue STEM degrees at post-secondary institutions (Reid & Feldaus, 2007). There must be support for research-based teacher preparation that is rigorous and focuses on the most effective teaching methods that promote student mastery of STEM content and development of necessary skills.

Educators need exceptional content knowledge and they must also be trained to identify students that are talented in STEM areas (National Science Board, 2010).

Enhancing the STEM pipeline also requires adequate rigor in K-12 classrooms because another strong indicator of whether students will successfully move through the pipeline, pursuing and attaining STEM degrees in college, is their engagement in a rigorous high school curriculum (National Science Board, 2003; Reid & Feldaus, 2007). This does not mean that students simply enroll in and complete a greater number of science and mathematics courses. To be effective, course curriculum must be challenging for students, requiring them to solve problems, think critically, and design innovative solutions, rather than engage in rote memorization and basic recall (Stearns et al., 2012). Opportunities for students with adequate rigor that can help them develop the necessary level of expertise in STEM content include dual enrollment, Advance Placement (AP) and International Baccalaureate (IB) programs, internships, and academic competitions (National Science Board, 2010; Scott, 2012). As students engage in the more challenging coursework, teachers should explicitly explain the connections of the content to the activity at hand to assist students in recognizing how mathematic and scientific principles are being applied in the STEM-focused problem solving process (Nathan et al., 2010).

The exposure to rigor and STEM content should not be limited to the high school setting (Sanders, 2009). Instruction that actively engages learners in STEM activities should exist throughout the entire K-12 schooling experience (Committee on Highly Successful Schools or Programs for K-12 STEM Education, 2011). In particular, elementary settings provide unique opportunities to introduce students to integrated

STEM education approaches that can pique their interest in STEM and create a strong foundation feeding into the upper levels of the STEM pipeline (Sanders, 2009). Research has shown that early experience with science can develop interest in STEM content that can ultimately influence future career outcomes (Tai, Liu, Malgese, & Fan, 2006). Early STEM exposure and interest development are particularly important for students from lower income households because these students tend to "fall out of" the top quartile in elementary grades at a higher rate than their peers from higher income households (National Science Board, 2010). Ensuring the mastery of STEM content early can promote and help maintain intellectual talent. Another important point regarding elementary STEM exposure is that high achieving students need to have the content presented at a faster pace to maintain their learning of and interest in STEM in early grades (National Science Board, 2010).

An additional issue plaguing K-12 STEM education relates to CTE implementation. Koehler et al. (2013) reported that in many high schools, technology education has been primarily addressed in CTE classes that generally emphasize the vocational aspects. They point out that this is problematic because many students who pursue higher-level mathematics and science courses, which are often devoid of engineering and technology content, do not participate in the vocationally-focused technology classes. This can contribute to a lack of exposure to technology and engineering concepts that would enhance advanced students' understanding of the math and science content being taught (Koehler et al., 2013). Another challenge related to CTE courses is there can be a "lack of theoretical content and formal reasoning needed to support later generalization, abstraction, and lifelong learning" (Tran & Nathan, 2010, p.

143). However, the Committee on Highly Successful Schools or Programs for K-12 STEM Education (2011) reported evidence that CTE can stimulate learning through real-world applications of knowledge and it "does not have to be in conflict with academic achievement" (p. 13).

Koehler et al. (2013) also reported the need for content integration as an additional issue K-12 education must address. Although the call to integrate technology and engineering content into science and math classes has been in the literature and government documents for years, it has not occurred consistently throughout the United States. In their 2013 study, Koehler et al. discovered that most states incorporate some engineering concepts into their science standards, but there are still some that do not. Of the states that do address engineering within their science standards, the depth and breadth of the inclusion varies greatly, with many states only having minimal inclusion. Furthermore, the focus is often heavily on the societal impacts of engineering and technology, rather than the key content and concepts. This focus indicates that the necessary rigor discussed earlier is not present in many K-12 classrooms (Koehler et al., 2013).

While current requirements in many states may not adequately address engineering standards in math and science courses, multiple education reform publications recommend that engineering and technology content should be explicitly integrated with traditional science and mathematics content (Koehler et al., 2013; Nathan et al., 2010). The concepts of mathematics, science, and technology are so closely linked that the American Association for the Advancement of Science (1993) reports they believe it is more challenging to teach them in isolation than merged together. This content integration should take place within school environments that encourage excellence and celebrate innovative thinking (National Science Board, 2010). Because of the volume of content and nature of the multiple disciplines included in STEM education, effective integration will likely require educators to engage in cross-discipline collaboration (Sanders, 2009).

The Role of Perceptions in STEM Education

Because of the increased attention in the academic area, there has been some study of educators' perceptions of STEM education (Brown, et al., 2011). Examining perceptions is valuable because perceptions contribute to attitudes and beliefs, which impact behaviors and practices (National Science Board, 2010). By exploring educators' perceptions of STEM, researchers may be able to identify potential impact on curriculum implementation and students' educational experiences (Diaz, Cox, & Adams, 2013). Gaining an understanding of the current perceptions regarding STEM education can help schools and districts prepare more effectively for future implementation, resources, professional development, and other programming needs (Turner, 2013).

In a 2011 study of STEM perceptions and understanding, Brown, Brown, Reardon, and Merrill interviewed 172 administrators and teachers of math, science, technology, and "other" disciplines. Only half of the participants were able to adequately define STEM education, with administrators and math teachers being the least able to provide accurate definitions. Incorrect definitions were generally too narrowly focused or not offered at all. The inability of educators to adequately define STEM indicates that there is not a universal, established understanding of what STEM education is or should be. Survey responses from this study further indicated that there is no clear vision for

STEM implementation, even among educators that believe it to be important (Brown et al., 2011).

There has also been research related to the perception of STEM as an academic pathway for students. There is evidence that educators' perceptions impact which students they will introduce engineering content to and in what manner (Diaz et al., 2013; Nathan et al., 2010). The National Science Board (2010) reported that when educators possess low expectations of students based on stereotypic or negative views of academic aptitude, it can adversely impact student participation and/or performance in instructional programs. Nathan et al. (2010) found that educators can act as "gatekeepers" to engineering curriculum; making decisions about which students are allowed to take pre-engineering courses based on past superior academic performance. According to the National Science Board (2010), this is problematic because some of the highest-potential, talented students may be from traditionally underrepresented populations. Additionally, these high potential students may not be those with the highest grades or best behavior, two groups about whom educators often hold preconceived notions. Students, particularly those that are intellectually gifted, can detect low expectations and negative attitudes from their teachers and school administrators. The detection of poor expectations and attitudes toward students can lead to reduced motivation, low self-efficacy, and lack of intellectual progress. Therefore, educators' perceptions can negatively impact the K-12 STEM pipeline that the nation needs to strengthen (National Science Board, 2010).

There is additional perception research that has been conducted in areas other than STEM education that have produced findings, which could have implications for STEM program implementation. For example, in a 2003 study examining principals' attitudes about inclusion of students with disabilities, Praisner highlights multiple key findings. First, she discovered that academic placement decisions are made based on administrators' beliefs and past experiences. She also points out administrators' attitudes and values impact the level of support they offer to educational change efforts. As a result of her analysis of the survey responses, Praisner (2003) concluded that assessment of attitudes needs to be incorporated into administrators' evaluations and attitude development should become part of the professional development process.

Project Lead the Way

As the need for quality STEM education has become more universally recognized across the country, a number of programs have emerged that offer instructional guidance focused on this academic area (Kelley, 2008). One of the most widely implemented pre-college STEM curricula in the United States is Project Lead the Way (Nathan et al., 2010; PLTW, 2014a; Tran & Nathan, 2010). PLTW offers STEM-focused curriculum coupled with a teacher professional development program intended to prepare students for the modern, global economy (Tai, 2012). The prepackaged curriculum is provided through sequences of courses that include rigorous, hands-on, interdisciplinary activities presented in a real-world context (Reid & Feldhaus, 2007). Within the PLTW system, there are five program offerings: Launch for grades K-5, Gateway to Technology for grades 6-8, Pathway to Engineering for grades 9-12, Biomedical Sciences for grades 9-12, and Computer Science (currently in development) for grades 9-12 (PLTW, 2014a).

PLTW is a 501(c)(3) nonprofit organization that began with the implementation of its Pathway to Engineering program in 12 New York high schools in 1997 (PLTW, 2014b). It has grown considerably since that time, with the variety of PLTW programs currently being implemented in over 5,000 schools in every state across the country (PLTW, 2014b). These schools include public, private, and charter settings in urban, suburban, and rural districts. They can be found in schools from a variety of economic environments, from the least to the most affluent (PLTW, 2014a).

Research Studies on the Impact of Project Lead the Way

In 2012, Tai reported on his examination of available literature regarding the effectiveness of PLTW programs on student motivation and achievement in content areas deemed important for entering science and engineering fields of study and careers. He found that there were three categories of studies that came in the form of published journal articles, reports, research briefs, dissertations, or theses. The three classifications were student-focused, teacher-focused, and principal/parent-focused. Tai's (2012) review revealed multiple student-focused studies that indicated positive impacts of PLTW programs on student outcomes as measured by standardized test performance. The teacher-focused research generally found that PLTW teachers reported the required summer training was valuable and effective, improving their ability to integrate STEM education into their classrooms. In the studies focusing on parents and administrators, both were found to have positive perceptions of PLTW (Tai, 2012).

In a 2010 quantitative study, Tran and Nathan found that the implementation of engineering-focused curricula such as PLTW offers opportunities, but there are also challenges that must be overcome. Their analysis revealed that for students to make meaningful connections between the math and science content and projects that are addressed in class, the connections need to be explicitly pointed out. At the time of their research, courses such as the first-level class, Introduction to Engineering Design, utilized multiple math and science standards, but the integration was implied rather than explicitly explained, which seemed to contribute to lower than expected student performance on standardized assessments in these subject areas. Tran and Nathan (2010) concluded that for academic programs targeting STEM education to have the desired impact, they must be implemented with fidelity and in a manner that is informed by research.

Reid and Feldhaus (2007) offered a discussion of issues that can be associated with implementing a prepackaged engineering program like PLTW. They identify some of these issues as the need for additional funding, possible building renovations, creation of suitable laboratories, and incorporating courses into the school's schedule. Addressing these issues is worthwhile, because the PLTW requirements of standardized curriculum implementation, intensive teacher professional development, counselor training, and a school certification process promotes quality and consistency. Reid and Feldhaus (2007) propose that students who complete a PLTW curriculum and are successful on the final examinations should be prepared to take on post-secondary studies in fields such as engineering.

Perceptions and Project Lead the Way

There is some evidence that teachers implementing PLTW courses have different perceptions and beliefs from STEM teachers that are non-PLTW (Nathan et al., 2010). Utilizing a specifically designed survey, the Engineering Education Beliefs and Expectations Instrument (EEBEI), Nathan et al. (2010) gathered responses from two groups of teachers, PLTW and non-PLTW, regarding some of their perceptions relating to engineering education. The results revealed that non-PLTW teachers felt more strongly that high academic achievement in math and science was required for successfully pursuing a career in engineering. The survey responses also indicated that PLTW teachers were more likely to perceive opportunities for integrating math and science content into engineering instruction. Based on their analysis of survey responses, Nathan et al. (2010) concluded that their findings highlight some challenges of STEM education and "reveal conflicting purposes of K-12 engineering education as being for a select few or to promote technological literacy for all students, which affects recruitment, instruction, and assessment practices" (p. 409).

In a study of Indiana high school principals in schools offering PLTW courses, Rogers (2007) focused on two research questions. The first inquired about the administrators' perceptions of PLTW's impact on their schools. The second concentrated on a potential relationship between the "principals' personal characteristics, experience, and school characteristics and their attitudes toward PLTW" (Rogers, 2007, p. 50). Research data were collected using a survey instrument containing both Likert-scale and open-ended responses. Analysis of the responses revealed that the participating principals had strong, positive perceptions of the impact PLTW has had on their teachers, students, and school as a whole. Some of the noted positive impacts included increased motivation and enthusiasm of students and teachers, improved critical thinking and problem-solving skills, enhanced engineering career awareness, and an increased use of relevant curriculum.

In another study of principals in Indiana that are leading schools with PLTW programming, Shields (2007) sought to gain an understanding of the barriers that school administrators' perceived as hindering the implementation of PLTW. He also wanted to investigate the demographics of schools and administrators that were most likely and least likely to utilize PLTW curricula. Shields (2007) gathered data using a survey instrument that asked both demographic questions and inquired about possible barriers through five-point Likert-scaled response questions. Data analysis revealed that most respondents felt PLTW was a valid component of technical education and the curriculum addresses skills students should learn. Furthermore, most of the surveyed principals believed their students would be interested in taking PLTW courses and that the various community stakeholders would support the use of PLTW in their schools. The most agreed upon barrier to PLTW implementation was expense of equipment and required summer teacher training. In examining relevant demographic data, Shields (2007) found that younger principals (under 40 years of age) more often agreed with the cost barrier of implementing PLTW and they were less familiar with the curriculum and possible funding sources to support implementation. Given these findings, Shields (2007) offered the conclusion that outreach activities should be conducted to make principals aware of possible funding sources that can support PLTW implementation.

School Leadership and STEM Education

STEM education, like any other instructional initiative, requires effective leadership to be successful (Praisner, 2003). According to the Interstate School Leaders Licensure Consortium (ISLLC) Standards (Council of Chief State School Officers [CCSSO], 2008), effective school administrators must provide visionary, instructional, organizational, collaborative, ethical, and advocacy leadership to the schools they serve. For schools and districts that want to provide students with quality STEM opportunities that will prepare them for higher education and employment in STEM fields, leaders will need to be highly functional in many of these leadership areas.

Brown et al. (2011) reported evidence of a lack of clear vision for STEM education, even by individuals who deem it to be important. Visionary leaders must work with the various stakeholders of their organizations to develop and carry out a common vision and mission. They must also create a plan to achieve the goals associated with the vision and mission (CCSSO, 2008). While these requirements are true for all K-12 administrators, there is evidence that visionary leadership is particularly important for those in STEM-focused schools. Scott (2012) found STEM schools' mission statements influenced the schools' focus and approach to program implementation. Scott also reported that STEM-focused schools were led by confident, visionary principals who are committed to positively impacting the lives of their students.

The second ISLLC standard, addressing instructional leadership, requires administrators to foster a positive culture and promote an instructional program that ensures learning for all students and encourages professional growth for the faculty members (CCSSO, 2008). Based on current research, administrators wanting to promote quality STEM instruction in their school or district will need to understand the instructional concepts of content integration, project-based learning, and program evaluation (Reid & Feldhaus, 2007; Sanders, 2009; Stearns et al., 2012). They must also possess a strong understanding of the principles of teaching and learning to ensure effective school practices occur in the classroom (National Commission on Excellence in Education, 1983). Furthermore, to be effective instructional leaders, principals must continue to upgrade their educational skills and be active participants in the professional development of their teachers (Merrill & Daugherty, 2010).

The ISLLC standard regarding organizational leadership requires the management of operations and resources to produce a safe and effective environment that promotes learning for all students (CCSSO, 2008). There are some very specific applications of this standard for principals in STEM-focused schools. They should organize schedules in a manner that allows for cross-curricular collaboration between teachers (Brown et al., 2011; Committee on Highly Successful Schools or Programs for K-12 STEM Education, 2011; Sanders, 2009). Additionally, because project-based, collaborative learning often requires environments that may not look like "traditional" classrooms, school leaders must also organize and create spaces that adequately support this aspect of STEM education (Reid & Feldhaus, 2007).

The fourth ISLLC standard focuses on collaboration. This standard requires the promotion of success for all students through collaboration with teachers and community members to address community interests and needs. It also calls for the development of relationships with community partners and the mobilization of community resources (CCSSO, 2008). With regard to STEM education, community partnerships can allow employers to assist teachers and students in better understanding the connection of their coursework to the real world beyond the school walls. Community partners can provide work place experiences and internships that can engage students and motivate them to pursue STEM careers. Principals must be willing to support these partnerships and be open to the pedagogical practices that they may require (Watters & Diezmann, 2013). In addition to industry partnerships, principals wanting to promote STEM learning should also seek out partnerships with institutions of higher learning to help support a smooth transition in the STEM pipeline between K-12 and post-secondary education (Merrill & Daugherty, 2010).

The fifth ISLLC standard requires educational leaders to act with ethics, integrity, and fairness as they work to encourage success for all students (CCSSO, 2008). The concept of social justice is a factor in carrying out this standard which means leaders must offer quality educational experiences for all students that meet their diverse needs (Brumley, 2012). The fifth standard also involves leaders considering the moral consequences of all decision making (CCSSO, 2008). Considering the common belief that STEM-related careers are key to personal and national economic prosperity, security, and advancement (COSEPUS, 2006, 2011; National Science Board, 2003; Nathan et al., 2010), the argument could be made that administrators are ethically bound to provide their students with STEM instruction that prepare them for the modern, global economy.

The sixth ISLLC standard calls for school administrators to promote the success of all students by "understanding, responding to, and influencing the political, social, economic, legal, and cultural context" in which they are operating (CCSSO, 2008, p. 15). One function required by this standard includes adapting leadership strategies to address emerging trends and initiatives that are relevant to school business. The current focus in STEM education nationwide is requiring many school leaders to adjust their leadership practices to address this initiative. Some of these adjustments include ensuring effective STEM instructional practices are being implemented, staying current on the political decisions that impact STEM education, and developing an understanding of the local and national STEM cultural factors that impact their school (Committee on Highly Successful Schools or Programs for K-12 STEM Education, 2011; Scott, 2012).

Conclusion

The need for quality STEM education has been well documented in multiple reports and professional literature pieces. Given that there still appears to be considerable room for growth and improvement in this area nation-wide, it is prudent to conduct additional research that can help guide future action in education. The methodology described in the following chapter will detail the plans for this study that will help gain insights from current administrators who are seeking to provide their students with effective STEM instruction through a PLTW curriculum offering. Because school leaders play a vital role in successful program implementation, this study can provide valuable information for moving forward with STEM education that leads to the desired student outcomes.

CHAPTER 3

METHODOLOGY

The need for quality STEM education in the United States requires research exploring factors that impact teaching and learning in this focus area. The mixed-method study may provide insights that will allow practicing educators to be more effective in their efforts to provide opportunities for students to gain the knowledge and skills necessary to be prepared for STEM careers. Building a stronger STEM pipeline in elementary and secondary education can help students be successful in the current global economy and assist the country in rebuilding its status as a leader in innovation and industry (COSEPUS, 2006, 2011).

This two-phase study utilized an online survey of current school administrators who were overseeing the implementation of some form of the PLTW curriculum to gather information regarding their understandings and perceptions of STEM education. The survey data were predominately quantitative in nature due to the categorical and Likert-scaled responses required for 18 of the 21 questions. There were three questions that allowed for open-ended responses. In the second phase, a purposefully-selected, representative sample of the survey respondents participated in a face-to-face or telephone interview with the researcher to allow for more in-depth qualitative data collection. The results of this research may assist in determining the professional development needs of school leaders working to provide their students with effective STEM education.

Population and Sample

The school administrators targeted for participation in the study were from schools that are currently implementing some aspect of the Project Lead the Way (PLTW) curriculum at the elementary, middle, or high school level. In the 2014-2015 academic year, there are 64 PLTW schools throughout the state. Of these schools, ten are charter schools, two are private schools, and the remaining are traditional public schools from 17 different parishes throughout the state (PLTW, 2014c). Figure 1 provides a map of Louisiana with the PLTW schools marked. All parishes, charter, and private schools where PLTW curricula were being implemented were contacted regarding study participation. Permission was granted from parish superintendents in seven parishes throughout Louisiana to invite PLTW administrators to participate in the study. Additionally, the appropriate executives granted permission to invite administrators from three charter schools and two private schools to participate in the study. The online survey instrument was distributed to the individual school administrators via a link embedded in an e-mail explaining the research project. Survey participants were asked to complete the survey within a two-week time period. One week after the initial e-mails were sent out requesting survey participation, a follow-up e-mail was sent to those who had not yet completed their survey. Ultimately, 36 administrators were invited to participate in the survey and 21 completed it.

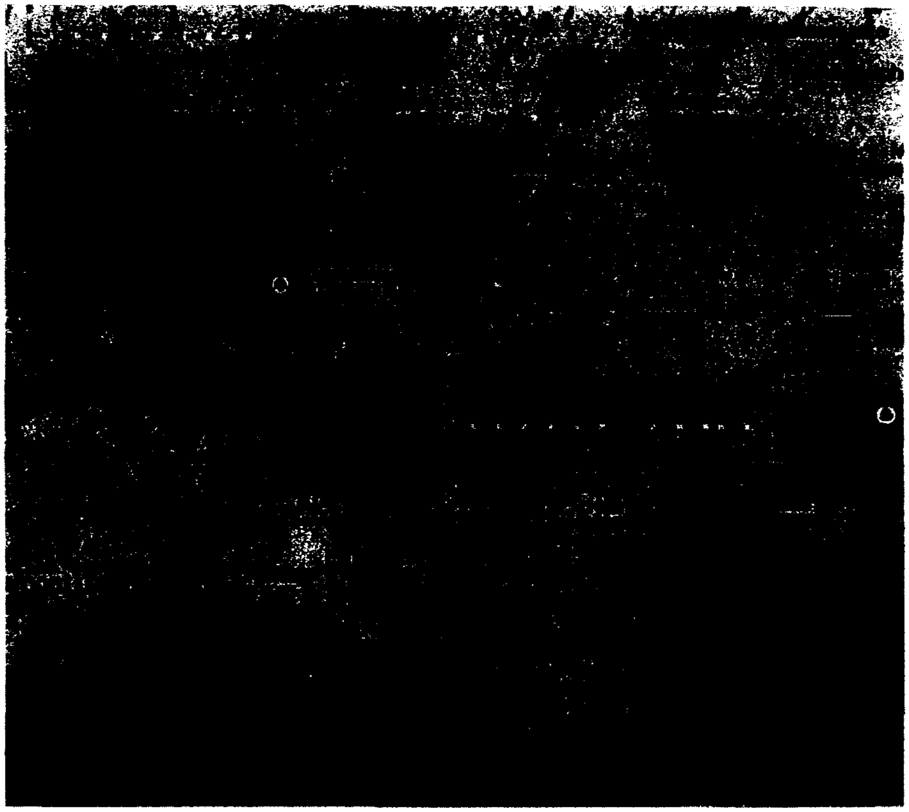

Figure 1. Map of PLTW Schools in Louisiana (PLTW, 2014c)

After survey responses were gathered, a purposeful sampling process was utilized to select respondents to participate in a follow-up face-to-face or telephone interview. Four interviews were conducted with an effort made to include an administrator from each different program level (elementary, middle, and high school) and representation from public and private school settings. Interview requests were made within three weeks of the survey response collection, with interviews being conducted during the following three-week time period.

Instrumentation

The first phase of the mixed-methods study focused on gathering information regarding school administrators' perceptions and understandings of STEM education utilizing a survey instrument that was developed in 2013 by a doctoral student at East

Tennessee State University to gain insight into educators' perceptions regarding STEM education and its implementation. The delivery method for the survey was through the online platform Survey Monkey. For the prior perception study conducted in Tennessee, the validity of the instrument was determined through reviews by a group of professional educators, a STEM program director, and the student's dissertation committee (Turner, 2013). Because the instrument was designed to be anonymous and was originally administered to both teachers and administrators, permission was requested and granted to adjust the instrument slightly to better fit the current study. A single question was added to identify the respondents' schools and all questions were framed with an administrative focus. Additionally, question 20, which inquired about the most important challenges facing STEM education, was converted to an open-ended question instead of a format that asked respondents to rank three available answer options. Multiple educational professionals reviewed the revised survey to ensure that the questions would provide valid and reliable data regarding administrators' perceptions of various aspects of STEM education.

The 21-item survey included both closed and open-form questions, with the first five questions gathering demographic data pertaining to the participants' professional experience and level of education. The remaining question composition included one question relating to the definition of STEM, three regarding the perceived need for STEM education, seven about classroom implementation, three concerning access to appropriate resources, and two regarding the perception of the current status of STEM education. One question required a *yes* or *no* response and one question provided *sometimes, often,* or *always* responses to multiple situations. Eleven questions utilized Likert scale responses with four answer options, *rarely, sometimes, often,* and *always,* or *strongly agree, agree, disagree, strongly disagree* (Turner, 2013).

For the second phase of this study more in-depth qualitative data were collected through follow-up interviews. The first portion of the interviews utilized the Levels of Use interview protocol (Hall, Dirksen, & George, 2006) (Appendix D). Three additional standardized interview questions were also posed to all interview participants (Appendix L). As necessary, probing questions were utilized during the interviews to obtain complete answers that provide sufficient qualitative data for meaningful analysis. The interview plan was developed to obtain qualitative data regarding how PLTW was being used and provide further perception information. The qualitative data from the interviews was compared to the quantitative and qualitative results from the Likert-scaled survey responses in the data analysis process.

Procedure

The first step in the procedure involved obtaining Institutional Review Board (IRB) approval prior to beginning the research study (Appendix G). Permission was granted by superintendents or other appropriate school leadership to invite school administrators from 36 of the 64 PLTW schools in Louisiana. Of these 36 schools, 31 are public schools in seven different parishes, three are charter schools, and two are private schools. Once IRB approval was granted (Appendix G), an e-mail explaining the study with an internet link to the Survey Monkey instrument was sent to the targeted school administrators (Appendix K). Based on its use in an earlier study (Turner, 2013), the survey was expected to take 15 minutes to complete and administrators were asked to provide their answers within a two week time period.

Once survey data were collected, participants' responses were analyzed to determine current perceptions and level of understanding regarding STEM education. Analysis of the initial online survey responses was used to develop a set of standard follow-up interview questions that will be included in all interviews. From the pool of survey respondents, four administrators agreed to engage in a follow up interview. The selection process for choosing interviewees included random selection from the following groups of respondents: public elementary school administrators, public high school administrators, public combination school administrators, and private school administrators. The formation of these selection groups ensured interview data were collected from administrators overseeing the implementation of PLTW programs at every available level. To obtain a random sample from within the identified groups, a lottery method was used. For this process, survey respondents from each were assigned numbers that were placed on individual cards. The cards for each group were shuffled and placed in a container so numbers were not visible. A single card was drawn from each group. After the initial drawings, an alternate from each group was drawn in the event that an initial interview participant was unavailable. It was necessary to use alternate drawing selections in some categories.

Interviews were conducted face-to-face or via telephone within a three-week time period. In addition the standard questions that were posed to all interviewees, clarifying and probing questions were utilized as needed to gather comprehensive answers. The purpose of the interviews was to obtain more detailed, credible data regarding the administrators' perceptions as well as STEM classroom practices. To gather the qualitative data about how STEM education implementation in the administrators' schools, the Levels of Use protocol was used for a portion of the interview. This protocol involves a focused interview process that uses a branching format to determine whether respondents are users or non-users of an innovation and the level of implementation for those that are classified as users (Hall, Dirksen, & George, 2006). In the interviews for this study, the "innovation" was a PLTW curriculum. Upon the completion of each interview, transcripts were generated and qualitative coding procedures were used in preparation for data analysis.

Data Analysis

Data analysis began with descriptive statistics of the responses to the first five survey questions. This provided demographic information about the survey respondents. Analysis was then performed to address each of the research questions identified in Chapter 1. For the first question, *How do high school administrators in Louisiana define STEM education?*, responses to survey question 7 were evaluated. Respondents' definitions of STEM were compared to a baseline definition created by combining definitions provided by the U. S. Department of Education (2007), Ejiwale (2012), Merrill (2009), Nathan et al. (2013), and Sanders (2009). This definition proposes that STEM education is a student-centered meta-discipline requiring teachers to utilize an integrated, collaborative approach to teaching and learning that involves hands-on, project-based problem solving with real-world applications to strengthen science, technology, engineering, and mathematics education in elementary, secondary, and post-secondary levels.

Based on literature, six "key terms" were identified within the baseline definition. The key terms were integrated, collaborative, hands-on, project-based, problem solving, and real-world applications. The definitions provided by the survey respondents were analyzed for the inclusion of the key terms (or suitable synonyms). The frequency of key terms and other relevant terms utilized by administrators most often in their definitions were recorded and ranked in order by occurrence. The definitions were also analyzed for emerging trends and significant occurrences.

To examine the second research question, *How do high school administrators in Louisiana perceive STEM education?*, data analysis was performed on survey questions 6, and 8 – 20. Descriptive statistics were calculated for each of the Likert-scaled questions to determine the frequency of response selection. For the open-ended question regarding the three most important challenges facing STEM education, responses were analyzed and coded for recurring terms and concepts. The most frequently reported challenges were identified and ranked in order of occurrence. Qualitative data from interview transcripts was also evaluated to address this research question. Triangulation between interview data and survey response data was performed to determine emerging trends and identify alignment, or lack of alignment, in the two data sources. For this portion of the analysis, the content and complexity of the responses survey questions regarding how the participants defined STEM education (question 7) and the most important challenges (question 20) were compared to the Levels of Use ratings.

Data analysis of survey responses and interview transcripts was used to examine the third research question, *3. What evidence exists to indicate administrators' understandings and perceptions of STEM education impact implementation and classroom behaviors?*. Information in the interview transcripts was rated based on the seven Levels of Use criteria, which are knowledge, acquiring information, sharing, assessing, planning, status reporting, and performing (Hall, Dirksen, & George, 2006). Additionally, each interview participant was given an overall rating for Levels of Use regarding STEM education implementation. There was an examination for trends between administrators' responses regarding understandings and perceptions of STEM education and their responses pertaining to implementation and levels of use. This examination led to a comparison analysis of the administrators who reported seeing STEM classroom practices the least with those who commonly reported always observing STEM classroom practices. The comparison focused on definitions, challenges, and other perception-focused questions.

Conclusion

Following this methodology produced data and results that can provide valuable insights for practicing educational leaders interested in fostering effective STEM instructional programs in their schools. Given the potential impact of understanding and perception on school administrators' professional practices, it is important to evaluate them. The knowledge learned in this study can be used to positively influence STEM program implementation, administrator professional development planning, and, ultimately, student academic outcomes.

CHAPTER 4

RESULTS AND ANALYSIS

Chapter 4 describes the results and analysis of this mixed-methods research. The study examined school administrators' understandings and perceptions of STEM education and how they impact program implementation in various schools throughout Louisiana. The results are presented as they relate to the three research questions. There were two phases of data collection. First, administrators completed a 21-item survey that included questions regarding demographic information as well as STEM perception inquiries (see Appendix A). The survey questions incorporated both scaled response choices and open response formats. Twenty-one of the 36 administrators that were asked to complete the survey provided responses. After the survey data were collected, four respondents were purposefully selected for follow-up interviews that utilized the Levels of Use protocol (Appendix D) along with three additional interview questions developed to gain further data addressing the second and third research questions. The selection process, using a lottery system within survey respondent groups, was designed to ensure representation of administrators overseeing the various Project Lead the Way (PLTW) programs at the elementary, middle, and high school levels, as well as public and private settings. Eighteen of the survey participants provided their school name in the final survey question, indicating they would be willing to participate in the follow-up interviews. However, five that were contacted for interviews declined participation.

Following the interviews, quantitative and qualitative data analysis techniques were used to examine the gathered information. All administrators have been assigned alias names when open response data is described.

Research Questions

1. How do administrators of schools in Louisiana implementing a Project Lead the Way (PLTW) curriculum define STEM education?
2. How do administrators of schools in Louisiana implementing a PLTW curriculum perceive STEM education?
3. What evidence exists to indicate administrators' understandings and perceptions of STEM education impact PLTW implementation and classroom behaviors?

Survey Respondents' Demographic Data. Administrative roles varied some among the 21 survey respondents; 86.36% were principals, 9.09% were assistant principals, and 4.55% was a director of pre-professional programs. Of the participating administrators, 9.09% worked in elementary schools, 27.27% worked in middle schools, 50.00% worked in high schools, and 13.64% worked in combination schools. Years of experience in current administrative roles were as follows: 27.27% had 0-4 years, 31.82% had 5-10 years, 18.18% had 11-15 years, and 22.73% had 15 or more years. There were 27.27% respondents with at least a Masters' degree, 40.91% with a Masters' +30, and 31.82% with a doctorate. Nineteen of the survey participants indicated that they were from public school districts and two were from private schools. One respondent declined to indicate district affiliation. Of the 19 public school administrators, three represented somewhat atypical situations. One was from a magnet school, one was in an alternative setting, and one worked in a charter school.

How Administrators Define STEM Education. The first research question was examined through the open-form survey question, "In your own words, define STEM education." The responses were compared to the previously established baseline definition which states that STEM education is a student-centered meta-discipline requiring teachers to utilize an integrated, collaborative approach to teaching and learning that involves hands-on, project-based problem solving with real-world applications to strengthen science, technology, engineering, and mathematics education in elementary, secondary, and post-secondary levels (Ejiwale, 2012; Merrill, 2009; Nathan et al., 2013; Sanders, 2009; U. S. Department of Education, 2007). Based on literature, the following were considered "key terms" within the baseline definition: integrated, collaborative, hands-on, project-based, problem solving, and real-world applications. Survey responses were analyzed for inclusion of these key terms (or suitable synonyms), with the frequency of each recorded. Other relevant terms or concepts that occurred multiple times were also recorded. The most frequently occurring terms and/or concepts from the survey participants' responses were ranked in order of occurrence. The data are displayed in Table 1.

Table 1 Definition Term/Concept Frequency

Term/Concept	**Frequency**
Real-world applications	6
Career guidance/awareness/preparation	5
Supplement/complement core curriculum	4
Connecting/integrating content	4
Hands-on instruction	3
Problem-solving	3
Technology-based	3

In addition to the data summarized in Table 1, there were other definition data worthy of reporting. No definitions included the key term collaborative and only one included the key term project-based. Three of the respondents simply stated that STEM education was instruction in science, technology, engineering, and math with no elaboration containing any of the key terms. Six definitions did not include the term "engineering" nor the STEM acronym with the "E" representing engineering and one of these also did not include the term technology (or the representing "T"). Examples of the definitions lacking a direct engineering reference include, "Emphasis on technical subjects: math and science with a strong technology component" and "A complement to science and math core instruction." The definition incorporating the greatest number of key terms was, "Courses that incorporate various disciplines in real world, hands on, relevant, project based curricula that help students understand the purpose of traditional STEM fields."

The data collected to examine how administrators define STEM education offered several insights. The analysis indicated that there is not a universally understood definition of STEM education among school administrators. Definitions can vary in both content as well as complexity. The wide range of definitions provided suggests a need for administrator professional development to foster more uniform, comprehensive understanding of STEM education.

Administrators' Perceptions of STEM Education. Both survey and interview responses provided data to examine the second research question. Survey data will be discussed here, while interview data will be presented later in the chapter. Several of the questions made rather general inquiries regarding perceptions of STEM education. When asked if they perceived a need for STEM education (question 6), 81.82% of the participants strongly agreed and 18.18% indicated that they agreed. None of the administrators surveyed disagreed or strongly disagreed that they perceived there was a need for STEM education. When asked to what extent STEM education was a topic of discussion in their district and/or school (question 8), 0% responded rarely, 22.73% responded sometimes, 50.00% responded often, and 27.27% responded always. Nearly all respondents, 95.24% said that their school has programs integrating the core concepts of STEM (question 9). When asked if they felt prepared for the implementation of STEM instruction in their schools (question 17), 23.81% of the participants indicated that they strongly agreed, 57.14% indicated that they agreed, 9.52% indicated that they disagree, and 9.52% indicated that they strongly disagreed. In replying to the statement, "The current condition of STEM education in Louisiana is meeting the needs of 21st century learners," 4.76% strongly agreed, 38.10% agreed, 47.62% disagreed, and 9.52% strongly disagreed (question 19).

Some of the survey items regarding the administrators' perceptions of STEM education inquired topics related to instructional support. In response to a question asking about STEM education professional development opportunities being regularly provided to teachers (question 14), 14.29% survey participants replied strongly agree, 38.10% replied agree, 38.10% replied disagree, and 9.52% replied strongly disagree. Fifteen percent of the respondents strongly agreed that they have adequate access to STEM assets, while 55.00% agreed, 25.00% disagreed, and 5.00% strongly disagreed (question 15).

In an open response question, survey participants were asked to identify what they perceived to be the three most important challenges facing STEM education (question 20). They were asked to rank them in order, listing the greatest need first. The responses were analyzed and coded for recurring terms and concepts. The most frequently reported challenges summarized in Table 2.

Table 2 Challenge Response Frequency

Challenge	Total Frequency	Frequency as a #1 Challenge
Funding/finance	12	6
Professional development/teacher training	8	4
Demands of "required" curriculum	5	1
Staffing/certified/qualified instructors	4	3
Technology	3	2
Time to teach STEM	3	1
Parent education/knowledge	2	1
Resources	2	1
Getting girls/non-traditional students to pursue STEM education	2	0
Commitment/support from education and political leaders	2	0
Developing and assessing project-based units	2	0

The responses regarding the most-commonly reported challenge were generally single worded "funding" or "finance," and in one case, "capital." Similarly, single-word or very short responses were generally offered in the categories of professional development, staffing, technology, time, and parent knowledge. Two of the responses coded as "professional development/teacher training" included some details of what the administrators thought the training should address. These responses stated, "PD for teachers that enables them to connect the STEM setting with the regular class setting" and "Helping traditional teachers understand about the applications of science and math in STEM careers." Some of the responses coded as "demands of required curriculum" offered a greater degree of detail as well. Examples include: "time to teach STEM specifics while teaching mandated subjects;" "it is not part of the required curriculum, therefore it does not get proper focus;" and "getting the state to substitute engineering and biomed courses for core requirements." In a specifically school leader-focused response, one high school assistant principal identified "administrator understanding and support for teachers" as challenge to STEM education.

Evidence Indicating Administrators' Understandings and Perceptions of STEM Education Impact Program Implementation and Classroom Practices. Several of the survey questions asked administrators about classroom practices within their schools. When asked to what degree they observed STEM instruction in the classroom setting (question 10), 9.52% indicated rarely, 38.10% indicated sometimes, 38.10% indicated often, and 14.29% indicated always. Responses regarding the frequency of observing inquiry-based, problem-solving activities in the classroom included 0% reporting rarely, 19.05% reporting sometimes, 66.67% reporting often, and 14.29% reporting always (question 11). When asked about the use of technology throughout their STEM programs (question 13), 9.52% replied rarely, 19.05% replied sometimes, 33.33% replied often and 38.10% replied always. Responses to a question regarding the observation of the use of STEM instructional techniques included 10.00% rarely, 40.00% sometimes, 35.00% often, and 15.00% always (question 16). When asked how often discussions are integrated into instruction that help students become aware of STEM careers (question 18), 23.81% replied rarely, 42.86% replied sometimes, 23.81% replied often, and 9.52% replied always.

In a question concerning whether STEM education provided more time for teaching with various instructional styles/resources associated with STEM education, survey participants were asked to respond sometimes, often, always, or not applicable (question 12). The results of this question are summarized in Table 3.

Table 3 Time for Teaching with Various Resources/Strategies in STEM Education

Is there more time for teaching with the following as a result of STEM education?

	Sometimes	**Often**	**Always**	**N/A**
Technology-Supported Learning Tools	4 (19.05%)	11 (52.38%)	5 (23.81%)	1 (4.76%)
Traditional Teacher-Led Instruction	11 (52.38%)	9 (42.86%)	0 (0%)	1 (4.76%)
Project-Based Learning	2 (9.52%)	13 (61.90%)	5 (23.81%)	1 (4.76%)
Workplace or Lab-Based Learning	5 (23.81%)	10 (47.62%)	4 (19.05%)	2 (9.52%)
Business/STEM Professionals	7 (35.00%)	7 (35.00%)	2 (20.00%)	2 (10.00%)

Because all of these administrators worked in sites registered as PLTW schools, which indicates at least some teachers should be utilizing one of the project-based curricula, the rarely, disagree, and strongly disagree responses to the questions pertaining to this research question prompted further analysis. The six administrators who replied "rarely" to one or more of the classroom practice/observation questions all reported that they agreed or strongly agreed with the statement, "I perceive a need for STEM education." However, an examination of the definitions provided by these administrators revealed that many of them lacked the key terms identified earlier that literature suggests are necessary to describe STEM education, such as integration of subjects, collaboration, hands-on, project-based, problem solving, and real-world applications. The definitions predominantly "defined the word with the word" or were overly vague. Examples of this include, "focuses on implementing engineering strategies and skills in different subjects," "emphasis in technical subjects: math and science with a strong technology component," and "science, technology, engineering, and math extensions to deepen core curriculum." The most frequently stated important challenges STEM education for these five administrators were staffing/qualified teachers (4), funding (3), training/professional development (2), and curriculum (2).

Another set of negative responses again called for more in-depth analysis. There were four administrators that disagreed or strongly disagreed with the statement, "I feel prepared for the implementation of STEM instruction in my school." Three of these were also in the group that replied "rarely" to at least one of the classroom practice/observation questions. And two of these additionally reported that they did not have adequate access to STEM resources.

In order to have a point of comparison with the negatively responding administrators, a similar response analysis was performed on the most affirmatively-responding survey participants, which were determined to be four administrators who replied "always" to at least four of the five questions pertaining to the frequency of STEM instructional practices and content presentation. Examination of these administrators' definitions revealed they were generally more comprehensive and included key terms that the negative responders omitted. All of the definitions provided by the highly-affirmative responders included all four components of the STEM acronym along with at least one of the "key terms," with the most comprehensive including four key terms.

All four of these affirmatively responding administrators agreed (2) or strongly agreed (2) that they felt prepared for the implementation of STEM instruction in their school. Similarly all four agreed (1) or strongly agreed (3) that they had adequate STEM assets. Within this group, analysis of the most important challenges revealed the inclusion of more complex issues facing STEM education. Funding was recorded twice. Other challenges included the need for more commitment from educational and political leaders, more females engaged in engineering, greater universal understanding of the need for STEM education. The nature of these challenges could suggest that these leaders have progressed past implementation issues and are now focusing on higher order problems.

This comparison provides some evidence that understandings and perceptions may influence the implementation of STEM education. Administrators with less comprehensive definitions of STEM education and lower-level-perception responses were more likely to report lower occurrences of STEM instructional practices.

The results and analysis discussion will now shift to data collected in the follow-up interviews. Of the 21 survey respondents, four participated in the interviews. The four interviewees were chosen using a purposeful selection process designed to make certain that data were obtained from administrators at the various grade levels and from both private and public settings.

Levels of Use Interviews. Interviews were conducted by the researcher in person at the principals' school sites or via telephone. At the beginning of the interviews, principals were asked some general background questions regarding the number of years in their current role, their area of certification for teaching, and other professional roles they have held. The interview then followed the Levels of Use basic interview protocol (Hall et al., 2006). In this protocol, the administrators were asked about strengths and weaknesses of PLTW at their sites, the effects of PLTW in their schools, how they are evaluating the program, plans for making adjustments to the program, and collaboration efforts. The Level of Use interview questions were designed and sequenced to collect data regarding behaviors associated with the use of an innovation. Based on participants' responses they can be classified at one of eight Levels of Use: Level 0 – Non-Use, Level I – Orientation, Level II – Preparation, Level III – Mechanical Use, Level IVA – Routine, Level IVB – Refinement, Level V – Integration, and Level VI – Renewal.

At the conclusion of the Level of Use protocol questions, the administrators were asked three additional questions: (1) How are you working to overcome the challenges you identified in the survey? (2) Do you believe your area of certification poses any advantages or disadvantages to being an administrator overseeing a STEM program? (3) As an administrator, are there things you must think about or do differently related to STEM programming? The first two of these questions were developed to gain additional perception data to address the second research question. The third question was created to provide data regarding both perception and, potentially, instructional practices.

The four interview transcripts were reviewed and rated using the C-BAM Levels of Use rating system (Appendix E). There was also analysis for emerging trends and themes in the qualitative data that related to the research questions. Aliases were used in the following interview narratives to preserve participant anonymity.

Interview #1. Jim has been a professional educator for 20 years. He has served as the principal of his elementary site for 8 years. Prior to taking on his current position, he was a classroom teacher, an athletic coach, and an assistant principal. His area of teaching certification was in health and physical education. His school served 547 third through fifth grade students, with 47.7% eligible for free or reduced lunch.

In his survey responses, Jim "agreed" with the statement, "I perceive a need for STEM education. He defined STEM education as "a complement to science and math core instruction." When asked about the three most important challenges facing STEM education, he identified one: "PD for teachers that enables them to connect the STEM setting with the regular class setting."

Levels of Use Interview Narrative. The 2014-2015 academic year was the third year Jim's school implemented a STEM enrichment program with their students, but it was the first year the school utilized the PLTW elementary Launch curriculum for this enrichment. In his school, a STEM teacher sees each class of students once a week for 45 minutes on a rotation basis. Other enrichments in the school that students attend on a rotation schedule include library, physical education, and gifted education (for student who qualify).

When asked about the strengths of the STEM program and PLTW at his site, Jim sited "integration of what is taking place in the classroom." He believes the STEM programming in his school is a "huge asset." He also identified the "hands-on nature of the curriculum" as a strength, as well as the fact that "students get to create a product by completing a process from start to finish." He felt that the "healthy competition" that can exist between the groups as they worked to complete projects was another strength. A final strength he noted was that the program encouraged students to be creative with science and math.

Jim identified the need for more teacher training and professional development as one weakness of the program at his site. He intended to address this by sending his PLTW Launch "lead" teacher to both mid-year and summer professional development/training opportunities conducted by PLTW. According to Jim, another issue was a general need to strengthen the overall program. He said "there is going to have to be an evolution of our program. Because society and the workforce require more technical jobs, we need to expose our students to those types of experiences. We need to show our students what they can do with this learning, what the next steps are for them, and what kind of training they can expect in the future. We have to get students interested in these fields." To address the need of building student interest, Jim's school has allowed students to showcase lesson products to other students within their school. They have also allowed the elementary students to take some of their products to the nearby middle school to show their work to the older students.

When asked if he was currently looking for any information about PLTW, Jim responded that he, and his team, are "looking for ways to expand the vision of the kids, so they can see 'What can I do with this?' The learning is fun right now, and it can stay fun." Although Jim values that the learning is fun for the students, he wants to find ways to help them understand how they can "make a living" with the STEM content they are learning.

In response to the question regarding talking with others about PLTW, Jim said that he was "just talking with a fellow principal recently." The other principal was sharing that his own children enjoyed STEM-related activities. Specifically, he pointed out that his children liked de-assembling a device, diagnosing a problem, and reassembling. The two discussed how "students seem to enjoy seeing how things are put together and how they work."

Jim identified several effects of STEM education and PLTW in his school. First, he said that the kids are having fun and making connections with math and science. He believes the program "complements what is going on in the regular classroom." Another effect Jim specified was the program "teaching the students the concept of teamwork." They must assign tasks and everyone has to be in agreement. He went on to explain, that as part of some group assignments "I've seen students have to work within a budget at a 'store' within in their classroom: purchasing items, returning things for a refund." A third effect was engaging students in research. "Kids have to research a topic or concept. I have seen them use the iPads for research and then sharing what they find with their group."

Jim responded that he engaged in both formal and informal evaluation of the STEM program in his school. Informally, he looks at the smiles on the kids' faces and sees how happy they are in the classes. He said, "They like showing me their work; their products. They want to tell me how many washers they were able to put in their boat before it sank. I can tell that they are seeing how the science and math work." The formal evaluation is done in connection with the formal teacher evaluations that all educators at his site experience. All teachers are formally evaluated three times each year based on the TAP (System for Teacher and Student Advancement) rubric. In these formal evaluations, Jim stated, "We connect to the TAP rubric. We look at how the teachers are making the content relevant to students; making sure the kids know why we are doing this...making connections."

When asked about getting feedback from the students, Jim responded that the students "are excited to show how things work. They like reporting their findings from the projects." As for what he does with the student feedback, Jim reported that he tries to show that he values the program. He also encourages comprehensiveness. "I try to support the program. If the students express an interest in something to their teacher and she brings it to me, I work to help get the resources they need."

Jim responded that he is not looking to make any changes with how they are using PLTW at this time. He said they "are working to evaluate how things are going now. It hasn't been in place long enough to change, but change will come as we learn more." When asked about plans for using PLTW as he looks ahead to later this year and beyond, Jim replied, "Stay the course." He did express an interest in having the STEM enrichment teacher assigned to his site full time (she is currently shared with another elementary site), but that change would be a district level decision, not something over which he has control.

At the time of the interview, Jim was "not really" working with others outside of the school in using the innovation. He said they have "done a little bit with the middle school, having our students visit there and their PLTW students come here." Jim also reported that he is not planning to make major modifications or replace the innovation at this time.

Additional Interview Question Responses. In the initial survey, Jim identified teacher professional development as a challenge facing STEM education. When asked about how he was working to overcome this challenge at his site, he said he is seeking professional development opportunities for his STEM teacher that enables her to connect the activities that occur in the STEM setting to the regular classroom content. He described plans to send the STEM enrichment teacher from his site to two upcoming professional development events hosted by PLTW.

When asked if his area of certification (health and physical education) and prior classroom experience being in an area outside the STEM disciplines offered him advantages or disadvantages as an administrator overseeing STEM program implementation, Jim replied that he felt like he had experiences that gave him an advantage. Although not classroom experiences, his father worked as a welder, mill right, and fabricator. Through this work, Jim's father "showed him how things like geometry, hydraulics, and pulleys worked." By working some in the manufacturing industry (prior to working as an educator), Jim believes he has "an understanding of how engineering and manufacturing work." He feels these experiences help him appreciate the importance of STEM education and why students need to be exposed the content and style of learning.

Jim did identify some things that have to be thought about and done differently as an administrator of a STEM program. He believes that you must ensure that teachers are "plugged in and making the appropriate connections" with the traditional core curriculum content. He believes STEM content involves more specialized instruction along with strategic scheduling that allows time to be devoted to it. He also believes activities beyond the classroom should also be part of STEM education, such as competitions.

Levels of Use Interview Rating. To determine the overall Level of Use of PLTW at Jim's school site, the Levels of Use rating sheet was utilized. The areas examined on the rating sheet include knowledge, acquiring information, sharing, assessing, planning, and status reporting (Hall et al., 2006). Jim was rated at Level of Use III, Mechanical Use, for knowledge and assessing. He was rated at Level of Use IVA, Routine, for acquiring information, sharing, planning, status reporting, and performing. Based on these category ratings, Jim's overall rating was Level of Use IVA, Routine. Defining characteristics of this level include stabilized use of the program, with little, if any plans for altering the ongoing implementation.

Survey and Levels of Use Summary. In his survey responses, Jim agreed with the statement, "I feel prepared for the implementation of STEM instruction in my school." He indicated that he "often" observed STEM instruction in classrooms, including inquiry-based, problem-solving activities, and project-based learning. He also indicated that "sometimes" there was the opportunity for more use of technology-supported learning tools, traditional teacher-led instruction, and workplace or lab-based learning. At his site, he selected that "sometimes" he observed STEM instructional techniques, students participated in discussions that made them aware of STEM careers, and technology was used to facilitate research, investigation, and design.

Jim disagreed with the statement "Professional development opportunities around STEM education are regularly provided to teachers in your school." He also identified the need for teacher professional development as the most important challenge he perceives facing STEM education. These responses indicate that teacher training and preparation are an area of concern for Jim with STEM education and PLTW program implementation. This concern reveals that he may not be fully aware of, and therefore has not fully utilized, the multiple-phase professional development system PLTW offers.

Jim's survey and interview responses were in alignment with each other. The activities that he reported were happening in his school supported his "sometimes" and "often" survey responses. This level of implementation could be expected on a campus that is at a Level of Use IVA, Routine. His interview revealed a fairly high level of understanding through the use of key defining terms such as integration, hands-on, and teamwork (collaboration). A higher level of understanding would also be expected for an administrator of a campus that is functioning at Level IVA.

Interview #2. Mark has been a professional educator for 16 years. He has been the principal of his school for just over a year. Prior to assuming the role of principal, he was the choir teacher at a high school within the same parish. Mark's area of teaching certification was in K-12 vocal music. His school is located in a small community and serves 683 students from pre-kindergarten through twelfth grade, with 64.5% eligible for free or reduced lunch.

In his survey responses, Mark "strongly agreed" with the statement, "I perceive a need for STEM education." He defined STEM education as "STEM students use their knowledge of science, technology, engineering, or math to try to understand how the world works and to solve problems. Their work often involves the use of computers and other tools." Mark identified the three most important challenges to STEM education as funding, training, and parent education.

Levels of Use Interview Narrative. The 2014-2015 academic year was the second year for the school to offer the middle school PLTW curriculum, Gateway to Technology (GTT). The school has two GTT teachers and offers the four of the modules: Automation and Robotics, Design and Modeling, Medical Detectives, and Flight and Space. At the time of the interview, 60 of the 132 middle school students participated in a PLTW class as one of their electives. 2014-2015 was the first year the school planned to offer the elementary curriculum, Launch, but due to a staffing issue, the curriculum has only been implemented in a very limited capacity. All 253 of the elementary students in grades first through fifth go to a weekly STEM enrichment period on a rotation schedule. The lessons have been predominately pulled from STEM curriculum options other than PLTW Launch, although the plan is to fully utilize the Launch in future years.

When asked about strengths and weaknesses of the PLTW program on his campus, Mark identified the primary weakness with PLTW as "situational, because we do not have a qualified instructor at the elementary level." He said there is a plan in place to make an improvement with the personnel, but it cannot be addressed until the summer when he expects to be able to make a hire that will allow him to "get personnel right with the elementary component." To further strengthen PLTW at his site, he also wants to find more incentives for students to increase interest and he wants to better inform parents about the program to increase their level of buy-in.

Mark stated that a strength of PLTW is having a "good instructor at the middle school level. She is owning the program. She is really doing a good job with the curriculum and her students. She is getting the students to buy in to the work." Mark said an additional strength of PLTW for his site was the level of support received from the district. "We have lots of support in getting teachers to training and getting the technology needed. Anything we've asked for so far, we have gotten." Mark went on to mention that he does have another middle school teacher who is doing "okay," but is not as successful at getting the students excited about the class like his other GTT instructor.

When asked about whether he is seeking new information about PLTW, Mark indicated that he was. He is looking for information for expanding the program. He was "interested in learning more about the middle school modules that we could add." He also wanted to learn more about the new elementary modules that PLTW is planning to add to the curriculum.

Mark said that he has talked some with others about PLTW. He was recently talking to his son, who attends another school, about the robotics component of GTT at his site. Mark has also talked with some of this son's teachers about "how they are doing robotics and some of the things we have done." He said he "talked to teachers from other districts really out of curiosity. I want to learn what they are doing. Compare it to what we are doing."

Mark's response to the inquiry regarding the effects of PLTW, generally referred more to prospective effects as the program matures. He said, "I believe it has the potential to improve our math and science performance and to inspire greater passion in students for the STEM subjects." He does feel that PLTW is "helping students find that 'spark' and we are trying to capitalize on that spark." Mark wants to make the students aware of the many STEM fields and get students interested in them as early as possible. He believes this is important because that interest can impact what students do at the post-secondary level and beyond. He believes getting students interested in STEM fields through programs like PLTW can help them become "productive citizens." He specifically mentioned some engineering fields that are prominent in his school's local area related to the oil industry.

As for program evaluation, Mark referenced the formal teacher evaluations that all teachers in his district must have as one way he assesses how the program is doing. However, he pointed out that "it's more than just scores on a rubric" that he uses to determine whether the program is working. He went on to say that "informally, there are classroom walkthroughs" where he sees that the students are excited about what they are doing. He gave an example of students being eager to ask him to "be the dead body in the Medical Detectives class." Mark considers the enthusiasm from the students as the primary feedback he has received from them. He said that they are trying to capitalize on the enthusiasm and allow them to "share their excitement with others. We've created opportunities where the students can share what they have done with others; giving them a chance to present to other teachers and students."

Mark reported that they have not made any major changes recently to how they are implementing PLTW. He again referenced the "need to make a personnel change at the elementary level," but he has to wait to see how he is "allowed to proceed on that." Mark said that he "will be looking at the two that have been doing it at the middle school level." He stated they will need to consider scheduling and whether they need to create some sort of rotation so more students are able to experience a greater number of the middle school modules. He does not want students to miss the opportunity to experience the PLTW curriculum.

When asked about plans for the future, Mark said he wanted "to evaluate our successes and failures of this year. Make better what is good, weed out what is bad." He again mentioned getting the right personnel in place at the elementary level. He wants to have at least three teachers devoted to PLTW in grades K-8. He was not working with others, outside of those he has worked with from the beginning of implementation. Mark had no plans for major modifications to the program nor to replace the curriculum.

Additional Interview Question Responses. When asked about overcoming challenges to STEM education that he identified in his survey response, Mark said that the first two, funding and training, were two that he believed challenged STEM education in general, but not particularly at his site. As he mentioned in an earlier response, his district has been able to financially provide for PLTW needs at his site, so funding was not a challenge he personally faced. Similarly, he felt the training provided by PLTW was adequate, so for his school's STEM program, he did not see training as a problem, but he believes it could be a challenge for others. Parent education was the third challenge he listed and that was something he is working to overcome at his school. He was trying to get parents involved and make sure they understand what STEM education and PLTW are on his campus. The school has put out information and he tries to verbally communicate with parents when he has the chance so they are informed about the program at the elementary and middle school levels. At the middle school level when students and parents may be trying to decide between two available electives such as band and PLTW, he "wants the parents to be able to make informed decisions." He does not want a situation where parents think STEM/PLTW is just something you can "do when you don't do band" or other available elective.

When asked if he felt his experience as music teacher offered him any advantages or disadvantages to being an administrator overseeing a STEM program, Mark replied that he felt like it gave him some advantage. Particularly because PLTW, like music, is "considered an elective." Therefore, he appreciates the need to create a master schedule where all students have the opportunity to take the PLTW classes. The courses must be offered opposite other classes in the master schedule so students have the choice to participate. He went on to say that you have to be careful "not to create a dumping ground" where students are simply placed in a class because there is nowhere else for them to go during that period.

Mark indicated that scheduling was one thing he believes you have to think about and deliberately consider when implementing a STEM program such as PLTW. As discussed earlier, he described how administrators must create schedules where students have the opportunity to participate in it. He said he does not "want to put a PLTW class in a position where it will fail." To elaborate on this idea, he used an example with band. He said, "Band has an established base of students that are loyal to it and want to take the class." Therefore, he knows he needs to set up the schedule so that students could have the opportunity to be in band class as well as PLTW if they are interested in doing so. He acknowledged that there will always be some situations where students must make choices, but he said he must ensure that, as much as possible, his schedule gives the most students the opportunity to participate in PLTW courses.

Levels of Use Interview Rating. The Levels of Use rating sheet was utilized to determine Mark's overall Level of Use of the PLTW program. Mark was rated at Level III, Mechanical Use, for the areas of knowledge, assessing, status reporting, and performing. He was rated at Level IVA, Routine, for sharing and planning, and was rated at Level IVB, Refinement, for acquiring information. His overall Level of Use rating was a Level III, Mechanical Use. Individuals operating at this level concentrate most efforts on the requirements for daily use of the innovation as they work to master the tasks that must be done to implement the innovation. Also at this level, changes are generally user-oriented while they address logistical issues associated with implementation (Hall et al., 2006).

Survey and Levels of Use Summary. On the survey, Mark agreed with the statement, "I feel prepared for the implementation of STEM instruction in my school." He replied that he "often" observed inquiry-based, problem-solving activities in the classroom setting and that there was often more time for project-based and workplace or lab-based learning in STEM classroom settings. He also indicated that technology was used often for research, investigation, and design, and students were often exposed to instructional discussions to help them gain awareness of STEM careers. Mark responded that he "sometimes" observed STEM instruction in the classroom setting and observed STEM instructional techniques. He felt STEM education "sometimes" provided more opportunities for incorporating business or STEM professionals in the classroom and for direct teacher-led instruction.

Mark's interview responses and rating of Level III were in alignment with his survey responses. It seems appropriate that an individual at the Mechanical Use level would report only sometimes seeing some of the typical characteristics of STEM education and often observing others while the school gets a program like PLTW implemented and functioning. The more foundational nature of his identified challenges also seem on target for a user at the Mechanical Use level.

Interview #3. Bill has been the principal of his current high school for ten years. His other professional roles included high school social studies teacher, athletic coach, and assistant principal. His teaching certification is social studies grades 6-12. Bill's school is a high school that serves 635 ninth through twelfth grade students, of which 40.5% receive free or reduced lunch.

On the survey, Bill indicated that he "strongly agreed" with the statement, "I perceive a need for STEM education." When asked to define STEM education, he offered the following, "It is the application of science, technology, engineering, and math that requires hands on learning and real-life problem solving." Bill identified the three most important challenges to STEM education as funding, getting more female students involved in engineering, and getting the state to substitute engineering and biomed courses for core requirements.

Levels of Use Interview Narrative. The school offers four classes in both the PLTW engineering and biomedical sciences pathways. They began the engineering pathway in 2009-2010 and the biomedical science pathway in 2011-2012. The PLTW courses are available as electives to the high school students. During the 2014-2015 school year there were about 150 students enrolled in the PLTW courses, with roughly half of those in each pathway.

Bill identified several things that he considered to be strengths of the program. He said, "besides the higher level of what they are being asked to do, they have to think, not regurgitate information. They have to be creative and apply their knowledge to real-world settings." He also said that a major strength is the connection students are making with business partners in the related industries. For example, "one student is working with a neonatal brain surgeon. Getting to watch surgery, follow a case from beginning to end. That experience is invaluable."

When asked about weaknesses, Bill responded that there was a distinct lack of females in the engineering program. He said that direct steps to pursue females for this pathway have not been taken. The school has a scheduling guide that includes information about all of their course offerings, including the PLTW pathways. All students receive a copy of this and are given equal opportunities to sign up for any of the school's course offerings. But, in general, only low numbers of females have requested the engineering courses. The biomedical science courses have more gender-balanced rosters.

Bill said he is "not really" looking for new information about PLTW. He has some interest in the new computer science pathway that has recently been released, but he has not actively pursued information about it yet.

When asked about talking with others about PLTW, Bill replied that he does. "I really just talk about what our students are doing. And, not necessarily with just educators." For example, his son's father-in-law is an anesthesiologist, so Bill said that he may say, "Let me tell you what children in our program are doing…" As another example, one of the school counselor's sons is an engineer. Bill likes to discuss with him what the engineering students are doing. Bill said the response to activity descriptions is often, "I didn't do that until I was in college."

Bill explained a primary effect of PLTW in his school has been that it has "really helped students define, or not define, what they want to be when they leave here." He believes that with so much application and hands-on experiences, students really get a good idea if they want to pursue post-secondary degrees and careers in engineering or biomedical sciences. He has gathered this information from talking with students and classroom observations.

Bill said he informally evaluates the program through routinely being in the PLTW classrooms. He believes he gets the best information from talking with the students. He also said that PLTW is "the kind of program where teachers have to talk to me," as the school administrator. They may need help getting equipment and supplies, or setting up community partner meetings, or allowing students to go out on field experiences. Additionally, Bill said he learned a lot by recently going through the PLTW certification process for the biomedical sciences program at his school because it required the school to examine the state of its program. He also explained how the teachers are formally evaluated using the same instructional rubric as all of the teachers in district, so that is another method for program evaluation. One piece of feedback received from the certification team that he hopes to improve on is the "need to advertise the program more…get the word out" about the things that are going on with their PLTW courses.

When asked about recent changes in how they use PLTW, Bill referenced a master schedule change they implemented for the 2014-2015 school year. They moved biology to the ninth grade year (it had previously been a tenth grade course), which allowed students to take biology before the first biomedical science course. They felt this allowed the students to get some important background knowledge before taking the Principles of Biomedical Sciences course.

As Bill looked ahead to later in the year, he did describe some short term plans related to PLTW. He has some engineering teachers that were trained on the old Fishertechnik robotics system that PLTW used to utilize. He needs to get these teachers trained on the Vex robots on which the curriculum is now based.

Bill identified several people that his school works with in the implementation of PLTW. They have communicated with a local university that has made it possible for students to earn college credit for certain levels of PLTW end-of-course exam performance. He also discussed an energy company with a local presence that has given the school a significant amount of money through a multi-year grant. The school also works with the members of the biomedical sciences partnership team. This partnership team meets several times a year. The two biomedical science teachers are the coordinators of these meetings. Bill said he believes there several strengths to these collaborations, including potential college credit for the students, money to help fund the program, and potential adult mentors for the biomedical science students.

Bill did not name any particular kind of information that he was seeking in relation to these collaborations. When he talks to others about the collaborations, he mainly shares about "what the fourth year biomed students are doing with partnership team members." There is no formal evaluation process for how the collaborations function. Future plans for collaboration include building a community partnership team for the engineering pathway.

Additional Interview Question Responses. When Bill was asked about how he was working to overcome the challenges he listed in his survey responses, he said did not feel that he faced any "real challenges" at his site. He felt that his teachers do such a good job and with the district and community support his school has received, challenges were minimal. He listed funding because he feels like that is a problem for many schools, although it has not been an issue in his district. As for more girls in the engineering pathway, they utilize the steps he mentioned earlier to make all students aware of the program, but they were not taking specific actions to target female students. The challenge of the state recognizing courses from the pathways as science credit is not really a problem he can address at the school level.

When asked if his area of certification being social studies posed any advantages or disadvantages in overseeing a STEM program, Bill replied "no." He went on to explain, "I don't believe you have to be math, science, or technology certified to appreciate what this program can do for children." When asked if there are things that must be thought about or done differently related to STEM programming, he offered the following response, "PLTW is so tight and well done. It takes great teachers to do it well. My teachers love doing it, so I really don't have to do much extra. My teachers are so good, I just get out of the way and let them do their thing."

Level of Use Interview Rating. To determine Bill's overall Level of Use of PLTW on his campus, the Levels of Use rating sheet was used. The areas of acquiring information and assessing were rated at Level IVA, Routine. The areas of knowledge, sharing, planning, status reporting, and performing were rated at Level V, Integration. Based on these area ratings, Bill's overall Level of Use Rating was V, Integration.

Individuals operating at the Integration Level of Use collaborate with others in the use of their innovation to "impact the clients" (Hall et al., 2006).

Survey and Level of Use Summary. Bill replied on the survey that he "strongly agreed" with the statement, "I feel prepared for the implementation of STEM instruction in my school." He also indicated that he "always" observed STEM instruction in the classroom setting, including STEM instructional techniques, inquiry-based, problem-solving activities, and the use of technology to facilitate research, investigation, and design. He selected that discussion were often integrated into instruction to help students increase their STEM career awareness. He responded that because of STEM education, there is always more time for teaching with technology-supported learning tools, project-based learning, workplace or lab-based learning, and business or STEM professionals.

Bill's interview responses regarding regularly being in the PLTW classrooms on his campus and his descriptions of what the type of work the students engage in supported his survey responses that he frequently observes the practices associated with STEM education at his school. With his Level of Use V, Integration, rating it would be expected to regularly see such things as inquiry-based, project-based learning and technology-assisted research. Further, his response that STEM "always" provides more time for teaching with the use of business/STEM professionals is evidence of the collaboration component associated with Level V, Integration.

Interview #4. Tom has been serving as the principal of a private boys' school for two years. Prior to his current professional role, he served as assistant principal and before that as a Spanish teacher. He has worked as an educator for a total of 32 years. His school serves 875 eighth through twelfth grade male students. Because more students apply than the school has the capacity to serve, there is a selective admissions process utilized for student admittance.

Tom responded on the survey that he "strongly agreed" with the statement, "I perceive a need for STEM education." He defined STEM education as "courses that incorporate various disciplines in real world, hands on, relevant, project based curricula that help students understand the purpose of traditional STEM fields." He identified the three most important challenges facing STEM education as understanding the need, funding, and commitment on the part of the educational and political leaders.

Levels of Use Interview Narrative. Tom's school offers both the engineering and biomedical sciences PLTW pathways for the ninth through twelfth grade students. The engineering pathway has been in place since the 2010-2011 academic year and the biomedical sciences pathway has been in place since 2011-2012. The five engineering and four biomedical sciences courses are available as elective credits that the students may choose to take. In the eighth grade, all of the students take part in four of the nine-week GTT modules: Design and Modeling, Automation and Robotics, Medical Detectives, and Magic of Electrons. The GTT component of PLTW was added to the school in academic year 2014-2015. To implement these courses there are four engineering teachers, three biomedical sciences teachers, and two GTT teachers.

When asked about the strengths of PLTW, Tom replied, "The teacher training is phenomenal. It comes off the shelf. There is no need to reinvent the wheel. It is ready to go." He said this is important because, "when you are dealing with this large an expense, you want to get it right." He went on to point out other strengths such as the program's articulation to national standards, logical sequencing, and the fact that it is an established program that has been tested and shown to be effective.

Tom identified expense as the primary weakness. He said, "It's expensive. You have to budget year-to-year to maintain the program." However, he also offered that when you "look at the long term, it is a good value for the money." To address this weakness of high expense, he works to "maximize the use of the equipment and the trained teachers." Tom knows of some schools that just have one section of the courses, which he considers wasteful. At his school, for example, they offer the Introduction to Engineering Design class to 80 students which brings down the "per pupil cost." The same logic drives the reasoning behind all of the eighth graders on his site engaging in the GTT curriculum. Tom listed several funding sources he utilizes to cover the expenses associated with PLTW programming. These included tuition, grants, and donations from a local oil services company.

Tom was seeking some information about PLTW at the time of the interview. He said they are "looking at the new computer science curriculum" that was being field tested by PLTW. The school may consider adding the pathway if the field testing goes well. Tom also discussed that the school is considering creating their own complementary course related to off-shore engineering because of its importance to the school's local economy. However, he recognized that this will be a difficult undertaking on their own, but is looking into it due to parent and student interest in the subject.

Tom responded affirmatively when asked about talking with others about PLTW. He said the community has a "lot of curiosity" about the program, so he answers questions about the courses and the things the students do in them. He said that he advertises the program because it makes his school "attractive to people" who are considering attending the school. Tom also "talks up" the program with other private schools within his network of schools. Lastly, he spoke of presentations he has made at multiple educational conferences regarding PLTW.

When identifying effects of PLTW in his school, Tom offered several. He did qualify his answer by saying the PLTW was one of several curriculum changes made over the past few years, so it was "hard to isolate" the effects to just PLTW, but he still believes PLTW is a factor in some positive academic outcomes. First, ACT science scores have increased. Second, students are more interested in upper level math courses such as calculus. There is also an increased interest in upper level science courses.

The only evaluation that Tom said is done for the PLTW program is examining students' end-of-course exam scores and teachers are evaluated, as are all teachers on campus, annually. He did identify some feedback received from students. Tom stated that the PLTW courses are "some of the favorite classes" on the campus. Because of the students' interest in the courses, they have had to expand the number of offerings, including some of the upper level classes such as Digital Electronics and Civil Engineering.

A recent change to the program was the addition of GTT for the eighth graders. It is being used as a supplement to the science curriculum. They decided adding GTT would be good because it would give the students going into the high school engineering or biomedical science pathways a head start. Tom offered the example of how "GTT and IED (Introduction to Engineering Design) are sequenced well. The students learn about journaling and some of the procedural things before they begin the high school engineering class."

When asked about plans for later in the year, Tom again mentioned the school was looking at the new computer science curriculum. In particular, they were "considering adding the Computer Science and Software Engineering class." He expressed concern about the computer science pathway as PLTW had it set up due to the first course being a half credit. Tom said he was "at a loss how to fit it in the schedule" because he did not know what other half credit he would pair it with in his schedule.

Tom expressed that he has been working with others to support the implementation of PLTW in his school. The school has two partnership teams in place to support their PLTW pathways, one for engineering that meets two to three times each year and one for biomedical sciences that meets one to two times each year. The partnership teams are composed primarily of parents of students and alumni of the school, but there are some local businessmen as well. The collaboration with these individuals has provided for "field trips, guest speakers, and funding." Tom believes a strength of the partnership teams is that the "collaborations have a positive impact for the students because it gives them some real-world experiences." Tom said that they look to the partnership team members for information that will help strengthen their program. He does not do any formal evaluation of the collaborations with the partnership teams. Tom did say they "do evaluate field trips, but it's more about placing the field trips appropriately." The field trips are examined to determine the course or grade level of students for which they are most appropriate. He gave the example of a local university's engineering open house. The school decided that it was best suited for junior level students. When asked about future plans for these collaborations Tom replied, "The partnership teams will change over time. Some members will fall away and new members will join. It is an evolving team."

Additional Interview Question Responses. In response to how he is overcoming the challenges he identified in the initial survey, Tom said that he listed challenges that he sees to STEM education in general, not particularly challenges faced at his site. For example, when he stated "understanding the need," Tom was referring to some public schools with which he is familiar. At his school, "families get it. You graduate high school, got to college, figure out what you want to do for a career." He believes that if more students were given the opportunity to experience programs like PLTW, they "might find a reason to go to college." Tom expressed frustration when he hears that schools create "a little exclusive club" of PLTW students. He was talking to a local public high school principal that has over 800 students but only 18 participate in PLTW. Tom sees that as a "waste of money." He offered the questions, "Where is this attitude coming from? Why is it just a few kids?" Tom believes that PLTW schools should work to include as many students as possible in their programs.

When asked he felt his certification as a Spanish teacher provided him with any advantages or disadvantages as an administrator overseeing a STEM program, Tom replied "no" to being at a disadvantage. He went on to say, "In foreign language programs, students learn by doing. Kids have to use the language to learn it. This same concept transfers to any subject. PLTW kids learn by doing." He also pointed out that administrators must "pick teachers carefully." PLTW classes are not lecture settings.

The teachers have to be willing to "show kids how to do things, and then back out and let the students do the work."

Tom responded that he believes there are some things you have to think about and do differently pertaining to STEM education programming. He specifically identified, "space needs, budget differently, and equipment becomes outdated." Tom said his school is lucky to have grant money, but there is an almost "constant need to fund raise." He recognized that it can be "difficult in education to funnel resources." The challenge can be implementing STEM programming while not having to "draw down other budgets." But, Tom said that can be done.

Levels of Use Interview Rating. The Level of Use rating sheet was utilized to determine Tom's overall Level of Use rating. The area of assessing was rated IVB, Refinement. The areas of knowledge, acquiring information, sharing, planning, status reporting, and performing were rated Level V, Integration; resulting in an overall rating of Level V, Integration. As was previously discussed, at the Integration Level of Use, users work with others in the use of their innovation to "impact the clients." In Tom's situation he is working with a variety of other people regularly to enhance the impact PLTW can have on his students' education.

Survey and Levels of Use Summary. Tom replied on the survey that he strongly agreed with the statement, "I feel prepared for the implementation of STEM instruction in my school." He also responded that he "always" observes STEM instruction in the classroom setting, with STEM instructional techniques, inquiry-based, problem-solving activities, and technology-facilitated research, investigation, and design. Additionally, he reported that discussions are always integrated into instruction to help students become aware of STEM careers. He indicated that STEM education always allows more time for project-based and workplace or lab-based learning, and it often allows more time for technology-supported learning tools and utilizing business/STEM professionals.

Tom's interview responses supported his survey answers. It is expected for a user that has been able to surpass the Mechanical Use, Routine, and Refinement Levels of Use to report that activities and practices characteristic of STEM education are regularly utilized. Also, the nature and complexity of the challenges he listed on his survey and then elaborated on in his interview along with his discussion of collaboration with others in the implementation of PLTW support his Level V, Integration rating.

Summary of Interviews

Following the Levels of Use interview protocol and rating the participants based their responses, Mark was rated Level III, Mechanical Use, Jim was rated Level IVA, Routine, and Bill and Tom were rated Level V, Integrated. Both of the Level V-rated users have been overseeing the implementation of PLTW for more than five years, while the lower level rated users had less experience with using PLTW. Mark had been supervising the use of PLTW at his school for just over a year. Jim's school was in its first year of PLTW implementation, but it was the third year the school had utilized some type of STEM-focused enrichment period with their students. As expected, higher Levels of Use were associated with more experience with the program.

All four of the interviewees talked about making connections to college and careers through STEM education. Jim spoke of the need to expose his students to content and experiences that will get them interested in STEM fields and help them understand what they can do with this learning beyond elementary school. Mark also expressed the need to use PLTW to get students interested in STEM fields as early as possible because of how it could impact students' plans beyond the K-12 setting. Bill felt one important effect of PLTW was how it helped students define what they want to do when they leave high school because the hands-on application of knowledge gives the students a realistic idea of the types of work required in the engineering and biomedical sciences fields. He also talked about how valuable the connections are that his students make to local industry partners because, again, they are able to see and understand STEM careers first-hand. Like Bill, Tom also talked about how industry partners can provide students with valuable real-world experiences and insights. Tom further expressed that he believes student involvement in PLTW may inspire students to pursue college who might not otherwise see the need.

The importance of high quality teachers in PLTW programs was another reoccurring topic throughout the interviews. Mark spoke of having a strong middle school instructor who was "owning the program." Because of her enthusiasm for the program, she was successful implementing the curriculum and getting the students to "buy in" to what they were learning. Part of Mark's plans for the future of his PLTW program involve getting the "right" personnel in place at the elementary level so that component of his program can experience similar success. Bill pointed out that it requires great teachers to implement PLTW well. He elaborated that teachers must conduct the classes in a manner where students do more than just memorize and recite information. Students should be given opportunities to be creative and apply their knowledge in real-world settings. He said his teachers love teaching the classes and they do it well, so that makes successful program administration easier. Tom stated that administrators should be careful in their selection of PLTW teachers. Because the classes are not lecture settings, teachers must be selected that are willing to guide students, but ultimately let them do the work.

None of the interviewed administrators had teaching experience in a STEM related field and none of them felt this hindered their ability to oversee the implementation of a STEM program like PLTW. In fact, most quickly identified personal experiences that related to STEM education or some aspect of it. For example, Jim had prior experience in the manufacturing industry that he felt have him a strong understanding of engineering concepts and helped him appreciate its value for his students. Mark's experience as a music teacher provided him with a fairly unique perspective that he felt was useful. Having been an "elective" teacher, he understood how a master schedule can support or hinder the success of a non-core class. With that in mind, he works to ensure he schedule is not an impediment to PLTW success. Tom felt that his experience as a Spanish instructor had some similarities to STEM instruction, because in both cases, "students learn by doing." He said foreign language students must use the language to learn it and, similarly, PLTW students learn by using them STEM content in hands-on activities. He felt this similarity helped him support the style of teaching required in STEM education.

The interviewees did identify some things that must be thought about or done differently with regard to STEM programming. Jim, Mark, and Tom all pointed out the need for strategic scheduling that gives the most students the opportunity to participate in the PLTW courses. Jim also emphasized that teachers must be invested in the program and committed to connecting the STEM activities to the core curriculum content. Tom offered some additional things STEM administrators must think about and plan for, including unique space needs, budgeting differently, and replacing equipment and technology as it becomes outdated.

Themes

Several themes that emerged as the survey and interview data were reviewed. One was the theme of variation. This can be first seen in the variety of definitions the administrators provided in their survey responses. The definitions varied in content, including a wide-range of key terms and concepts and they also varied in complexity. This variation represents a range of levels of understanding and knowledge possessed by current STEM administrators.

There were also notable variations in the perceived challenges to STEM education. Not only were there a number of different challenges identified, but how they were ranked differed as well. As with the definitions, there was a wide range of complexity among the reported challenges. There were fairly straightforward challenges such as obtaining needed technology or other resources. Then there were relatively complicated issues like securing appropriate commitment and support from educational and political leaders.

Variety was similarly seen in the backgrounds of the administrators working to oversee STEM program implementation. All four of the administrators that participated in the interviews had different professional backgrounds and none of them were in STEM fields of study. Their areas of teaching certification included health and physical education, choral music, social studies, and foreign language.

A second theme that emerged was capacity building. The need for qualified instructors to implement STEM instruction and PLTW courses was reported in surveys as one of the most important challenges facing STEM education by multiple respondents. This need was reiterated in interview responses. The related topic of professional development and teacher training was also common on the surveys and in the interviews. These responses indicated a perceived need to build the capacity of teachers charged with implementing STEM classes. This need arises from specialized nature of the content and the technical, hands-on, project-based, problem-solving approach that is often utilized in these classes.

In addition to the need for building capacity among classroom teachers, there were also responses suggesting a need for capacity building in school leaders. Nearly 20% of the participating administrators responded that do not feel prepared for the implementation of STEM instruction in their school. This percentage is particularly interesting considering these are administrators in schools that have taken the initiative to utilize some component of a fairly comprehensive STEM program at their sites. These survey responses, paired with the interview responses regarding special considerations that school leaders should make when implementing STEM education programs, indicate a need for administrative capacity building.

A third theme found in the survey and interview data was connections. In the classroom, connections must be made between the content and its real-world applications. Action should also be taken to ensure students make connections between STEM activities and the core content it demonstrates, utilizes, and reinforces. Further, connections should be made between STEM education and how it relates to a range of potential career fields. The two high school administrators that work with partnership teams to support their PLTW programs revealed that connections to local industry leaders and post-secondary institutions are another important component of STEM education.

Summary

For school leaders to implement an initiative, they must have an understanding of what it is and take the actions required for implementation (CCSSO, 2008). This understanding will influence how they work to put programming such as STEM education in place on their campuses. In addition to understanding, their perceptions of the initiative and its relating factors will also play a role in the behaviors they exhibit in their administration of the program (National Science Board, 2010). As the instructional leaders of their schools, administrators' behaviors will impact the educational activities and practices that the teachers utilize in the classrooms with their students (CCSSO, 2008; Nathan et al., 2010).

Given the high profile status of STEM education in the United States at this time, some may assume that there is a universal understanding and definition of what it is. However, the data collected in this study revealed a discrepancy between how current literature defines STEM education and how some practicing principals define STEM education. This lack of a common definition is likely a contributing factor to the wide range of implementation practices and varying effects that schools report as a result STEM programming, even programs that are well defined and extensively developed like PLTW. There was evidence from the surveys that administrators who cannot comprehensively define STEM education lead schools had a lower incidence of STEM instructional practices in the classroom.

All of the administrators replied to the survey that they agreed or strongly agreed with the statement, "I perceive a need for STEM education." While they all reported perceiving the need, they did not all feel prepared for the implementation of STEM instruction in their schools, even though they all indicated that STEM education is a topic of discussion in their district or school at least "sometimes." Contributing factors for those who do not feel prepared for the implementation could be revealed by examining two other survey responses. In one, some administrators indicated that they do not believe they have adequate access to STEM assets and in another some of them felt that STEM professional development opportunities are offered regularly for their teachers. These perceptions regarding lack of preparedness were associated with lower occurrence of STEM instructional practices in the classroom.

Looking at the perceived challenges facing STEM education provided insight into what might be hindering schools from experiencing effective STEM programming. The equipment, technology, and training associated with STEM courses are expensive, therefore it is logical that most frequently recorded challenge was funding. The need for professional development/teacher training was second highest reported challenge or program weakness. The next most commonly recorded challenge was the demands of required curriculum. This response is likely a result of the accountability driven culture of modern education, where non-assessed subjects tend to take a "back seat" to tested subjects.

Data from the interviews revealed higher levels of understanding of STEM education resulted in a higher Level of Use rating. The administrators with the highest Level of Use ratings also provided the two most comprehensive definitions on the survey based on key term analysis. These administrators also reported "always" seeing the instructional practices associated with STEM education in the classrooms at their schools.

CHAPTER 5

FINDINGS, CONCLUSIONS, LIMITATIONS, AND RECOMMENDATIONS

Discussion of Findings

As the instructional leaders on their campuses, administrators have the opportunity to play a critical role in their schools' ability to provide quality STEM education (Scott, 2012). Successful school administrators need to constantly improve their understanding of instructional practices to effectively lead their schools through program implementations, like STEM, that produce the desired student learning outcomes (CCSSO, 2008; Merrill & Daugherty, 2010). There is evidence that educators' understandings, beliefs, and perceptions critically influence decision making, academic action, instructional planning, course offerings, and implementing change initiatives (Diaz, Cox, & Adams, 2013; Nathan et al., 2010; National Science Board, 2010; Praisner, 2003). Therefore, it is important to examine leaders' beliefs and perceptions regarding STEM education because of the influence they can have on school objectives, instructional practices, and students' learning expectations (Nathan et al., 2010).

The purpose of this study was to examine administrators' understandings and perceptions of STEM education and look for their potential influences on program implementation and classroom practices. Initial data were gathered through the Educators' Perception of STEM Education Implementation Survey (Appendix A) which provided information regarding administrators' perceptions and understandings of STEM education as well as demographic data. Follow-up interviews were conducted with a sample of the survey respondents to gain more in-depth information about STEM program implementation. The Levels of Use Interview protocol (Appendix D) was used to gather data about behaviors associated with the use of PLTW. Several researcher-developed supplemental questions were included in the interviews as well.

Research Questions

1. How do administrators in Louisiana implementing a PLTW curriculum define STEM education?

Responses to an open-ended question, "In your own words define STEM education," from the Educators' Perception of STEM Education Implementation Survey provided data for this research question. The online survey was administered in December 2014. The terms/concepts that occurred most frequently in the definitions generated by the respondents included real-world applications (6 occurrences) and career (5 occurrences). The concepts of complementing core curriculum and content integration each occurred four times. The terms hands-on instruction, problem-solving, and technology-based each occurred three times.

While it was valuable to look at the verbiage included in the definitions, insights were also gained from omissions in the definitions. Three of the administrators simply defined STEM education as instruction in science, technology, engineering, and math; with no other defining characteristics included. Six other definitions lacked the term "engineering" or the acronym STEM with the "E" representing engineering. None of the definitions included the term collaboration and only one of the definitions included the term project-based, both of which are generally considered as defining characteristics of STEM education (Ejiwale, 2012; Nathan et al., 2013; Sanders, 2009).

2. How do administrators of schools in Louisiana implementing a PLTW curriculum perceive STEM education?

All of the survey participants agreed or strongly agreed with the statement, "I perceive a need for STEM education." However, four replied that they did not feel prepared for the implementation of STEM instruction in their schools, even though all reported that at least "sometimes" STEM education was a topic of discussion in their district or school. Over half of the administrators disagreed or strongly disagreed that STEM education in Louisiana is meeting the needs of 21st century learners.

Nearly half of the participants indicated that professional development opportunities were not regularly provided for teachers in their schools. These responses reveal there is the perception of need for more STEM professional development for teachers. More evidence of this need was provided in the open ended question regarding the most important challenges facing STEM education. The second most frequent response was professional development/teacher training. This challenge related to the fourth most frequently named challenge, the need for qualified teachers. Presumably, the perceived lack of professional development is contributing to the need for qualified teachers. The need for professional development also presented in one of the interviews.

The most commonly named challenge facing STEM education was funding, with over half of the administrators including it in their list. Given the considerable expense associated with equipment, technology, and training associated with STEM courses, the high frequency of funding as a challenge is understandable. In his interview, Tom named the expense of PLTW as the primary weakness of the program, but he went on to explain he believed the program quality makes it a good investment.

Another frequently identified challenge facing STEM education was the demands of the required curriculum. There was more than one aspect to this category of statements. Some administrators referred to the challenge of finding time to teach STEM content with all of the currently required standards that must be taught. Some administrators at the high school level referred to the course requirements for graduation, implying that some students may not have room in their schedules for STEM elective courses.

Collectively, the responses regarding administrators' perceptions of STEM education reveal a picture where they believe there is a need, but the current state of STEM education is not where it should be to address this need. Some of the perceived challenges also indicate a lack of knowledge and understanding about some aspects of PLTW, the STEM program with which all of these schools are at least registered. For example, the responses identifying lack of professional development for teachers as a challenge reveal that the school administrators may be unaware of the three-phase professional development component that consists of online Readiness Training, followed by face-to-face Core Training (which lasts from three to ten days depending on the course) held every summer across the country, and online Ongoing Training that is available any time (PLTW, 2015). Another example can be found in the responses regarding the demands of required or core curriculum. These responses suggest that some administrators may consider STEM instruction as strictly something done outside of core instruction. This thinking is not in alignment with some professional literature that reports STEM instructional methods can provide students with a context for their content learning that promotes internalization of material and supports content recall (Reid & Feldhaus, 2007; Sanders, 2009)

3. What evidence exists to indicate administrators' understandings and perceptions of STEM education impact program implementation and classroom behaviors?

The survey data did provide some evidence that a lower level of understanding, as measured by definition analysis and challenge alignment to PLTW program, may have an impact on program implementation and classroom practices. For example, six survey respondents replied rarely to at least one of the questions regarding the frequency of occurrence of STEM instructional practices or content presentation. Five of these offered simplistic definitions of STEM education that were lacking many, if not all, of the foundational elements that literature indicates are necessary to adequately define STEM education. These omitted terms include integration of content, collaboration, hands-on, problem-solving, project-based learning, and real-world application (Ejewale, 2012; Merrill, 2009; Reid & Feldhause, 2007; Roberts, 2013; Stearns et al., 2012).

Within this same group of six administrators, four responded that they did not feel prepared for the implementation of STEM instruction in their schools. Two of those that did not feel prepared to implement STEM instruction also do not believe they have adequate STEM assets. The most frequently stated important challenges STEM education for these six administrators were staffing/qualified teachers (4), funding (3), training/professional development (2), and curriculum (2). In a similar situation to one described in the discussion of research question two, the presence of professional development and curriculum on this list reveals a lack of knowledge regarding PLTW program components. As previously discussed, PLTW has a three-phase professional development program that is fairly comprehensive. PLTW also offers a detailed curriculum that includes daily lesson plan guidance, curriculum alignment to national standards, an online learning platform, project-based learning experiences, grading rubrics, and, at the high school level, online end-of-course assessments (PLTW, 2015).

In contrast to the six respondents who reported that they rarely observed some of the STEM instructional practices, there were four participants that replied "always" to at least four of the five questions regarding the frequency of occurrence of STEM instructional practices or content presentation. Definition analysis from these four respondents found that their definitions were more comprehensive and contained a higher frequency of the STEM education key terms. All four of these administrators agreed or strongly agreed that they were prepared for the implementation of STEM education in their schools. They also offered more complex challenges facing STEM.

The comparison of these pieces of data for these two subgroups within the study participants provide some evidence that administrators' understanding and perceptions regarding STEM education can influence instructional practices in the classroom. A deeper understanding of STEM education and positive perceptions could be contributing factors to the higher reported frequency of STEM instructional practices in the classroom.

The interview data also offers some evidence that administrator understandings and perceptions can impact program implementation and classroom practices. The two administrators with the higher, Level V, Integration rating provided two of the most comprehensive STEM education definitions with each including more of the STEM key terms than the definitions of Level III and Level IVA rated users. Similarly, the challenges identified by the Level V users are less about basic program function and more about program growth and development that will enhance student involvement and student outcomes. These higher Level of Use rated administrators may focus on more advanced, global issues because the use of STEM instructional practices in the PLTW classrooms on their site is part of the regularly occurring behaviors associated with the program; therefore they can direct their attention on more complex concerns.

While these data do not establish a causality between administrators' understandings and perceptions and program implementation and classroom practices, they do suggest that there is likely some influence. Administrators with a greater understanding and more accurate perceptions of STEM are more likely to engage in the actions necessary to support the appropriate use of STEM instructional practices in the classroom. They are more prepared to ensure that curricula like those available through PLTW are implemented with fidelity.

Conclusions

The Educators' Perception of STEM Education Implementation Survey provided demographic information, as well as data regarding understandings and perceptions about STEM education and its implementation. The Levels of Use interview narratives along with response narratives to supplemental questions provided more in-depth information of the administrators' understandings and perceptions and the behaviors they engage in as they use the PLTW program at their school. Several themes emerged from analysis of the survey responses and interview narratives. These themes were variation, connections, and capacity building. Conclusions, based on the small sample in this study, are presented below:

1. There is not a universally understood definition of STEM education, which results in a wide-range of implementation practices that produce varying degrees of success.
2. While administrators may perceive a need for STEM education, they may not feel prepared to address the need, even when implementing a comprehensive, targeted program like PLTW.
3. Administrators' perceptions of challenges facing STEM education can vary considerably in both content and complexity depending on their level of understanding and familiarity with programming.
4. Successful STEM administrators can come from a variety of instructional fields.
5. Successful STEM education requires administrators to think about and engage in some activities differently, such as strategic scheduling, careful teacher selection, and planning for equipment and technology replacement.
6. Administrators' understandings and perceptions about STEM education can influence program implementation and classroom practices.

Limitations

This mixed-methods research study gathered survey data from 21 administrators of schools in six public school districts and one private school organization, all in Louisiana. All of the schools were registered to implement at least one of the PLTW curricula. Four of the survey respondents participated in interviews that followed the Levels of Use protocol with several researcher-developed supplemental questions included after the protocol questions. Given these investigative techniques, the following limitations should be considered:

1. The small sample size (n = 21), with four follow-up interviews, requires caution when considering making general assumptions based on the findings reported here.
2. Given the high profile of STEM education and the participants' awareness that their role in its implementation were the focus of this study, responses may have been biased.

Recommendations

Administrators are called on to be the instructional leaders of their schools. What they understand about a program and how they perceive it can impact their professional practices, which can influence implementation, both school-wide and at the classroom level. When implementing specialized programming like STEM education, it is important for administrators to have a comprehensive understanding and possess accurate perceptions. Based on the findings of this study, school administrators looking to successfully implement a STEM program like PLTW would benefit from personal research on the program along with professional development that enhances their understanding and perception of STEM education. The following recommendations are offered:

1. Administrators preparing to implement a STEM program should gather information about the program from both the organization that offers the program as well as, if possible, other administrators that are already utilizing the program.

2. Administrator professional development should be included along with teacher professional development regarding STEM program implementation.
3. Strategic, focused district-level support for administrators should be in place to ensure the school leaders are appropriately informed and have the necessary resources as they work to implement STEM program.
4. Administrators should develop a program-specific method for evaluating the STEM program on a pre-determined time schedule to monitor implementation and progress toward desired outcomes.

Future Research

Based on the findings of this research, the following suggestions for future research are offered:

1. A study following the same protocol could be conducted with a larger target population by including administrators that are implementing a wider variety of STEM programs. A larger sample size would improve the applicability of the findings.
2. A study that includes data collection of STEM teachers' experiences with administrators working to oversee a STEM program may provide insights into how and why classroom practices are influenced by administrative understandings and perceptions.
3. A study with an expanded version of some of the Likert-scaled survey questions where administrators are asked to explain and/or identify examples of what they consider to be STEM instructional practices, inquiry-based, problem solving, and

project-based learning. This study could ask administrators to quantify their responses of rarely, sometimes, often, and always.

The success of any program implementation at the school level is influenced significantly by the actions and decisions of the administrator. Therefore, these school leaders must ensure they possess the knowledge and understanding necessary to make choices and engage in behaviors that promote efficient, productive program utilization. This is particularly true for programs targeting highly specialized content like STEM. Ill-informed administrators with inaccurate understandings and perceptions are at risk of creating wasteful, frustrating situations that do not produce the desired student outcomes.

APPENDIX A

EDUCATORS' PERCEPTION OF STEM EDUCATION IMPLEMENTATION SURVEY

Educators' Perception of STEM Education Implementation Survey

1. Are you employed as a/n:

   Principal Assistant Principal

2. Do you work within the elementary setting, middle school setting, high school setting, or a combination setting?

   Elementary Middle School High School Combination

3. How many years of experience do you have within this role?

   0 -4 5 – 10 11 – 15 15+

4. What is the highest level of advanced degree that you hold?

   Bachelors' Masters' Masters' +30 Doctorate

5. In which school district are you employed?

6. I perceive a need for STEM education.

   Strongly Agree Agree Disagree Strongly Disagree

7. In your own words, define STEM education:

8. To what extent has "STEM Education" been a topic of discussion in your district and/or school?

   Rarely Sometimes Often Always

9. Some schools and districts have implemented programs and courses focused on STEM education. Does your school or district have programs which integrate core concepts of STEM?

   Yes No

10. To what degree do you observe STEM instruction in the classroom setting?

    Rarely Sometimes Often Always

11. How often do you observe inquiry-based, problem-solving activities in the classroom setting?

Rarely Sometimes Often Always

12. Is there more time for teaching with the following as a result of STEM?

Technology-Supported Learning Tools	Sometimes	Often/Always
Traditional Teacher-Led Instruction	Sometimes	Often/Always
Project-Based Learning	Sometimes	Often/Always
Workplace or Lab-Based Learning	Sometimes	Often/Always
Business/STEM Professionals	Sometimes	Often/Always

13. Is technology used throughout your STEM program as a tool to facilitate research, investigation and design?

Rarely Sometimes Often Always

14. Professional development opportunities around STEM education are regularly provided to teachers in your school.

Strongly Agree Agree Disagree Strongly Disagree

15. I have adequate access to STEM assets (libraries, agencies, professionals, museums, etc).

Strongly Agree Agree Disagree Strongly Disagree

16. The unique characteristics of STEM education may require the use of alternative instructional techniques for effective instruction of STEM concepts. To what degree do you observe STEM instructional techniques?

Rarely Sometimes Often Always

17. I feel prepared for the implementation of STEM instruction in my school.

Strongly Agree Agree Disagree Strongly Disagree

18. In a nine week period, how often are discussions integrated into instruction that help students become aware of STEM careers?

Rarely Sometimes Often Always

19. The current condition of STEM education in Louisiana is meeting the needs of 21st Century Learners.

Strongly Agree Agree Disagree Strongly Disagree

20. In your opinion, what are the 3 most important challenges facing STEM education? Please rank your top 3 most important challenges with 1 being the greatest.

21. This question will not be used for reporting purposes. The response to this item will be used to identify a sample of survey respondents who will be asked to participate in a brief follow up interview. Please indicate the school in which you serve as an administrator: ________________________.

APPENDIX B

PERMISSION TO USE SURVEY

Misty Davis

From: Turner, Kristen
Sent: Wednesday, August 20, 2014 3:39 PM
To: MISTY DAVIS
Subject: Dissertation Survey

Misty,
I give you permission to use my survey to support your study. Do you mind to credit me with the survey development within your dissertation? Also, if it is altered, please notate that as well.

Thank you,

Kristin Turner, Ed.D.
Interim Principal: Kennedy Elementary School
Kingsport City Schools
Kingsport, TN

APPENDIX C

LEVELS OF USE OF AN INNOVATION

Levels of Use of an Innovation

Nonuse: State in which the use has little or no knowledge of the innovation, has no involvement with the innovation, and is doing nothing toward becoming involved.

Orientation: State in which the user has acquired or is acquiring information about the innovation and/or has explored or is exploring its value orientation and its demands upon the user and the user system.

Preparation: State in which the user is preparing for first use of the innovation.

Mechanical Use: State in which the user focuses most effort on the short-term, day-to-day use of the innovation with little time for reflection. Changes in use are made more to meet user needs than client needs. The user is primarily engaged in a stepwise attempt to master the tasks required to use the innovation, often resulting in disjointed and superficial use.

Routine: Use of the Innovation is stabilized. Few if any changes are being made in ongoing use. Little preparation or thought is being given to improving innovation use or its consequences.

Refinement: State in which the user varies the use of the innovation to increase the impact on clients within immediate sphere of influence. Variations are based on knowledge of both short- and long-term consequences for clients.

Integration: State in which the user is combining own efforts to use the innovation with the related activities of colleagues to achieve a collective effect on clients within their common sphere of influence.

Renewal: State in which the user reevaluates the quality of use of the innovation, seeks major modifications or alternatives to the present innovation to achieve increased impact on clients, examines new developments in the field, and explores new goals for self and the system.

APPENDIX D

LEVELS OF USE INTERVIEW PROTOCOL

Are you using the innovation?	To distinguish between users and nonusers; to break LoU 0-II from LoU III-IV
What do you see as the strengths and weaknesses of the innovation in your situation? Have you made any attempt to do anything about the weaknesses?	To probe Assessing and Knowledge Categories.
Are you currently looking for any information about the innovation? What kind? For what purpose?	To probe Acquiring Information Category.
Do you ever talk with others about the innovation? What do you tell them?	To probe Sharing Category and check Decision Point E.
What do you see as being the effects of the innovation? In what way have you determined this? Are you doing any evaluating, either formally or informally, of your use of the innovation? Have you received any feedback from students? What have you done with the information you get?	To probe Assessing Category.
Have you made any changes recently in how you use the innovation? What? Why? How recently? Are you considering making any changes?	To distinguish between LoU III user-oriented changes), LoU IVB (impact-oriented changes), and LoU IVA (no or routine changes); to probe Status Reporting and Performing Categories.
As you look ahead to later this year, what plans do you have in relation to your use of the innovation?	To probe Planning and Status Reporting Categories.

Are you working with others (outside of anyone you may have worked with from the beginning) in your use of the innovation? Have you made any changes in your use of the innovation based on this coordination?	To separate LoU V from III, IVA, and IVB. If a positive response is given, LoU V probes (below) are used.
Are you considering making or planning to make major modifications or to replace the innovation at this time?	To separate LoU VI from III, IVA, IVB, and V.

How do you work together? How frequently?	To verify Decision Point E; to probe Performing Category.
What are the strengths and the weaknesses of this collaboration for you?	To probe Knowledge Category.
Are you looking for any particular kind of information in relation to this collaboration?	To probe Acquiring Information Category.
When you talk to others about your collaboration, what do you share with them?	To probe Sharing Category?
Have you done any formal or informal evaluation of how your collaboration is working?	To probe Assessing Category.
What plans do you have for this collaborative effort in the future?	To probe Planning Category.
Can you summarize for me where you see yourself right now in relation to the use of the innovation? (Optional Question)	To get a concise picture of the user's perception of his/her use or nonuse.

[redacted]	
Have you made a decision to use the innovation in the future? If so, when?	To separate LoU 0 from I; to probe Status Reporting, Planning, and Performing Categories; to separate LoU I from II.
Can you describe the innovation for me as you see it?	To probe Knowledge Category.
Are you currently looking for any information about the innovation? What kinds? For what purposes?	To probe Acquiring Information Category.
What are the strengths and weaknesses of the innovation for your situation?	To probe Assessing Category.
At this point in time, what kinds of questions are you asking about the innovation? Give examples if possible.	To probe Assessing, Sharing, and Status Reporting Categories.
Do you ever talk with others and share information about the innovation? What do you share?	To probe Sharing Category.
What are you planning with respect to the innovation? Can you tell me about any preparation or plans you have been making for the use of the innovation?	To probe Planning Category.
Can you summarize for me where you see yourself right now in relation to the use of the innovation? (Optional Question)	To get a concise picture of the user's perception of his/her use or nonuse.

APPENDIX E

LEVELS OF USE RATING SHEET

LEVEL OF USE RATING SHEET (CBAM, 1975)

Tape #: Site: Interviewee:

Date: / / I.D.#: Rater:

[redacted]

Nonuse	O	O	O	O	O	O	O	O
Decision Point A								
Orientation	I	I	I	I	I	I	I	I
Decision Point B								
Preparation	II	II	II	II	II	II	II	II
Decision Point C								
Mechanical Use	III	III	III	III	III	III	III	III
Decision Point D-1								
Routine	IVA	IVA	IVA	IVA	IVA	IVA	IVA	IVA
Decision Point D-2								
Refinement	IVB	IVB	IVB	IVB	IVB	IVB	IVB	IVB
Decision Point E								
Integration	V	V	V	V	V	V	V	V
Decision Point F								
Renewal	VI	VI	VI	VI	VI	VI	VI	VI
User is not doing:	ND	ND	ND	ND	ND	ND	ND	
No information in interview:	NI	NI	NI	NI	NI	NI	NI	

Is the individual a past user? Yes No If so, what was their last LoU? ________________

How much difficulty did you have in assigning this person to a specific LoU? None 1 2 3 4 5 6 7 Very much

Comments about interviews—

General comments—

APPENDIX F

HUMAN SUBJECTS COMMITTEE FORM

Do you plan to publish this study?	✓ YES ▫ NO
Will this study be published by a national organization?	▫ YES ✓ NO
Are copyrighted materials involved? Do you have written permission to use copyrighted materials?	✓ YES ▫ NO ✓ YES ▫ NO
COMMENTS:	

STUDY/PROJECT INFORMATION FOR HUMAN SUBJECTS COMMITTEE

Describe your study/project in detail for the Human Subjects Committee. Please include the following information.

TITLE: An Examination of Administrators' Perceptions of STEM Education and Their Influence on Classroom Practices in Louisiana

PROJECT DIRECTOR(S): Misty Davis, Dr. Dawn Basinger

EMAIL: misty.davis@desotopsb.com, dbasing@latech.edu

PHONE: 318-464-4278, 318-257-2382

DEPARTMENT(S): Education

PURPOSE OF STUDY/PROJECT: The purpose of this study is to examine administrators' understandings and perceptions of STEM education.

SUBJECTS: Louisiana school administrators from schools that are currently implementing at least one Project Lead the Way curriculum in their school.

PROCEDURE: This two-phase mixed-methods study will begin with the administration of a 21-item online survey administered to Louisiana school administrators that are currently leading schools that are implementing at least one Project Lead the Way STEM curriculum. Permission has been obtained from district leadership (or appropriate leadership in the case of charter schools and private schools) to distribute surveys in seven parishes, two charter schools, and two private schools throughout Louisiana. The second phase of the study will include a minimum of four administrators from the survey respondent pool being asked to engage in a

follow up interview. Quantitative and qualitative data analysis will be performed to gain insights into administrators' understandings and perceptions regarding STEM education.

INSTRUMENTS AND MEASURES TO INSURE PROTECTION OF CONFIDENTIALITY, ANONYMITY: The 21-item Educators' Perception of STEM Education Implementation survey developed by Kristen B. Turner will be used to obtain perception data in the first phase of the study. Follow-up interview questions will be developed based on the data analysis of the survey results. All data collected will remain confidential and only be viewed by the researcher.

RISKS/ALTERNATIVE TREATMENTS: None

BENEFITS/COMPENSATION: None

SAFEGUARDS OF PHYSICAL AND EMOTIONAL WELL-BEING: This study involves no treatment or contact that could compromise physical or emotional well-being. All information collected will be kept confidential. Only the researcher will be allowed to access the survey and interview data.

Note:	**Use the Human Subjects Consent form to briefly summarize information about the study/project to participants and obtain their permission to participate.**

APPENDIX G

HUMAN USE COMMITTEE REVIEW

LOUISIANA TECH
UNIVERSITY

MEMORANDUM

OFFICE OF UNIVERSITY RESEARCH

TO: Ms. Misty Davis and Dr. Dawn Basinger

FROM: Dr. Stan Napper, Vice President Research & Development

SUBJECT: HUMAN USE COMMITTEE REVIEW

DATE: November 19, 2014

In order to facilitate your project, an EXPEDITED REVIEW has been done for your proposed study entitled:

"An Examination of Administrators' Perceptions of STEM Education and Their Influence on Classroom Practices in Louisiana"

HUC 1248

The proposed study's revised procedures were found to provide reasonable and adequate safeguards against possible risks involving human subjects. The information to be collected may be personal in nature or implication. Therefore, diligent care needs to be taken to protect the privacy of the participants and to assure that the data are kept confidential. Informed consent is a critical part of the research process. The subjects must be informed that their participation is voluntary. It is important that consent materials be presented in a language understandable to every participant. If you have participants in your study whose first language is not English, be sure that informed consent materials are adequately explained or translated. Since your reviewed project appears to do no damage to the participants, the Human Use Committee grants approval of the involvement of human subjects as outlined.

Projects should be renewed annually. ***This approval was finalized on November 19, 2014 and this project will need to receive a continuation review by the IRB if the project, including data analysis, continues beyond November 19, 2015.*** Any discrepancies in procedure or changes that have been made including approved changes should be noted in the review application. Projects involving NIH funds require annual education training to be documented. For more information regarding this, contact the Office of University Research.

You are requested to maintain written records of your procedures, data collected, and subjects involved. These records will need to be available upon request during the conduct of the study and retained by the university for three years after the conclusion of the study. If changes occur in recruiting of subjects, informed consent process or in your research protocol, or if unanticipated problems should arise it is the Researchers responsibility to notify the Office of Research or IRB in writing. The project should be discontinued until modifications can be reviewed and approved.

If you have any questions, please contact Dr. Mary Livingston at 257-2292 or 257-5066.

A MEMBER OF THE UNIVERSITY OF LOUISIANA SYSTEM
P.O. BOX 3092 • RUSTON, LA 71272 • TEL: (318) 257-5075 • FAX: (318) 257-5079
AN EQUAL OPPORTUNITY UNIVERSITY

APPENDIX H

HUMAN SUBJECTS CONSENT FORM

HUMAN SUBJECTS CONSENT FORM

The following is a brief summary of the project in which you are asked to participate. Please read this information before signing the statement below.

TITLE OF PROJECT: **An Examination of Administrators' Perceptions of STEM Education and Their Influence on Classroom Practices in Louisiana**

PURPOSE OF STUDY/PROJECT: **The purpose of this study is to examine administrators' understandings and perceptions of STEM education.**

PROCEDURE: **This two-phase mixed-methods study will begin with the administration of a 20-item online survey administered to Louisiana school administrators that are currently leading schools that are implementing at least one Project Lead the Way STEM curriculum. Permission will be obtained from district leadership prior to the survey distribution. The second phase of the study will include a minimum of five administrators from the survey respondent pool being asked to engage in a follow up interview. Quantitative and qualitative data analysis will be performed to gain insights into administrators' understandings and perceptions regarding STEM education.**

INSTRUMENTS: **The 20-item Educators' Perception of STEM Education Implementation survey developed by Kristen B. Turner will be used to obtain perception data in the first phase of the study. Follow-up interview questions will be developed based on the data analysis of the survey results.**

RISKS/ALTERNATIVE TREATMENTS: The participant understands that Louisiana Tech is not able to offer financial compensation nor to absorb the costs of medical treatment should you be injured as a result of participating in this research.

The following disclosure applies to all participants using online survey tools: This server may collect information and your IP address indirectly and automatically via "cookies".

EXTRA CREDIT: If extra credit is offered to students participating in research, an alternative extra credit that requires a similar investment of time and energy will also be offered to those students who do not choose to volunteer as research subjects.

BENEFITS/COMPENSATION:

I, ____________________, attest with my signature that I have <u>read and understood the following description of the study,</u> "________________________", and its purposes and methods. I understand that my participation in this research is strictly voluntary and <u>my participation or refusal to participate in this study will not affect my relationship with Louisiana Tech University or my grades in any way.</u> Further, I understand that I may withdraw at any time or refuse to answer any questions without penalty. Upon completion of the study, I understand that the results will be freely available to me upon request. I understand that the results of my survey will be <u>confidential, accessible only to the principal investigators, myself, or a legally appointed representative.</u> I have not been requested to waive nor do I waive any of my rights related to participating in this study.

______________________________   ____________

Signature of Participant   Date

CONTACT INFORMATION: The principal experimenters listed below may be reached to answer questions about the research, subjects' rights, or related matters.
Misty Davis: mkd013@latech.edu
Dr. Dawn Basinger: dbasing@latech.edu

Members of the Human Use Committee of Louisiana Tech University may also be contacted if a problem cannot be discussed with the experimenters:
Dr. Stan Napper (257-3056)
Dr. Mary M. Livingston (257-2292 or 257-5066)

APPENDIX I

C-BAM COPYRIGHT PERMISSION LETTER

SEDL License Agreement

To: Misty Davis (Licensee)
8906 E. Wilderness Way
Shreveport, LA 71106

From: Nancy Reynolds
Information Associate
SEDL
Information Resource Center-Copyright Permissions
4700 Mueller Blvd.
Austin, TX 78723

Subject: License Agreement to reprint and distribute SEDL materials

Date: November 14, 2014

Thank you for your interest in using an excerpt from the book *Measuring Implementation in Schools: Levels of Use* written by Gene E. Hall, Debra J. Dirksen, and Archie A. George, and published by SEDL in 2006. From this book, you have asked to use Appendix A: The Basic Interview Protocol, pages 53-56.

This excerpt will be referred to as the "work" in this License Agreement. SEDL is pleased to grant permission for the use of the work cited above by the Licensee, a doctoral student at Louisiana Tech University in Shreveport, LA, in a dissertation titled *An Examination of Administrators' Perceptions of STEM Education and Their Influence on Classroom Practices in Louisiana*. The following are the terms, conditions, and limitations governing this permission to reproduce and distribute the work:

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Voice: [illegible]
Fax: 512-476-[illegible]

p. 2, SEDL License Agreement

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I'm e-mailing you a PDF of this agreement. Please print and sign one copy below, indicating that you understand and agree to comply with the above terms, conditions and limitations, and send the original back to me. If you wish to keep a copy with original signatures, please also print, sign, and return a second copy and, after I receive and sign it, I'll return it with both of our signatures to you.

Thank you, again, for your interest in using an excerpt from SEDL's publication *Measuring Implementation in Schools: Levels of Use*. If you have any questions, please contact me at 800-476-6861, ext. 6548 or 512-391-6548, or by e-mail at nancy.reynolds@sedl.org.

Sincerely,

Nancy Reynolds — November 17, 2014

Nancy Reynolds for SEDL — Date signed

Agreed and accepted:

Signature: Misty Davis — 11/14/14

Date signed

Printed name: Misty Davis

APPENDIX J

LETTER TO SUPERINTENDENTS

Superintendent,

As a requirement of the degree of Doctor of Education of Educational Leadership through Louisiana Tech University, I am writing a dissertation on administrators' perceptions of science, technology, engineering, and math (STEM) education in Louisiana. Specifically, my research is focusing on administrators of schools implementing a Project Lead the Way (PLTW) curriculum. This study is examining school leaders' understandings and perceptions regarding STEM education because of the influence they have on professional practices, the management of program implementation, and program maintenance.

The research consists of the voluntary completion of an online survey utilizing the Survey Monkey platform. The 21-item survey will take approximately 15 – 20 minutes for participants to complete. After all survey responses have been received, five respondents will be asked to participate in a follow-up interview that is expected to last 30 – 45 minutes. The interviews may be conducted face-to-face or via telephone. The five interview participants will be purposefully selected to generate representative sample of the survey respondents.

I am seeking your permission to send the previously mentioned online survey to administrators in your district of schools registered as PLTW schools. In your district, this would include the following schools: If you would like further information regarding the study prior to granting permission, please do not hesitate to contact me via e-mail (misty.davis@desotopsb.com) or phone (318-464-4278). Your consideration in the matter is greatly appreciated.

Sincerely,

Misty Davis

APPENDIX K

LETTER TO PRINCIPALS

Principal,

As a requirement of the degree of Doctor of Education of Educational Leadership through Louisiana Tech University, I am writing a dissertation on administrators' perceptions of science, technology, engineering, and math (STEM) education in Louisiana. Specifically, my research is focusing on administrators of schools implementing a Project Lead the Way (PLTW) curriculum. This study is examining school leaders' understandings and perceptions regarding STEM education because of the influence they have on professional practices, the management of program implementation, and program maintenance.

I am requesting your assistance with this research by completing a 21-item online survey that should take approximately 15 minutes to answer. Your district administration has granted permission for me to send this survey to you as an administrator of a PLTW school. However, your participation is voluntary. I realize that as a school administrator, there are many demands on your time, but I am hopeful that you can take the time to provide input regarding your perceptions of STEM education. I believe it can be very valuable as we seek to better understand STEM in Louisiana schools.

There will be a second phase of this study in which at least five survey respondents will be asked to participate in a brief follow-up interview. These interviews, which may take place face-to-face or via telephone, are expected to last approximately 30 minutes.

If you agree to be part of this study, follow the link below to the online survey. There is a required informed consent statement at the beginning of the survey that must be answered before proceeding to the survey questions. All responses will be confidential. If you have any questions or concerns, please contact me at misty.davis@desotopsb.com or 318-464-4278. Thank you for your consideration of participation in this research study.

Sincerely,

Misty Davis

APPENDIX L

ADDITIONAL INTERVIEW QUESTIONS

Additional Interview Questions

1. How are you working to overcome the challenges you identified in the survey?
2. Do you believe your area of certification poses any advantage or disadvantage to being an administrator overseeing a STEM program?
3. As an administrator, are there things you must think about or do differently related to STEM programming?

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