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Northeast Tennessee Educators’ Perception of STEM Education Implementation

Kristin Turner
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Northeast Tennessee Educators’ Perception of STEM Education Implementation

A dissertation
presented to
the faculty of the Department of Educational Leadership and Policy Analysis
East Tennessee State University
In partial fulfillment
of the requirements for the degree
Doctor of Education of Educational Leadership

by
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August 2013

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Key Words: 21st Century Skills, Common Core, Constructivism, Critical Thinking, Global Competition, Problem Solving, Project Based Learning, STEM
ABSTRACT

Northeast Tennessee Educators’ Perception of STEM Education Implementation

by

Kristin Turner

A quantitative nonexperimental survey study was developed to investigate Northeast Tennessee K-8 educators’ perceptions of STEM education. This study was an examination of current perceptions of STEM education. Perceived need, current implementation practices, access to STEM resources, definition of STEM, and the current condition of STEM in Northeast Tennessee were also examined. The participating school districts are located in the Northeast Region of Tennessee: Bristol City Schools, Hamblen County Schools, Johnson City Schools, Johnson County Schools, Kingsport City Schools, Sullivan County Schools, and Washington County Schools. Educational professionals including both administrators and teachers in the elementary and/or middle school setting were surveyed.

The closed and open form survey consisted of 20 research items grouped by 5 core research questions. Quantitative data were analyzed using single sample t tests. A 4 point Likert scale was used to measure responses with a 2.5 point of neutrality rating. The open-ended question was summarized and recorded for frequency.

Research indicated that Northeast Tennessee K-8 educators perceive a need for STEM education to a significant extent. However, many do not feel prepared for implementation. Lack of
professional development opportunities and STEM assets were reported as areas of need. Teachers reported implementation of inquiry-based, problem solving activities in their classrooms. The majority of participants reported that the current condition of STEM education in Northeast Tennessee is not meeting the needs of 21st century learners. Challenges facing STEM instruction include: funding designated for STEM is too low, professional development for STEM teacher is insufficient, and STEM Education in K-8 is lacking or inadequate.
DEDICATION

I am thankful for the loving support and guidance from my family throughout this doctoral process. This has truly been a family commitment as we worked to fulfill my goal of achieving my doctoral degree. Brian, you willingly provided time for me to study and write while you cared for our children. You have supported me each step of the way: proofing my papers, providing tutoring in statistics, and always being aware of articles that provide further support to my learning. I could not have done this without you. To my amazing children, Molly, Lily, and Will, you have been my biggest cheerleaders and sources of inspirations throughout my studies. When exhaustion kicked in, you were able to make me smile and gain energy to keep going. I love you dearly and pray that my perseverance has served as a source of inspiration for you in life.

I am also thankful for my wonderful parents and in-laws for their continual encouragement and praise each step of the process. Thank you for your words of encouragement and belief in me throughout this journey. As a child, you instilled in me the desire to be the best I can be. For this, I am forever grateful.

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I could never have completed my doctoral degree without the support of each and every one of you!
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To my ELPA cohort and professors, thank you for your continual support throughout this journey. I not only learned about leadership, but how to make this world a better place. Your leadership and guidance will serve me throughout my life.

I would like to express a sincere thank you to Dr. Glover, my committee chair. You have provided tremendous guidance throughout my ELPA journey and dissertation process. Thank you for helping me to see the “bigger picture.” Your wisdom will continue to guide me in my leadership journey as I work to make a positive impact on our educational system.

To my committee members, Dr. Good, Dr. Foley, and Dr. Govett, thank you for your feedback throughout this dissertation journey. Dr. Good, your statistics support has helped this “literacy minded individual” to complete a quantitative dissertation. Thank you for your excellent instruction. Dr. Foley, throughout the ELPA journey, you have served as mentor to me. I am thankful for your guidance and support each step of the way. You have provided a real-world application view of leadership that has helped with me decision making in the school setting. Dr. Govett, thank you for your insight into STEM instruction and the ETSU STEM Hub.

Lastly, I wish to thank my fellow ELPA cohort members. We learned and laughed together. You are each amazing leaders and I am thankful for your friendship.
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CHAPTER 1

INTRODUCTION

The investigation of STEM education (Science, Technology, Engineering, and Mathematics) is growing in importance in today’s school systems. “STEM education is an area of study but it is also a way of teaching and learning that is project-based, collaborative, and focused on solving real-world problems. STEM programs educate the whole student, emphasizing innovation, problem solving, critical thinking, and creativity” (Tennessee STEM Innovation Network, 2012, What is STEM paragraph, paragraph 8). STEM professionals impact our daily lives with the resources and technological advances we have come to depend upon. STEM is our future.

The A Nation at Risk report of 1983 created the perception of the United States “... as a society that no longer dominated the international economy and an education system confused by its purpose” (Manzo, 2000, p.130). The state of Tennessee was identified as having a low ranking compared to other states within our nation. With a ranking status of 32nd out of 50 states and the District of Columbia in NAEP science results, a need for improvement in Tennessee is evident (NAEP, 2012).

An increase in STEM related jobs is also predicted. Nationally, an increase of one million (33%) more workers than previously used in the United States in STEM fields are needed in the next decade (Gates & Mirkin, 2012). In the state of Tennessee an anticipation of an additional 14,000 jobs between 2008 and 2014 will be needed (Tennessee STEM Innovation Network, 2012). We must be prepared to meet this rising demand. With the receipt of Race to the Top 14.7 million in funds in Tennessee, a plan for STEM implementation was developed (TSIN, 2012). A
collaboration with the Tennessee Department of Education and Battelle Memorial Institute was developed to focus on instructional practices and student learning in STEM across Tennessee. The Tennessee STEM Innovation Network was then developed as the driving force for this work. “Tennessee students will lead the nation in STEM knowledge, skills, and practices as critical and creative thinkers, problem solvers, innovators, and collaborators to compete and succeed in the state’s emerging innovation economy” serves as the vision statement for this work (TSIN, 2012, p.4). This Network is designed to:

- Generate and share new knowledge of what works in STEM education
- Promote clearly articulated indicators of quality
- Develop quality STEM tools with partners
- Offer interactive, on-going access to tools, exemplars and partners through an on-line presence
- Connect state STEM partners to innovative policies and practices across the country (TSIN, 2012, p.15)

The Theory of Change for STEM in Tennessee states: “If Tennessee fully coordinates and aligns STEM policies, practices and partners to increase student interest, participation and achievement in STEM, expands student access to effective STEM teachers and leaders, reduces its STEM talent and skills gap and builds community awareness and support for STEM, then it will lead the nation in STEM – talent development” (TSIN, 2012, p.4). With the identification of six STEM Platform Schools and six Regional STEM Innovation Hubs, the state of Tennessee will have a connected support system for the focused implementation of STEM education.
The Northeast Tennessee region has a STEM Innovation Hub and STEM platform school designed to support implementation of the previously mentioned four goals and multiple supporting strategies. The following school districts are supported by this Innovation Hub: Bristol, Carter, Cocke, Greene, Greeneville City, Hamblen, Hawkins, Johnson, Johnson City, Kingsport, Sullivan, Unicoi, and Washington. The STEM Hub provides professional learning, curriculum support, activities, business partnerships, and resources to support science, technology, engineering, and math skills.

Strength in STEM related skills is necessary to best prepare our students for success in the global workforce (Lantz, 2009). The goal of STEM education is to provide students with skills necessary for success in today’s workforce. These skills are defined as: real world problem solving, inquiry, and creative and critical thinking. Society demands these skills to maintain competitiveness in the global economy. Through STEM students are taught through constructivist, project based methods aimed to build content understandings and application of knowledge (Lantz, 2009).

Not only is strong content knowledge necessary for success in the workforce, but 21st century skills of collaboration, communication, problem solving, and critical thinking are required as well. Mathematics Common Core Curriculum standards have been developed to support student learning with a kindergarten through 12th grade vertical alignment and advances our nation in a common rigorous curriculum (achieve.org, 2012). The Next Generation Science Standards have established criteria for scientific knowledge that will help prepare students for the 21st century workforce (National Research Council, 2012).
Schools must be prepared to support student learning in new and different ways that guide preparedness for the global workforce (Glover, 2013). Effective leaders build collaborative structures that support planning for rigorous activities that incorporate STEM, provide professional learning opportunities for teachers to build content knowledge, and strengthen instructional strategies, support curriculum understandings, guide analysis of student achievement data.

_Statement of the Problem_

The purpose of this research is to discover current perceptions of K-8 educational professionals regarding STEM implementation. With knowledge and awareness of our current reality in Northeast Tennessee, schools and school districts can better prepare for future STEM resources, professional development, and programming. Through the integration of STEM into the classroom setting, schools and school districts will be providing students with necessary knowledge for success in college and/or the workforce in the 21st century.

_Research Questions_

This study was an investigation of the perceptions of Northeast Tennessee K-8th grade educators and administrators on: perceived need for STEM instruction, aspects of STEM instruction, classroom STEM implementation, access to STEM resources, and district STEM implementation. To provide context into understanding Northeast Tennessee K-8 educators’ perception of STEM education, this study was guided by the following research questions.
1. How do educational professionals in Northeast Tennessee define STEM?

2. To what extent do educational professionals in Northeast Tennessee perceive a need for STEM instruction?

3. To what extent do educational professionals in Northeast Tennessee say they implement STEM?

4. To what extent do educational professionals in Northeast Tennessee perceive they have adequate resources available to implement STEM education across the curriculum?

5. To what extent do educational professionals perceive the current condition of STEM in Northeast Tennessee is meeting the needs of 21st century learners?

**Significance of the Study**

Understanding current perceptions of STEM instruction in Kindergarten through eighth grade classrooms is essential for planning for support for our region. As we continue to build understandings of STEM best practices for teaching and learning, we can develop an action plan for success. With the identification of the ETSU Northeast Tennessee STEM Hub located in Johnson City, Tennessee a system for support has been established. The Innovation Academy of Northeast Tennessee was established with the purpose of providing Northeast Tennessee with current STEM best practices along with 21st first century skills (TSIN, 2012). To best implement STEM instruction beyond the identified STEM school in Northeast Tennessee, our region must understand our current application and needs for implementation.

The study of current perceptions of educational professionals in Northeast Tennessee on the integration of STEM education will support schools and school districts in the
implementation process. As the educational realm focuses more heavily on STEM instruction, it is essential that knowledge acquired through the study will be applicable to schools in Northeast Tennessee as our region continues to offer support for schools and school districts in the implementation process. This information will also aid schools and school districts in guiding students toward STEM related careers as well as college and career readiness for societal success.

**Limitations**

This study of current perceptions of educational professionals in Northeast Tennessee on the integration of STEM education is conducted through the use of a survey. Due to the voluntary nature of the survey instrument, the return rate is less predictable. Also, with surveying only Northeast Tennessee educational professionals, the sample size is slightly restricted and may not be generalizable to other populations. The limitations of my study are clarified below:

1. Due to a voluntary survey completion, the resulting return rate is impacted.
2. Due to the dissemination of surveys through district superintendents and administrators, the resulting return rate is impacted.
3. Due to a specific geographical region, the results may not be generalizable beyond the specified sampled population.
Delimitations

Due to the specified group of teachers and administrators completing the survey, a delimitation of this narrow group was identified. The use of multiple choice survey questions limits the answer options for the identified population.

1. A specified group of Northeast, Tennessee educational professionals consisting of teachers and administrators was surveyed.
2. A survey consisting of multiple choice questions was used for manageability.

Definition of Terms

To guide the reader in understanding necessary terms within this dissertation, I selected to further clarify the meaning of the following vocabulary. These key terms are necessary for full comprehension of the implications of this report.

Engineering: “a systematic and often iterative approach to designing objects, processes, and systems to meet human wants and needs” (National Research Council, 2012).

Nation at Risk Report: “Described the United States as a society that no longer dominated the international economy and an education system confused by its purpose” (Manzo, 2000, p.130).

PISA: Programme for International Student Assessment (PISA), tests 15 year old students in the real-world application of literacy in math, reading, and science (2012)

Professional Learning Community: “Educators committed to working collaboratively in ongoing process of collective injury and action research to achieve better results for the students they serve (DuFour, DuFour, Eaker, & Many, 2006, p. 217).

STEM: “STEM education is an area of study but it is also a way of teaching and learning that is project-based, collaborative, and focused on solving real-world problems. STEM programs educate the whole student, emphasizing innovation, problem solving, critical thinking, and creativity” (TSIN, 2012, What is STEM paragraph, paragraph 8).

Technology: “Technology results when engineers apply their understanding of the natural world and of human behavior to design ways to satisfy human needs and wants” (National Research Council, 2011, p. 12).

TIMMS: Trends in International Math and Science Study (TIMMS). This assessment tested fourth and eighth graders around the world in the areas of Math and Science (2012).

Twenty-first century skills: “Advocates of 21st Century skills favor student-centered methods for example, problem-based learning and project-based learning – that allow students to collaborate, work on authentic problems, and engage with the community” (Rotherham & Willingham, 2009, p.2).

Overview of the Study

This research study is organized into five chapters. Chapter 1 presents an introduction to the study of the perceptions of STEM education of Northeast Tennessee Educational Professionals. It also provides the statement of the problem, five research questions, significance
of the study, definitions of terms, delimitations and limitations, and an overview of the study. Chapter 2 provides a review of relevant literature and research on the topic of STEM education and the implementation of STEM in the school setting. Chapter 3 provides the description of the study, research questions and null hypotheses, research design, population, data collection procedures, instrumentation, and data analysis. Chapter 4 provides an analysis of data. Chapter 5 presents a summary, conclusion, and recommendations for practice and research.
CHAPTER 2

LITERATURE REVIEW

Science, Technology, Engineering, and Mathematics (STEM) education is a topic of great interest in 21st Century education. “STEM education is an area of study but it is also a way of teaching and learning that is project-based, collaborative, and focused on solving real-world problems. STEM programs educate the whole student, emphasizing innovation, problem solving, critical thinking, and creativity” (Tennessee STEM Innovation Network, 2012, What is STEM paragraph 8). The national focus on ensuring the United States maintains a competitive position in the global economy has brought forward a priority for the educational system to provide opportunities for integrated studies incorporating the areas of STEM. A demand for a new approach to the instruction of science concepts has been expressed. The National Research Council stated that “by the end of 12th grade, students should have sufficient knowledge of science and engineering to engage in public discussions on science-related issues, to be critical consumers of science education related to their everyday lives, and to be able to continue to learn about science throughout their lives” (Committee on Conceptual Framework for the New K-12 Science Education Standards, National Research Council, 2012, p. 1). The National Research Council developed the goals of increased number of students in STEM related fields, expansion of the STEM workforce, and increased science literacy to meet the current demands (2012).

The goal of STEM education is to provide students with skills necessary for success in today’s workforce. These skills are defined as: real-world problem solving, inquiry, and creative and critical thinking. Society demands these skills to maintain competitiveness in the global economy. Through STEM, students are taught through constructivist methods aimed to build
content understandings and application of knowledge (Lantz, 2009). “Critical thinking skills, skills in collaboration, and skills for working in groups are not only work skills; they are, as they have always been, essential citizenship skills as well” (Schlechty, 2009, p. 15).

*History of Global Competition and Education*

A national focus on preparing students for global competitiveness began as early as 1940 with an emphasis on developing standards for ensuring military and technological preparedness. As a result, increased importance of science and mathematical content was brought to the forefront of education. The 1957 launch of the Sputnik I by the Soviet Union produced additional concern for the United States’s educational system and the current mathematical and science standards. The United States responded to Sputnik with the National Defense Education Act (NDEA) of 1958 that provided $887 million dollars toward math, science, and foreign studies and research over a 4-year time period (Armstrong, 2006). “NDEA was passed because of the perceived connection between education and efforts to counter the Soviets” (Zhao, 2010, p. 31). With the fear of losing global competitiveness, the United States revised science and mathematical standards with the goal of integrating scientific principles through constructive learning. Studies of science and mathematics moved to the forefront (Armstrong, 2006) with the expectation for students to apply their knowledge in meaningful ways. As we moved into the 21st century, our nation was again portrayed as behind in science and mathematical performance (Manzo, 2000). In 1969 the National Assessment of Educational Progress (NAEP), also known as the “Nation’s Report Card,” was developed to measure United States’s science, mathematics, and reading achievement (Armstrong, 2006). The *A Nation at Risk* report produced in April of ...
1983 by the National Commission on Excellence in Education was viewed by many as political propaganda. This document showcased that 35 states required only 1 year of mathematics courses in high school in 1980 (Editors, 2008). It also portrayed our Nation “ . . . as a society that no longer dominated the international economy and an education system confused by its purpose” (Manzo, 2000, p. 130). Schlechty presented the idea that the authors of the A Nation at Risk report focused on the lowering of standards among schools. As a result of this political view of our educational system, a focus on national academic standards with a common curriculum was established (Armstrong, 2006). The following recommendations made by the National Commission on Excellence in Education were presented:

1. Five “new basics” of high school curriculum: four years of English, three years each of math, science, and social studies; and a semester of computer science. In addition, the commission recommended two years of foreign language for the college-bound.

2. Higher expectations for academic performance: rigorous and measurable standards and heightened admissions requirements at postsecondary institutions

3. More time for learning: better use of the school day, lengthened school days, or a longer school day.

4. Better teachers and teaching: better preparation of teachers, and more recognition and rewards for teaching as a profession.

5. Government intervention (leadership) and accountability . . . (Zhao, 2010, p. 33).

In 1990 President Bush along with the nation’s governors developed objectives for improvement that focused on raising high school graduation rates, ensuring content area competency, and
overall making the United States number one in science and math by the year 2000 (Armstrong, 2006, p. 6).

The Goals 2000 law signed by President Clinton in 1994, put into action the creation of national standards aimed to ensure academic achievement. Soon after the Improving America’s School’s Act focused on the development of performance standards, assessment development, and benchmark for measuring progress (Armstrong, 2006, p. 7).

A focus on academic achievement was established with clear criteria for measurement for results through the development of the No Child Left Behind Act (NCLB) of 2001. NCLB established annual testing in reading and math with the expectation of meeting Adequate Yearly Progress each year with the goal of 100% proficiency by 2014 (Armstrong, 2006). Schlechty stated, “the No Child Left Behind legislation is, in fact, simply a culmination of noninvolvement to a position where the U.S. Department of Education is viewed as one of the most influential policy agencies in the nation, surpassed only by the U.S. Congress” (2009, p. 147). Yong Zhao (2010) expresses a concern over the regulations found within NCLB. Within an increased focus on student achievement, he states that increased testing focused instruction is occurring. Within NCLB, a good education is defined by levels of proficiency on assessments. The American Competitiveness Initiative Act (ACI) of 2006 proposed by President Bush emphasized the need for America to encourage children to take rigorous math and science courses to support national competition. In the State of the Union Address, President Bush stated, “If we ensure that America’s children succeed in life, they will ensure that America succeeds in the world” (as cited in Zhao, 2010, p. 14).
Global Comparison

Attention to national standards and international benchmarking is becoming more prevalent (Zhao, 2010). As our nation continues to move into the 21\textsuperscript{st} century, the perception of a subpar educational ranking still exists. According to the 2009 Programme for International Student Assessment (PISA, 2012), testing 15 year old students in the real-world application of literacy in math, reading, and science, the United States ranked 31\textsuperscript{st} in math, 23\textsuperscript{rd} in science, and 17\textsuperscript{th} in reading out of 71 tested countries. The Trends in International Math and Science Study (TIMMS) yielded similar results. This assessment tested fourth and eighth graders around the world and placed United States fourth grade math students in eleventh place and United States eighth grade math students in ninth place. Science data was fairly similar with United States fourth grade students in eighth place and United States eighth grade students in eleventh place. With each assessment, the United States scored just slightly over the average scale score (2012). The National Assessment of Educational Progress (NAEP) demonstrated equally startling data. This assessment tested fourth and eighth grade students in the areas of math, reading, and science. The United States fourth and eighth graders fell below the scale score in each of the tested areas. Our nation is demonstrating improvement on the NAEP with an increase in average scores from 2004-2008 in the areas of reading and math for ages 9, 13, and 17 (2012).

The National Academies released a report in October of 2005 titled *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* presenting that in South Korea, 38\% of all undergraduates receive their degrees in natural science or engineering. In France, the figure is 47\%, in China, 50\%, and in Singapore, 67\%. In the United States, the corresponding figure is 15\%. The U.S. Department of Labor identified 1.2 million job openings in STEM related fields in 2008 (Change The Equation, 2012).
Furthermore, 31% of Tennessee’s eighth graders scored at or above proficient in science on the Nation’s Report Card. Tennessee ranks 32nd out of 50 states and the District of Columbia in NAEP science results (Nations Report Card, 2012). Of Tennessee High School Seniors 16% are college ready. It is predicted that by 2018 Tennessee will have more than 100,000 STEM jobs (Tennessee STEM Innovation Network, 2012). The Georgetown University Center on Education and the Workforce predicts that 54% of these new jobs will require a postsecondary requirement. However, only 21% of adults in Tennessee actually have a college degree (Tennessee Core, 2013). Tennessee needs qualified workers to fill these roles, but STEM education is about more than just workforce development. It is also about inspiring the next generation of leaders to help solidify Tennessee's future as a leader in the global STEM marketplace. When fully realized, the goal of TSIN is to have an impact on students across the entire state. Whether urban or rural, experienced or inexperienced, every child deserves to have access to a quality STEM education (TSIN, 2012). This is supported by “... technological innovation accounted for almost half of U.S. economic growth over the past 50 years, and almost all of the 30 fastest-growing occupations in the next decade will require at least some background in STEM” (Change The Equation, 2012).

*Education Reform*

The debate over determining a solution for guiding the United States educational system back to global competitiveness continues to exist. Zhao (2010) argued that a paradigm shift is necessary for education reform. “Rather than limiting an examination of what might be with our assumption of superior knowledge, a new, postmodern search for wisdom can reveal possible
futures and enable the development of the requisite variety need for participation in a society that must continually adapt” (Glover, 2013, p. 88). With a search for wisdom, individuals are continual learners.

The Educate to Innovate initiative presented by President Obama declared a need for a focus on the development of problem solving, critical thinking, collaboration and open-ended inquiry skills necessary for preparedness in the 21st century workforce (Dejarnette, 2012). Gates and Mirkin (2012) recommend that active learning, discovery-based research, rigorous mathematics instruction is needed to prepare student. Today’s technologically driven workforce demands that individuals be able to solve real-world problems through the processes of investigation, model building, data analysis, presentation of evidence-based reasoning, and communication of findings (Moon & Singer, 2012). Glover (2013) described classrooms where the teacher is involved in understanding the interests and thoughts of the students in order to develop engaging learning. A focus on creativity and innovation is necessary for new learning for our nation’s future. “Engaging students in work that results in their need to learn material that is essential to their education as citizens in a democracy and to their right to claim to be well-educated human beings is the primary business of schools” (Schlechty, 2011, p. 8).

21st Century Skills

21st Century skills are core components of STEM education. These processes support students in the level of knowledge application necessary for success in STEM related fields. “Advocates of 21st Century skills favor student-centered methods -for example, problem-based learning and project-based learning – that allow students to collaborate, work on authentic
problems, and engage with the community” (Rotherham & Willingham, 2009, p. 2). The Partnership for 21st Century Skills described 21st century skills as:

- **Core Subjects** (English, reading or language arts, world language, arts, mathematics, economics, science, geography, history, government, and civics) and 21st century themes (global awareness; financial, economic, business, and entrepreneurial literacy; civic literacy; health literacy)

- **Learning and Innovation Skills** (creativity and innovation skills, critical thinking and problem-solving skills, communication and collaboration skills)

- **Information, Media, and Technology Skills** (information literacy, media literacy, ICT [information and communication literacy] literacy)

- **Life and Career Skills** (flexibility and adaptability, initiative and self-direction, social and cross-cultural skills, productivity and accountability, leadership and responsibility) (Zhao, 2010, p. 134-135).

These twenty-first century skills define a globally competent person who is able to function in an interdependent world, allowing individuals to communicate and respect diverse cultures. The global world breaks down the barrier of distance, allowing for continual interaction within the global community. “We need citizens who can lead global efforts to reduce distrust and fear among different people” (Zhao, 2010, p. 155).

Twenty first century skills require that students are actively engaged in the learning process, constructing their knowledge with the teacher as the facilitator of learning. Glover (2013) stated that the constructivist framework of Pragmatism will guide America into the future. The focus on practice supports the construction of knowledge through experience. “Pragmatists must build on their knowledge by extending and trying to understand personal experience. They
must live questions. They must try to learn” (Glover, 2013, p. 53). Schlechty (2011) defines engagement by the following four components:

1. The engaged student is attentive, in the sense that he or she pays attention to and focuses on the tasks associated with the work being done.
2. The engaged student is committed. He or she voluntarily (that is, without the promise of extrinsic rewards or the threat of negative consequences) deploys scarce resources under his or her control (time, attention, and effort, for example) to support the activity called by the tasks.
3. The engaged student is persistent. He or she sticks with the task even when it presents difficulty
4. The engaged student finds meaning and value in the tasks that make up the work (p. 14).

The teacher is responsible for designing innovative lessons based on student interests and real-world topics and becomes a guide, leading the students to high levels of learning (Schlechty, 2011). A focus on metacognition, real world questions, problem solving, creativity, inquiry, improvement of solutions, and collaboration supports students in their acquisition of knowledge. Inquiry guides students to high levels of learning resulting in a “discipline based” way of thinking (Stephenson, 2012). Benjamin Bloom designed a framework for high levels of learning known as Bloom’s Taxonomy. These learning objectives help to define levels of learning that “. . . goes deep into the cognitive frames students use to organize their world” (Schlechty, 2011, p. 23). The following criteria are used to design learning activities that support application of knowledge:
• Creating – putting together ideas or elements to develop an original idea or engage in creative thinking.

• Evaluating – judging the value of ideas, materials, and methods through the development and application of standards and criteria.

• Analyzing – breaking information down into its component elements.

• Applying – using strategies, concepts, principles, and theories in new situations.

• Understanding – inferring, exemplifying, classifying, and comparing

• Remembering – recalling and recognizing given information (Schlechty, 2011, p. 22).

When students have commitment to their learning, they are more apt to put energy and effort into the learning process. With a search for understanding comes motivation (Brooks & Brooks, 1999). “Rather than viewing schools as teaching platforms, schools must be viewed as learning platforms” (Schlechty, 2011, p. 9). The focus is on providing engaging work that stimulates high levels of understanding and application. When students are able to assume subject matter in meaningful ways, they are better able to apply their knowledge to new situations. Schlechty (2011) designed a framework for designing engaging work:

1. Product focus

2. Content and substance

3. Organization of knowledge

4. Clear and compelling standards

5. Protection from adverse consequences

6. Affiliation

7. Affirmation
8. Novelty and variety
9. Choice
10. Authenticity

This is the type of learning necessary to contribute to society (Schlechty, 2009, p. 51). “What is needed are schools that are organized to liberate minds and inspire performance rather than organizations that are designed to ensure compliance with little attention to meaning and value” (Schlechty, 2009, p. 112). Glover (2013) supported this thinking when he described learning that supports diversity. Through his framework focused on “Development Empowerment,” the learner is viewed “as an agent who develops responsibility . . . “(Glover, 2013, p. 7).

_Future Ready Tennessee_

With the receipt of Race to the Top 14.7 million in funds in Tennessee, a plan for STEM implementation was developed (TSIN, 2012). A collaboration with the Tennessee Department of Education and Battelle Memorial Institute was developed to focus on instructional practices and student learning in STEM across Tennessee. The Tennessee STEM Innovation Network was then developed as the driving force for this work. “Tennessee students will lead the nation in STEM knowledge, skills, and practices as critical and creative thinkers, problem solvers, innovators, and collaborators to compete and succeed in the state’s emerging innovation economy” serves as the vision statement for this work (TSIN, 2012, p. 4). This Network is designed to:

- Generate and share new knowledge of what works in STEM education
- Promote clearly articulated indicators of quality
• Develop quality STEM tools with partners
• Offer interactive, on-going access to tools, exemplars and partners through an on-line presence
• Connect state STEM partners to innovative policies and practices across the country (TSIN, 2012, p. 15)

The Theory of Change for STEM in Tennessee focuses on the coordination of STEM policies and practices to positively impact student achievement, ultimately developing more highly skilled students (TSIN, 2012). With the identification of six STEM Platform Schools and six Regional STEM Innovation Hubs, the state of Tennessee will have a connected support system for the focused implementation of STEM education. Four implementation goals were developed to support successful STEM education:

Goal #1: Increase student interest, participation and achievement in STEM - places greatest priority on Tennessee’s STEM learners.

1.1. Establish Regional STEM Innovation Hubs.

1.2. Launch STEM Platform Schools.

1.3. Expand Student Access to Rigorous and Advanced STEM Courses.

1.4. Identify, Develop and Share STEM Curriculum Tools.

Goal #2: Expand student access to effective STEM teachers and leaders - recognizes that educators have the greatest impact on student achievement.
2.2 Replicate Proven Models and Disseminate Characteristics of Effective STEM Teacher Training Programs.

2.3 Use STEM Schools as Learning Labs.

2.4 Boost STEM Teacher Supply.

2.5 Enhance STEM Teacher Capacity and Reach.

2.6 Increase and Disseminate Quality STEM Professional Development.

Goal #3: Reduce the state's STEM talent and skills gap - acknowledges the imminent STEM talent and skills gap that the state of Tennessee will face by 2018.

3.1 Increase Accelerated STEM Learning Opportunities.

3.2 Continue to Develop Meaningful Partnerships between Business and Education

3.3 Dramatically Increase STEM Postsecondary Degree Production.

Goal #4: Build community awareness and support for STEM - is aimed squarely at building a base of diverse partners and supporters to communicate the rising importance of STEM education in workforce development and job creation to all Tennesseans, beginning at the grassroots level and working up.

4.1 Build Communication Tools, Develop Messages and Identify Delivery Channels.

4.2 Conduct Media Outreach.

4.3 Identify and Showcase Exciting STEM Public Events.

Northeast Tennessee STEM Innovation Hub

The Northeast TN region has a STEM Innovation Hub and STEM platform school designed to support implementation of the previously mentioned four goals and multiple supporting strategies. The following school districts are supported by this Innovation Hub: Bristol, Carter, Cocke, Greene, Greeneville City, Hamblen, Hawkins, Johnson, Johnson City, Kingsport, Sullivan, Unicoi, and Washington. The STEM Hub provides professional learning, curriculum support, activities, business partnerships, and resources to support science, technology, engineering, and math skills. The Vision of the Northeast TN STEM Innovation Hub “is to design and incubate STEM educational models of excellence, while leveraging partnerships in alignment with economic development, to empower all students to excel in a rapidly changing world” (http://www.netstemhub.com/hub-goals-and-activities). The Mission of the ETSU Northeast Tennessee STEM Innovation Hub will interconnect K-12 Schools, higher education institutions, businesses, foundations/non-profits, and community organizations to design, develop, and demonstrate innovative, sustainable and transferable STEM learning experiences. These STEM collaborations seek to engage students, develop a skilled work force, and increase STEM literacy throughout the region.

Goals:

The ETSU STEM Hub goals are to:

1. Assist in the design, launch, and sustainment of the Kingsport/Sullivan County Platform School

2. Amplify and accelerate the reach and impact of the STEM Platform School’s best practices, including people, tools, and networks
3. Document effects of new learning experiences on short-term and long-term student learning, student motivation, and college and career trajectories and performance, with the intent to publish new findings in the education literature

4. Enhance communication of STEM education in the region by publication of quarterly electronic newsletter

5. Coordinate and support efforts to seek funding from federal and private foundations to support STEM education models that prepare students for college and career

6. Strengthen instructional practices in K-12 STEM Hub Classrooms through professional development for teachers and administrators in inquiry

7. Provide a communication network to enhance sharing of expertise and strengthening existing collaboration while building new partnerships

8. Connect regional STEM assets with the TSIN and with regional and statewide STEM initiatives (http://www.netstemhub.com/hub-goals-and-activities).

**Approaches to STEM Education**

The 2011 *National STEM report* concludes, “... the nation’s education system is not producing enough STEM-capable students to keep up with demand both in traditional STEM occupations and other sectors across the economy that demand similar competencies” (TSIN, 2012, p. 6). Microsoft developed the *Change the Equation report* to influence changes in STEM education in hopes of motivating youth toward pursuing STEM related careers. The report outlines the following components of STEM education:

- High School Diploma + Postsecondary Credential
The report also outlines the following principles for successful STEM implementation:

1. “Support adoption and implementation of Common Core Math Standards and Next Generation Science Standards (or standards as rigorous).
2. Urge all states to use a common high cut score to pass state assessments aligned to Common Core Math Standards and Next Generation Science Standards.
3. Weight science equally with other subjects in state accountability systems.
4. Recognize that standards, assessments and accountability are necessary but not sufficient.
5. Align curriculum, learning resources, technology, teaching, and management to help all students meet or exceed the standards.
6. Use data and research, including CTEq’s State Vital Signs, to inform STEM policy development and implementation.
7. STEM teachers must be properly prepared, evaluated and compensated. Recruitment and retention of high-performing students to the STEM teaching profession is critical.
8. Incentivize effective STEM teachers to teach in high poverty, high minority schools.


The National Research Council is focused on educating the public on STEM careers and expanding the STEM workforce (Committee on Highly Successful Schools or Programs in K-12 STEM Education, National Research Council, 2011, p.11).

Research on approaches to STEM education has focused on the outcome of STEM education, types of available STEM schooling, and instructional school level practices. Effective STEM education has a clearly defined curriculum aimed to deepen STEM learning, greater amounts of instructional time devoted to STEM learning, adequate resources for instruction, and teacher preparedness. A positive school culture for learning and strong leadership that drives change characterize effective STEM schools (National Research Council, 2011).

Outcome

The National Research Council concludes that it is difficult to determine success of STEM education due to the lack of current research on this topic and the difficulty to measure success. Achievement measures demonstrate academic growth, but this is only a portion of STEM goals.

Although it is difficult to measure interest and motivation (‘joy at the prospect of discovery’), creativity (‘a culture of innovation’), or commitment to ‘ethical behavior and the shared interests of humanity’, it is essential to do so given the importance of preparing students to be leaders in STEM innovation – and not just good test takers (National Research Council, 2011, p. 13).
Types of Schooling

The National Research Council (2011) has identified four types of STEM education: Selective STEM schools, Inclusive STEM schools, Career and Technical Education schools (CTE), and STEM in Comprehensive schools. Selective STEM schools invite highly talented and motivated students to attend and are organized around STEM disciplines. They are characterized by expert teachers, sophisticated lab equipment, and apprenticeships. This school setting has proven to have a great impact on students choosing STEM careers. The Inclusive STEM setting is organized around STEM disciplines but does not have selection criteria for participation. Research has found increased achievement in science and math assessments, less absenteeism, and greater impact on students taking more advanced courses. The CTE option for STEM education is aimed at providing students exposure to STEM careers through practical applications. The goal is to prepare students for STEM related careers through increased engagement to reduce the high school dropout rate. STEM instruction in the Comprehension School setting is based upon increased achievement in all disciplines through an integrated instructional approach. It has been found to prepare next generation scientists, increase participation in the STEM workforce, and increase science literacy (National Research Council, 2011).

Integrated Curriculum

STEM education is no longer viewed as the instruction of STEM subjects in isolation, yet the subjects of science, technology, engineering, and math are integrated with a focus on real world problem solving (Saunders, 2009). Morrison defines STEM as a meta-disciplinary
approach defined as “the creation of a discipline based on the integration of other disciplinary knowledge into a new ‘whole’” (as cited in Lantz, 2009, p. 1). Curricular Integration focuses on multidisciplinary teams of teachers organizing instructional materials and strategies to support students with making meaning across content areas (California Center for College and Career, 2010, p. 2). Figure 1 represents STEM curriculum integration.

*Figure 1. STEM Curriculum Integration (Adapted From California Center for College and Career, 2010, p. 2)*

Research has shown a significant impact on student engagement when instruction is interconnected and meaningful (California Center for College and Career, 2010). The integration of STEM subjects is standards driven and is focused on application of knowledge through performance-based learning and assessment. Figure 2 represents a tool for standards based curriculum and performance mapping to support planning for STEM instruction.
Figure 2. Standards Based Curriculum and Performance Mapping (Adapted From the California Center for College and Career, 2010, p. 7)

STEM units are defined by the following criteria: project-based, real-world problem solving, science inquiry, self-directed inquiry. As a result, STEM students are described as: problem-solving, innovators, inventors, self-reliant, logical thinkers, and technologically literate (Lantz, 2009).

Instructional and School Level Practices

Professional Learning

Increased levels of professional learning are necessary for highly effective instruction. STEM instructors need strong content knowledge in STEM disciplines, increased instructional
time in science and math content areas, and available STEM resources of labs, supplies, and resources. To achieve highly effective instruction, our nation must ensure that teachers are equipped with strategies to meet the needs of all learners (Darling-Hammond, Chung Wei, Andree, Richardson, & Orphanos, 2009).

The National Staff Development Council stated, "The term ‘professional development’ means a comprehensive, sustained, and intensive approach to improving teachers’ and principals’ effectiveness in raising student achievement . . .” (Learning Forward, 2012, par. 1). Research demonstrates that effective professional development is related to student-achievement gains. Professional learning should be intensive, on-going, and connected to practice. It should be focused on student learning and address the teaching of specific curriculum content as well as align with school improvement priorities and goals. Building strong working relationships among teachers guides the learning process (Darling-Hammond, 2009). “Rather than seeing schools as teaching platforms, schools must be viewed as learning platforms . . . Rather than defining teachers as instructors, teachers must be defined as designers, leaders, and guides to instruction” (Schlechty, 2011, p. 9-10).

School Culture

Research has found that highly effective STEM schools are defined by their positive school culture for learning. The roles of professional capacity, community ties, instructional guidance, and student centered approach were identified (National Research Council, 2011). Schmoker described the known elements of effective schools as “. . . common curriculum, sound lessons, and authentic literacy” (2011, p. 9). Through collaborative conversations, teams of
teachers can work together to plan high-quality instruction and formative assessments that meet the rigorous curriculum demands in all content areas. DuFour, DuFour, Eaker, and Many (2006) described a Professional Learning Community (PLC) as a collaborative group of individuals focused on student learning. “Educators committed to working collaboratively in ongoing process of collective injury and action research to achieve better results for the students they serve” (DuFour et al., 2006, p. 217).

PLCs are driven by the following four critical questions: What is it we expect students to learn? How will we know when they have learned it? How will we respond when they don't learn? How will we respond when they already know it?

Through the sharing of knowledge teachers build capacity and organizational coherence. These core areas support collaborative teams in maintaining their focus on planning for meaningful and engaging instructional activities that meet the needs of all learners.

Conversations regarding the development of common rubrics and proficiency samples to measure mastery of the identified standards ensure learning for all students (Wiggins & McTighe, 2007). Data conferencing serves as a key component for measuring success. “The job is to ensure that learning occurs, and when it doesn’t, to intervene decisively, quickly, and often” (Wiggins & McTighe, 2007, p.140). Routine data analysis guides collaborative teams in understanding curriculum standards and measuring students’ progress toward meeting them. Data conferencing is critical for understanding the current level of achievement to plan for improvement. Through data conferencing, teams work together to analyze their data to plan for student learning. Discussions revolve around examples of student proficiency based upon developed benchmarks, work samples, and anchor papers (DuFour et al., 2006). “By regularly . . . examin[ing] student work, teachers properly focus on the broader goals and mission-related
aims (understanding, transfer, habits of mind) and avoid fixating on standardized test scores alone” (Wiggins & McTighe, 2007, p. 163).

**Effective Leadership**

“. . . strong school leaders who understand the “STEM approach” and fully use it to transform the delivery of education” (TSIN, 2012, p. 3) are necessary for successful STEM reform. To ensure that all students are prepared for success in the work force or college, instructional leaders must serve as visionaries who work alongside other stakeholders, motivating and inspiring each individual toward continual reflection of instructional practices. Instructional leaders develop an organization of learners that function as a unified front focused on the common goal of student achievement. “When members of an organization understand the purpose of the organization, know where it is headed, and then pledge to act in certain ways to move in the right direction . . . commitments and covenant” are developed (DuFour et al., 2006, p. 25).

Effective leaders are trusted by all stakeholders and continually seek their input. Through open questioning and reflective thinking, new learning can occur. Dialogue is the driving force for the development of new understandings. Open dialogue is described as deep listening in which the participants aim to understand others’ views. Respect for others’ thoughts is necessary. The suspension of assumptions follows with the opportunity for all participants to *voice* their own thinking. When this process is used, participant’s views are expressed with a goal of the development of new meaning (Glover, 2013). “That is why systemic change – change that is simultaneously top down and bottom up and touches all the interconnected parts of the
organization – is essential” (Schlechty, 2011, p. 127). Educators must all be contributing leaders in the quest to design the future (Glover, 2013).

A culture of continual learning for all stakeholders will result in improved instructional practices and positive gains in student learning. The ability to adapt and change is necessary for growth (Glover, 2013). “Communities are organized around relationships and ideas. They create structures that bond people together in an oneness and that bond them together to a set of shared values and ideas” (Sergiovanni, 2009, p. 97). Through the development of trusting relationships, individuals feel valued and respected. When people understand how their work impacts the entire system, they are more passionate, committed, and connected (Fullan, 2008).

A culture that supports learning is necessary to make the educational shifts required to support STEM education and develop the 21st century skills necessary for success in the global economy. “True leaders are teachers. True teachers are learners. True learners are leaders” (Glover, 2013, p. 111). Effective implementation of STEM education is based upon teacher content knowledge and resource availability, professional learning, supportive school culture, and effective school leadership (National Research Council, 2011).

**Curriculum: National Standards**

Today’s educators are faced with the challenge of preparing students for college and career readiness (CCR) in the 21st Century. The Common Core State Standards were developed as a roadmap for ensuring that each student is able to meet the rigorous demands of College and Career Readiness. They are designed to replace the “mile wide and inch deep”
curriculum that previously existed (Zhao, 2010, p. 59). “Although the standards describe what students are expected to understand and be able to do at each grade level. They are not a curriculum; that is, they are not organized and sequenced for instruction” (Briars, Asturias, Foster, & Gale, 2012, p. 116). The standards were developed as a first step in providing students with a high-quality education to prepare them for success in college and the workforce.

The Common Core State Standards were designed by a diverse group of teachers, experts, parents, and school administrators, so they reflect both aspirations for children and the realities of the classroom. The standards are benchmarked to international standards to guarantee that our students are competitive in the emerging global marketplace (corestandards.org, 2010). “Simply put, ‘college and career readiness’ is the umbrella under which many education and workforce policies, programs and initiatives thrive” (achieve.org, 2012, par. 4).

**National Mathematics Standards: Common Core.** The Common Core State Standards were designed to ensure students are college and work force prepared when they leave the K-12 educational system. They are internationally vested to ensure preparation for college and career. The standards are based upon a clear definition of expectations for success. The National standards for instruction in math and English language arts have been adopted by 46 States (achieve.org, 2012). The following criteria served as the basis for the Common Core National Standards:

- Are aligned with college and work expectations;
- Are clear, understandable, and consistent;
• Include rigorous content and application of knowledge through high-order skills;

• Build upon strengths and lessons of current state standards;

• Are informed by other top performing countries, so that all students are prepared to succeed in our global economy and society; and

• Are evidence-based (corestandards.org, 2010).

Common Core Mathematical standards are built upon process and proficiency skills for student success. Process skills defined by the National Council of Teachers of Mathematics (NCTM) are: problem solving, reasoning and proof, communication, representations, and connections. Proficiency skills defined by the National Research Council are: adaptive reasoning, strategic computing, conceptual understanding, and procedural fluency (corestandards.org, 2010). The Common Core Mathematical processes were developed to incorporate both process and proficiency skills:

1. Make sense of problems and persevere in solving them.

2. Reason abstractly and quantitatively.

3. Construct viable arguments and critique the reasoning of others.

4. Model with mathematics.

5. Use appropriate tools strategically.

6. Attend to precision.

7. Look for and make use of structure.

8. Look for and express regularity in repeated reasoning (corestandards.org).
Figure 3 demonstrates the interconnectedness of the Common Core mathematical process and proficiencies as they relate to student learning to student learning.

<table>
<thead>
<tr>
<th>Overarching Habits of Mind</th>
<th>Reasoning and Explaining</th>
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</thead>
<tbody>
<tr>
<td>1. Make sense of problems, and persevere in solving them.</td>
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<tr>
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<td>3. Construct viable arguments and critique the reasoning of others.</td>
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<tr>
<td><strong>Modeling and Using Tools</strong></td>
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<tr>
<td>4. Model with mathematics.</td>
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<td>5. Use appropriate tools strategically.</td>
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<tr>
<td><strong>Seeing Structure and Generalizing</strong></td>
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<tr>
<td>7. Look for and make use of structure.</td>
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</table>

*Figure 3. Adapted From Common Core Mathematical Practices (Briars, Asturias, Foster, & Gale, 2012, p. 32)*

The K-5 standards build a foundational support for mathematics concepts with a shift from procedural knowledge to a conceptual understanding. The middle school standards build upon the K-15 standards with a focus on preparing eighth graders for Algebra and high level mathematics. The high school standards are designed to build upon the foundational skills and apply them in real world ways. The standards promote student engagement in problem solving, learning connected to prior knowledge, questioning and justification of thinking, evaluation and explanation of work, multiple representations of thinking and procedures, continual review of learned concepts (Briars, Asturias, Foster, & Gale, 2012). The goal of the Mathematics
Common Core Standards is to build a strong mathematical foundation so that students are able to apply their knowledge in meaningful ways (corestandards.org, 2010).

National Common Core English Language Arts for Content Areas of Science and Social Studies were designed to support the integration of literacy skills (corestandards.org, 2010). As a greater focus upon the integration of arts, reading, and writing into STEM is established, otherwise known as STREAM (Science, Technology, Reading, Engineering, Arts, and Math), standards for this work as necessary. “Moreover, since words are our primary means of public expression, anyone who has not mastered their creative use is simply under-prepared for communicating in any discipline, including the STEM subjects” (Bernstein, 2011, 1). Common Core Standards for English language arts in the Content areas support the implementation of critical thinking in reading, writing, speaking, and listening (corestandards.org). Today’s learners should be able to identify important facts and information found within media. The use of high quality texts support critical thinking and supports students with evidence-based reasoning (www.corestandards.org) These skills are used to support 21st century learners in the acquisition and communication of content specific knowledge (corestandards.org). “When writing is incorporated in learning and assessment, there is increased opportunity to produce the ideal situation for active, attentive learning with collaboration, revision, and metacognition through personalization, and creativity” (Willis, 2011, p.17).

National Science Standards. An identified focus on science standards has been expressed to meet the demands of the technologically driven workforce. The National Academy of Sciences stated its goal of students appreciating science, possessing strong content knowledge,
expressing knowledge in meaningful ways, continued learning in real-world contexts, and the pursuit of science related fields of study and occupation with a goal of improving students understanding of science. These recommendations are designed to address the challenge the United States is facing in regard to global competitiveness (National Research Council, 2012). The committee determined that fewer standards taught in greater depth would support greater levels of inquiry and knowledge application. Science standards are based upon:

- **Scientific and engineering practices:**
  - Asking questions
  - Developing and using models
  - Planning and carrying out investigations
  - Analyzing and interpreting data
  - Using mathematics and computational thinking
  - Constructing explanations (for science) and designing solution (for engineering)
  - Engaging in argument from evidence
  - Obtaining, evaluation, and communicating information

- **Crosscutting concepts that unify the study of science and engineering through their common application across fields**
  - Patterns
  - Cause and Effect: Mechanism and explanation
  - Scale, proportion, and quantity
  - Systems and system models
  - Energy and matter: Flows, cycles, and conservation
- Structure and function
- Stability and change

- Core ideas in four disciplinary areas: physical sciences; life sciences; earth and space sciences; and engineering, technology, and application of sciences
  - Physical Sciences
  - Life Sciences
  - Earth and Space Sciences

These core dimensions are designed to support increased scientific knowledge through the alignment of curriculum, assessments, and professional learning. The goal of a newly designed focus on scientific instruction will guide students in their understanding of scientific core ideas and the world around them. The Next Generation Science Standards will identify content and science and engineering practices that all students should learn from kindergarten to high school graduation (achieve.org, 2012).

"College and career readiness" is the umbrella under which many education and workforce policies, programs, and initiatives thrive. From high-quality early education and strong, foundational standards in elementary school to rigorous career and technical education programs and college completion goals, college and career readiness is the unifying agenda across the P-20 education pipeline (achieve.org, 2012).
Conclusion

“All who work in around the school would view their primary task as helping to ensure that each day, each student is provided tasks that are engaging and designed in ways that result in profound learning of those things parents and communities believe are important for students to learn” (Schlechty, 2009, p.118). The search for knowledge in 21st century education is based upon the application of knowledge in real-world situations. Effectiveness in our society requires individuals to have: strong content knowledge, the ability to analyze and synthesize information, the ability to collaborate and respect others’ thinking, the ability to use technology effectively, the ability to effectively communicate, and the ability to take ownership of their learning.

Students must be able to apply their knowledge in meaningful ways (Stephenson, 2012). A project-based learning environment supports students in the acquisition and life-long application of knowledge (Rotherham & Willingham, 2009). It is our duty to “help every citizen develop the skills, attitudes, and habits of mind necessary” to be productive in today’s society (Schlechty, 2009, p. 120).

Effective leadership that motivates individuals to be reflective practitioners for continual improvement guides schools toward necessary change. The creation of a positive school culture supporting relationship development and collaboration promotes learning for all stakeholders. Continual professional learning and growth is the foundation for positively impacting student learning (DuFour et al., 2006).

The expectation for students to have strong content knowledge, be active participants in their learning through constructivist environments, real-world problem solvers, collaborative, and communicators of knowledge have been clarified (Lantz, 2009). STEM education provides the platform for developing learning opportunities to support students in engaging activities
incorporating the areas of science, technology, engineering, and mathematics (Schlechty, 2011). With a strong educational foundation, an increased application of STEM knowledge and pursuit of STEM related careers, the United States is preparing itself for success in the global society (TSIN, 2012).
CHAPTER 3

RESEARCH METHODOLOGY

Description of the Study

STEM education is a topic of great interest in 21st Century education. The national focus on ensuring the United States maintains a competitive position in the global economy has brought forward a priority for the educational system to provide opportunities for integrated studies incorporating the areas of science, technology, engineering, and mathematics (STEM). The goal of STEM educators is to provide students with skills necessary for success in today’s workforce: real-world problem solving, inquiry, and critical thinking. Students are taught through constructivist methods aimed to build content understandings and application of knowledge. In order for Northeast Tennessee school districts to successfully implement STEM education, they must first understand the state of current perceptions and implementation. Through this quantitative research study, I will provide context into understanding Northeast Tennessee K-8 educators’ perceptions of the implementation of STEM education. Information regarding current perceptions of STEM education will form a context for future planning of STEM related instruction.

Research Questions and Null Hypotheses

The study was guided by the following eight research questions and null hypotheses:

1. How do educational professionals in Northeast Tennessee define STEM?
2. To what extent do educational professionals in Northeast Tennessee perceive a need for STEM instruction?

H0₂₁: Administrators in Northeast Tennessee do not perceive a need for STEM instruction to a significantly positive or negative extent.

H0₂₂: Teachers in Northeast Tennessee do not perceive a need for STEM instruction to a significantly positive or negative extent.

3. To what extent do educational professionals in Northeast Tennessee say they implement STEM education?

H0₃₁: Administrators in Northeast Tennessee do not implement STEM education to a significantly positive or negative extent.

H0₃₂: Teachers in Northeast Tennessee do not implement STEM education to a significantly positive or negative extent.

4. To what extent do educational professionals in Northeast TENNESSEE perceive they have adequate resources available to implement STEM education across the curriculum?

H0₄₁: Administrators in Northeast Tennessee do not have access to professional development available to implement STEM education across the curriculum to a significantly positive or negative extent.

H0₄₂: Teachers in Northeast Tennessee do not have access to adequate access to professional development available to implement STEM education across the curriculum to a significantly positive or negative extent.

H0₄₃: Administrators in Northeast Tennessee do not have access to STEM assets available to implement STEM education across the curriculum to a significantly positive or negative extent.
H044: Teachers in Northeast Tennessee do not have access to adequate access to STEM assets available to implement STEM education across the curriculum to a significantly positive or negative extent.

5. To what extent do educational professionals perceive the current condition of STEM in Northeast Tennessee?

H051: Administrators in Northeast Tennessee do not perceive the current condition of STEM in Northeast Tennessee to a significantly positive or negative extent.

H052: Teachers in Northeast Tennessee do not perceive the current condition of STEM in Northeast Tennessee to a significantly positive or negative extent.

The study was also used to gather demographic data regarding the participants’ current employment status as a teacher or administrator, designation of: elementary school, middle school, or both, years of experience, and level of degree in questions 1-5. The following subgroups were evaluated through the use of a developed survey.

1. Definition of STEM: Question 7 addresses this component.

2. Perceived need for STEM instruction: Questions 6, 8, and 12 address this component.

3. Classroom STEM implementation: Questions 9, 10, 11, 13, 16, 17, and 18 address this component.

4. Access to STEM resources: Questions 13, 14, and 15 address this component.

5. Perception of Northeast Tennessee STEM: Questions 19 and 20 address this component.
Instrumentation

The web-based survey instrument, Survey Monkey, was used as a resource for developing the research tool. The survey was reviewed by a group of Kingsport City Schools Personnel, Dr. Jack Rhoton (ETSU STEM Hub Director), and my dissertation committee for validity. The closed and open form survey consisted of 20 items grouped by five core research questions. A Yes or No response was determined for questions 9 and 12. A Likert scale was used to measure responses with a mean of 2.5 for the categories of Strongly Agree, Agree, Disagree, and Strongly Disagree and the categories of Rarely, Sometimes, Often, and Always. The open-ended question focused on defining STEM was summarized and recorded for frequency. Question 20 rated the top 3 responses and was recorded for frequency. The survey is located in Appendix A.

Population

The participating school districts are located in the Northeast Region of Tennessee. The following school districts were invited to participate in the research: Bristol City Schools, Carter County Schools, Cocke County Schools, Greene County Schools, Elizabethton City Schools, Greeneville City Schools, Hamblen County Schools, Hancock County Schools, Hawkins County Schools, Johnson County Schools, Johnson City Schools, Kingsport City Schools, Sullivan County Schools, Unicoi County Schools, and Washington County Schools. The following districts agreed to participate in the research and disseminated the survey to teachers and administrators within the district: Bristol City Schools, Hamblen County Schools, Johnson City Schools, Johnson County Schools, Kingsport City Schools, Sullivan County Schools, and Washington County Schools. Educational professionals teaching in the elementary and/or middle
school setting were surveyed. Elementary and/or middle school administrators were also
surveyed. Elementary and middle school populations were chosen due to the various formats of
STEM education implementation in these settings as well as their participation in the Northeast
Tennessee STEM Hub. The study was used to gather demographic data regarding the
participants’ current placement, years of experience, level of degree, and school system
employment.

*Data Collection Procedures*

A research proposal was submitted to IRB and approved before beginning the research
process. A permission letter and copy of the research survey was also mailed to the
Superintendent of Schools of Bristol City Schools, Carter County Schools, Cocke County
Schools, Greene County Schools, Elizabethton City Schools, Greeneville City Schools, Hamblen
County Schools, Hancock County Schools, Hawkins County Schools, Johnson County Schools,
Johnson City Schools, Kingsport City Schools, Sullivan County Schools, Unicoi County
Schools, and Washington County Schools requesting permission to access elementary and
middle school teachers’ and administrators’ perceptions of STEM education. A copy of the letter
is located in Appendix B. Upon receipt of IRB and school system approval, the developed survey
was distributed through Survey Monkey to district superintendents and administrators to
disseminate to elementary and secondary educational professionals in the identified school
systems for voluntary completion. The survey was anonymously completed to maintain
confidentiality. An estimated completion time of 15 minutes was established. A survey window
of 2 weeks was determined.
Data Analysis

A quantitative nonexperimental survey study was used to provide the most in-depth understanding of perception of STEM education in Northeast Tennessee. A series of single sample t tests was used to answer research questions 2, 3, 4, and 5. Single sample t tests were used to determine statistical significance comparing the means with 2.5, representing neutrality for research questions 2, 3, 4, and 5. Data were analyzed at the .05 level of significance. The Statistical Package for the Social Sciences (SPSS) was used for data analysis. Survey Monkey calculated data was used for summarizing data. Descriptive statistics were also used to summarize additional insight into questions 1, 2, 3, 4, and 5. Patterns and perceptions identified through the open-ended and ranking questions were recorded for frequency.

For research question 1, the researcher compared teacher and administrator definitions to the previously determined STEM definition of, “STEM education is an area of study but it is also a way of teaching and learning that is project-based, collaborative, and focused on solving real-world problems. STEM programs educate the whole student, emphasizing innovation, problem solving, critical thinking, and creativity” (Tennessee STEM Innovation Network, 2012, What is STEM paragraph, paragraph 8). The most frequently occurring terms were recorded for frequency and ranked in order of occurrence.

Research Design

A quantitative nonexperimental survey study was developed to investigate Northeast Tennessee Elementary and Middle School teachers’ and administrators’ perceptions of STEM education. A web-based survey provided the quantitative perception of Northeast Tennesse
educational professionals along with one open-ended question to support an understanding of individual perceptions. This study was an examination of current perceptions of STEM education. Perceived need, current implementation practices, access to STEM resources, definition of STEM, and current condition of STEM in Northeast Tennessee were also examined.
CHAPTER 4

DATA ANALYSIS

The purpose of this quantitative nonexperimental research study was to provide context into understanding Northeast Tennessee K-8 educators’ perceptions of the implementation of STEM education. Information regarding current perceptions of STEM education will form a context for future planning of STEM related instruction. Survey data were acquired through the use of a survey and disseminated to participating school districts through Survey Monkey. The data were then analyzed through the Survey Monkey data analysis program and the Statistical Package for the Social Sciences (SPSS).

Demographic Data

Data were collected on teachers and administrators within the following school districts: Bristol City, Hamblen County, Johnson City, Johnson County, Kingsport City, Sullivan County, and Washington County School Districts. The survey was administered between the dates of May 6, 2013 - May 24, 2013.

The survey requested the following demographic information of all participants: Educational setting, years of experience, and highest level of advanced degree held. Descriptive statistics were used to summarize the following data. Eighteen administrators participated in the study. Of those, 17.65% worked at the elementary level, 23.53% worked at the middle school level, and 58.82 worked at a combined elementary and middle school level. Surveyed administrators shared the following levels of experience within their roles: 47.06% had 0-4 years
experience, 23.53% had 5-10 years experience, and 29.47% had greater than 15 years experience. Surveyed administrators shared the following levels of advanced degrees held: 11.11% hold master’s degrees, 16.67% hold masters + 30 degrees, 44.46% hold educational specialists degrees, and 27.78% hold doctoral degrees.

One hundred fifty-two teachers participated in the study. Of those, 50.34% worked at the elementary level, 44.22% worked at the middle school level, and 5.44% worked at a combined elementary and middle school level. Surveyed teachers shared the following levels of experience within their roles: 22.37% of teachers had 0-4 years experience, 28.29% had 5-10 years experience, 17.76% had 11-15 years experience, and 31.58% had greater than 15 years experience. Surveyed teachers shared the following levels of advanced degrees held: 32.89% hold bachelor’s degrees, 51.68% hold master’s degrees, 9.40% hold masters + 30 degrees, 4.70% hold educational specialists degrees, and 1.34% hold doctoral degrees.

Analysis of Research Questions

Research Question 1

How do educational professionals in Northeast Tennessee define STEM?

This open form survey question revealed the following definitions of STEM education when coded for frequency. The researcher compared teacher and administrator common terms to the previously determined STEM definition of “STEM education is an area of study but it is also a way of teaching and learning that is project-based, collaborative, and focused on solving real-world problems. STEM programs educate the whole student, emphasizing innovation, problem
solving, critical thinking, and creativity” (Tennessee STEM Innovation Network, 2012, What is STEM paragraph, paragraph 8). The most frequently occurring terms were recorded for frequency and ranked in order of occurrence in Table 1.

Table 1

Administrator and Teacher Definition of STEM Education

<table>
<thead>
<tr>
<th>Defining Term</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Focused</td>
<td>37</td>
<td>29.6%</td>
</tr>
<tr>
<td>Education</td>
<td>19.2</td>
<td>24%</td>
</tr>
<tr>
<td>Learning</td>
<td>20</td>
<td>16%</td>
</tr>
<tr>
<td>STEM</td>
<td>18</td>
<td>14.4%</td>
</tr>
<tr>
<td>Integrating Science, Technology, Engineering, and Math</td>
<td>19</td>
<td>15.2%</td>
</tr>
<tr>
<td>Focus on Science</td>
<td>14</td>
<td>11.2%</td>
</tr>
<tr>
<td>Hands On</td>
<td>10</td>
<td>8%</td>
</tr>
<tr>
<td>Project-Based</td>
<td>9</td>
<td>7.2%</td>
</tr>
<tr>
<td>Application</td>
<td>7</td>
<td>5.6%</td>
</tr>
</tbody>
</table>
**Research Question 2**

To what extent do educational professionals in Northeast Tennessee perceive a need for STEM instruction?

$H_{02_1}$: Administrators in Northeast Tennessee do not perceive a need for STEM instruction to a significantly positive or negative extent.

$H_{02_2}$: Teachers in Northeast Tennessee do not perceive a need for STEM instruction to a significantly positive or negative extent.

Two single sample t tests were conducted to evaluate whether there is a significant difference in the mean for perceived STEM instruction rating and the 2.5 point of neutrality, which was the test value. The grouping variables were administrators’ perceived need for STEM instruction and teachers’ perceived need for STEM instruction. The administrators’ test was significant, $t (11) = 6.167$, $p < .001$. Therefore $H_0: 2_1$ was rejected. The teachers’ test was also significant, $t (127) = 6.80$, $p < .001$. Therefore, $H_0: 2_2$ was rejected. The administrators’ average score ($M = 3.42$, $SD = .515$) and teachers’ average score ($M = 3.00$, $SD = .832$) were significantly higher than the 2.5 point of neutrality. The 95% confidence interval for the difference in means ranged from .50 to 1.24 for the administrators test. The 95% confidence interval for the difference in means ranged from .35 to .65 for the teachers’ test. The research significance demonstrated that both administrators and teachers perceive a need for STEM instruction in the agree to highly agree range.

Of administrator survey participants, 58.33% indicated they agreed to a need for STEM instruction, while 41.67 % indicated they strongly agreed to a need for STEM instruction. Of teacher survey participants, 7.26% strongly disagreed to a need for STEM instruction, 13.71% disagreed to a need for STEM instruction, 54.03% agreed to a need for STEM instruction, and 25% strongly agreed to a need for STEM instruction. Figure 5 represents these data.
Research Question 3

To what extent do educational professionals in Northeast Tennessee say they implement STEM education?

H₀₃₁. Administrators in Northeast Tennessee say they do not implement STEM education to a significantly positive or negative extent.

H₀₃₂. Teachers in Northeast Tennessee say they do not implement STEM education to a significantly positive or negative extent.
Two single sample t tests were conducted to evaluate whether there is a significant difference in the extent of STEM implementation rating and the 2.5 point of neutrality, which was the test value. The grouping variables were administrators’ implementation of STEM instruction and teachers’ implementation of STEM instruction. The administrators’ test was not significant, \( t (11) = .000, p = 1.00 \). Therefore, Ho: \( H_1 \) was retained. The teachers’ test was significant, \( t (123) = 4.99, p < .01 \). Therefore, Ho: \( H_2 \) was rejected. Administrators’ average score \( (M = 2.50, SD = .674) \) was equal to the 2.5 point of neutrality. The teachers’ average score \( (M = 2.10, SD = .882) \) was significantly lower than the 2.5 point of neutrality. The 95% confidence interval for the difference in means ranged from -.428 to .428 for the administrators test. The 95% confidence interval for the difference in means ranged from -.552 to -.238 for the teachers test.

To further understand the implementation of STEM instructional strategies, the researcher examined the percentage of time spent on inquiry-based, problem-solving activities in the classroom setting. Educators rarely used inquiry-based, problem-solving activities in the classroom 4.32% of the time. Educators sometimes used inquiry-based, problem-solving activities in the classroom 39.57% of the time. Educators often used inquiry-based, problem-solving activities in the classroom 43.52% of the time. Inquiry-based, problem-solving activities in the classroom setting were always used 10.79% of the time. Figure 6 represents these data.
Descriptive statistics were used to identify the most often used STEM instructional strategies. Research participants indicated the following alternative instructional techniques as the most often used techniques for the instruction of STEM concepts with a ranking of sometimes or always used. These data are represented in Table 2.

Figure 5. Implementation of Inquiry-Based, Problem-Solving Activities
Table 2

*Use of Alternative Instructional Techniques Ranking*

<table>
<thead>
<tr>
<th>Technique</th>
<th>Percentage of Often/Always Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Technology-Supported Learning Tools</td>
<td>57%</td>
</tr>
<tr>
<td>2. Traditional-Teacher Led Instruction</td>
<td>53%</td>
</tr>
<tr>
<td>3. Project-Based Learning</td>
<td>48%</td>
</tr>
<tr>
<td>4. Workplace or Lab-Based Learning</td>
<td>27%</td>
</tr>
<tr>
<td>5. Business/STEM Professionals</td>
<td>10%</td>
</tr>
</tbody>
</table>

Survey data also indicated that 79.29% of participating schools and districts implemented programs and courses that integrate the Core Concepts of STEM education. Figure 7 represents these data.
Research Question 4

To what extent do educational professionals in Northeast Tennessee perceive they have adequate resources available to implement STEM education across the curriculum?

H₀⁴₁: Administrators in Northeast Tennessee do not have access to professional development available to implement STEM education across the curriculum to a significantly positive or negative extent.

H₀⁴₂: Teachers in Northeast Tennessee do not have access to adequate access to professional development available to implement STEM education across the curriculum to a significantly positive or negative extent.

H₀⁴₃: Administrators in Northeast Tennessee do not have access to STEM assets available to implement STEM education across the curriculum to a significantly positive or negative extent.
Teachers in Northeast Tennessee do not have access to adequate access to STEM assets available to implement STEM education across the curriculum to a significantly positive or negative extent.

Two single sample t tests were conducted to evaluate whether there is a significant difference in the availability of Professional Development for STEM implementation rating and the 2.5 point of neutrality, which was the test value. The grouping variables were the administrators’ perception of availability of Professional Development for STEM implementation rating and the teachers’ perception of availability of Professional Development for STEM implementation rating.

The administrators test was not significant, \( t (11) = .432, p = .674 \). Therefore, \( H_0: \mu_1 \) was retained. The administrators’ average score (\( M = 2.58, SD = .669 \)) was not significantly greater than the 2.5 point of neutrality. The 95% confidence interval for the difference in means ranged from -.341 to .508 for the administrators’ test. The research demonstrates that administrators perceive access to STEM professional development above the neutrality rating of 2.5. The teachers’ test was significant, \( t (114) = 3.25, p = .002 \). Therefore, \( H_0: \mu_2 \) was rejected. The teachers’ average score (\( M = 2.30, SD = .675 \)) was significantly less than the 2.5 point of neutrality. The 95% confidence interval for the difference in means ranged from -.329 to -.080 for the teachers’ test. The research demonstrates that teachers perceive access to STEM professional development below the neutrality rating of 2.5.

Two single sample t tests were conducted to evaluate whether there is a significant difference in the availability of assets for STEM implementation rating and the calculated mean of 2.5 representing neutrality. The grouping variables were administrators’ perception of availability of assets for STEM implementation rating and teachers’ perception of availability of
STEM assets for STEM implementation rating. The administrators’ test was not significant, $t(11) = .886, p = .394$. Therefore, Ho: 4$_3$ was retained. The administrators’ average score ($M = 2.67, SD = .651$) was not significantly greater than the 2.5 point of neutrality. The 95% confidence interval for the difference in means ranged from -.247 to .581 for the administrators’ test. The research demonstrates that administrators perceive access to STEM assets above the neutrality rating of 2.5. The teachers’ test was not significant, $t(114) = 1.696, p = .093$. Therefore, Ho: 4$_4$ was retained. The teachers’ average score ($M = 2.40, SD = .632$) was not significantly less than the 2.5 point of neutrality. The 95% confidence interval for the difference in means ranged from -.217 to -.017 for the teachers’ test. The research demonstrates that teachers perceive access to STEM assets below the neutrality rating of 2.5.

Research Question 5

To what extent do educational professionals perceive the current condition of STEM in Northeast Tennessee is meeting the needs of 21st century learners?

HO5:$_1$ Administrators professionals in Northeast Tennessee do not perceive the current condition of STEM in Northeast to a significantly positive or negative extent.

HO5:$_2$ Teachers in Northeast Tennessee do not perceive the current condition of STEM in Northeast to a significantly positive or negative extent.

Two single sample t tests were conducted to evaluate whether there is a significant difference in the perceived condition for meeting the needs of 21st learners rating and the 2.5 point of neutrality, which was the test value. The grouping variables were the administrators’ perception of meeting the needs of 21st century learners’ implementation rating and teachers’
perception of meeting the needs of 21st century learners’ implementation rating. The administrators’ test was not significant, \( t(11) = .886, p = .394 \). Therefore, Ho: 5_1 was retained. The teachers’ test was significant, \( t(111) = 3.047, p = .003 \). Therefore, Ho: 5_2 was rejected. The administrators’ average score (\( M = 2.33, SD = .651 \)) was not significantly less than the calculated mean of 2.5 for neutrality. Teachers’ average score (\( M = 2.30, SD = .682 \)) was significantly less than the calculated mean of 2.5 for neutrality. The 95% confidence interval for the difference in means ranged from -.581 to .247 for the administrators’ test. The 95% confidence interval for the difference in means ranged from -.324 to -.069 for the teachers’ test. The research demonstrates that both administrators and teachers do not perceive the current condition of STEM education to be meeting the needs of 21st century learners.

The researcher also used a ranking system to determine the most pressing concerns regarding the current condition of STEM implementation in Northeast Tennessee. The order of ranking is demonstrated in Table 3.
Table 3

*Northeast Tennessee Educators’ Perceived Greatest Challenges Facing STEM Education.*

<table>
<thead>
<tr>
<th>Greatest Challenge</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Funding designated for STEM is too low</td>
<td>51</td>
<td>41.27%</td>
</tr>
<tr>
<td>Professional development for STEM teacher is insufficient</td>
<td>31</td>
<td>24.6%</td>
</tr>
<tr>
<td>STEM Education in K-8 is lacking or inadequate</td>
<td>16</td>
<td>12.7%</td>
</tr>
</tbody>
</table>
CHAPTER 5
SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS FOR PRACTICE AND FURTHER RESEARCH

Current Tennessee Education policies are grounded in a belief that STEM programs will enhance the ability of schools and school districts to provide the skills and knowledge students will need for success in college and the workplace. A quantitative nonexperimental research survey study was developed to investigate Northeast Tennessee Elementary and Middle School teachers’ and administrators’ perceptions of STEM education. The web-based survey provided the quantitative perception of Northeast Tennessee educational professionals along with one open-ended question to support an understanding of individual perceptions. The Statistical Package for the Social Sciences (SPSS) was used for data analysis. Patterns and perceptions identified through the open-ended and ranking questions were recorded for frequency.

Summary of the Study

The current perceptions of Northeast Tennessee K-8 educational professionals regarding STEM implementation were examined. Five research questions focused on current perceptions of STEM education. Perceived need, current implementation practices, access to STEM resources, definition of STEM, and current condition of STEM in Northeast Tennessee were examined to best understand STEM perceptions. Patterns and perceptions identified through the open-ended research question based upon the definition of STEM were ranked for frequency for question 1. Two single sample t tests were used to determine significance between administrators’ perceived need for STEM compared to a 2.5 test value representing neutrality.
and teachers’ perceived need for STEM as compared to a 2.5 test value representing neutrality to answer research question 2. Two single sample t tests were used to determine significance between administrators’ current observation of STEM practices as compared to a 2.5 test value representing neutrality and teachers’ current implementation of STEM practices as compared to a 2.5 test value representing neutrality to answer research question 3. Two single sample t tests were used to determine significance between administrators’ perception of availability of professional development compared to a 2.5 test value representing neutrality and teacher’s perception of availability of professional development compared to a 2.5 test value representing neutrality to answer question 4. Also, two single sample t tests were used to determine significance between administrators’ perception of availability of STEM assets compared to a 2.5 test value representing neutrality and teacher’s perception of availability of STEM assets compared to a 2.5 test value representing neutrality to answer research question 4. Two single samples t tests were used to determine significance between administrators’ perception of STEM education preparation for the 21st century learner compared to a test value of 2.5 representing neutrality and teachers’ perception of STEM education preparation for the 21st century learner compared to a test value of 2.5 representing neutrality for question 5. Top three challenges facing STEM education were also ranked for frequency for question 5.

Findings

This research study was focused on five research questions. The five questions and findings are discussed below.
**Research Question 1**

How do educational professionals in Northeast Tennessee define STEM?

Research participants were asked to define STEM in their own words. The researcher then compared recorded definitions with the previously determined definition and recorded for frequency. The following commonalities and frequently used terms were identified in order of frequency: Student Focused, Education, Learning, STEM, Integrating Science, Technology, Engineering, and Math, Focus on Science, Hands On, Project-Based, and Application.

**Research Question 2**

To what extent do educational professionals in Northeast Tennessee perceive a need for STEM instruction?

There was a significant difference between the mean score of both administrator and teacher perceived need for STEM instruction rating and the 2.5 point of neutrality. The mean score for administrators was 3.42 and teachers score was 3.0 compared to the 2.5 point of neutrality rating. With scores above the 2.5 neutrality rating, administrators and teachers agree to strongly agree to a need for STEM instruction.

**Research Question 3**

To what extent do educational professionals in Northeast Tennessee say they implement STEM education?

There was not a significant relationship between the administrators’ test score and the 2.5 point of neutrality rating. There was a significant relationship between the teachers’ test score and the 2.5 point of neutrality rating. The mean score for administrators was 2.5 and the mean score for
teachers was 2.10 compared to the calculated mean of 2.5 point of neutrality rating. With scores below the 2.5 neutrality rating, administrators and teachers rarely to sometimes implement STEM education.

To further understand the implementation of STEM instructional strategies, the researcher examined the percentage of time spent on inquiry-based, problem solving activities in the classroom setting. The data illustrated that 4.32% of educators rarely used inquiry-based, problem-solving activities in the classroom. While 39.57% of educators sometimes used inquiry-based, problem-solving activities in the classroom. Educators used inquiry-based, problem-solving activities in the classroom 43.52% of the time. Additionally, 10.79% of educators always used inquiry-based, problem-solving activities in the classroom setting. Additionally, data demonstrated the following alternative instructional techniques as the most often used techniques for the instruction of STEM concepts with a ranking of sometimes or always used: Technology-Supported Learning Tools -57%, Traditional-Teacher Led Instruction – 53, Project-Based Learning - 48%, Workplace or Lab-Based Learning - 27%, Business/STEM Professionals - 10%.

Lastly, survey data indicated that 79.29% of participating schools and districts implemented programs and courses that integrate the Core Concepts of STEM education.

Research Question 4

To what extent do educational professionals in Northeast Tennessee perceive they have adequate resources available to implement STEM education across the curriculum?

There was a significant relationship between the mean score of teachers’ perception of availability of professional development compared to the calculated mean of 2.5 point of neutrality. However, there was not significance between the administrators’ mean score of perception of
professional development compared to the calculated mean of 2.5 point of neutrality. The mean score for teachers’ access to professional development was 2.30 and the mean score for administrators was 2.58. Therefore, teachers perceive access to professional development to a lesser degree than administrators. There was not significance in either teachers or administrators’ access to STEM assets. Administrators’ mean score of 2.67 was above the 2.5 point of neutrality, while the teachers mean score of 2.40 was below the 2.5 point of neutrality. Therefore, teachers perceive access to STEM assets to a lesser degree than administrators.

Research Question 5

To what extent do educational professionals perceive the current condition of STEM in Northeast Tennessee is meeting the needs of 21st century learners?

There was not a significant relationship between the mean score of administrators’ perception of the current condition of STEM compared to 2.5 point of neutrality. There was a significant relationship between the mean score of teachers’ perception of the current condition of STEM compared to the calculated mean of 2.5 point of neutrality. The mean score for administrators was 2.33 and the mean score for teachers was 2.30 compared to the 2.5 point of neutrality rating. With scores below the 2.5 neutrality rating, administrators and teachers strongly disagree to disagree to the current condition of STEM meeting the needs of 21st century learners.

The researcher also used a ranking system to determine the most pressing concerns regarding the current condition of STEM implementation in Northeast Tennessee. The following concerns were ranked in order of greatest in the research survey: 1. Funding designated for STEM is too low, 2. Professional development for STEM teacher is insufficient, and 3. STEM Education in K-8 is lacking or inadequate.
An available option for providing additional feedback on the current condition of STEM was provided. The researcher identified the following positive comments regarding STEM implementation in Northeast Tennessee.

It is a great program that students respond and relate to. It helps students see problems they may be faced with when they go to work and gives them the opportunity to work through and solve these problems. STEM gives students the insight on what careers they may want to pursue.

Another participant shared the following strength, “The most exciting thing about STEM classrooms has been the excitement about learning evident in students in those classes.”

Concerns were also shared through this research study. One participant stated, “All schools in system should have STEM - not just a few. All students deserve the same quality education.” Another shared a concern regarding STEM programs

The greatest concern is that teachers see STEM as a "related arts" and are not incorporating these teaching/learning experiences on a wider scale within the regular classroom setting.”

Funding was expressed as a continual concern, “Funding is a problem. Not everyone has the technology they need.” Another participant stated,

As a science teacher, I feel STEM is important, but not at the expense of my regular class. Two years ago I had the funds and access to materials and tools I needed to teach science standards. Now I don't even have thermometers for measurement, and I cannot get any because our related arts STEM class gets all the funds.

Implementation of project-based learning was another area of concern for participants.
Inquiry based science is the red headed stepchild of Tennessee classrooms. Everyone knows it's lacking, but no one knows how to do it effectively in a time sensitive way. There are too many standards to teach in 180 days to use "best practices" such as inquiry based learning, hands on science, and allowing students to learn through projects.

Implementing project based learning in elementary classrooms is impossible with current schedules, curriculum maps and rigid classroom environments. Time to think outside the box if STEM is going to appear in elementary school.

Conclusions

Research participants were asked to provide their personal definitions of STEM. The researcher then compared participants’ definitions to the TSIN definition. Educators’ definitions of STEM were found to incorporate the following key terms of STEM: Student Focused, Education, Learning, STEM, Integrating Science, Technology, Engineering, and Math, Focus on Science, Hands On, Project-Based, and Application. This identification of commonalities in key terms as compared to the definition of STEM illustrates multiple levels of understanding of the meaning of STEM instruction.

The research uncovered a perceived need for STEM education by K-8 administrators and teachers. However, 62% of participants do not agree that the current condition of STEM education in Northeast Tennessee is meeting the needs of 21st century learners. Challenges facing STEM instruction included: Funding designated for STEM is too low, Professional development for STEM teacher is insufficient, and STEM Education in K-8 is lacking or inadequate.
The implementation of STEM courses and programs occurs to a great extent in Northeast Tennessee with an implementation percentage of 79%. The Tennessee STEM Innovation Network describes its vision for Tennessee students, “Tennessee students will lead the nation in STEM knowledge, skills, and practices as critical and creative thinkers, problem solvers, innovators, and collaborators to compete and succeed in the state’s emerging innovation economy” (TSIN, 2012, p.4). Research participants stated they used inquiry-based, problem-solving activities 56% of the time. The use of these higher-order thinking strategies would seem to support learners in an increasingly complex world. Participants also noted the use of the following instructional strategies that may better support student learning that will prepare students for a complex world: Technology-Supported Learning Tools -57%, Traditional-Teacher Led Instruction – 53%, Project-Based Learning - 48%, Workplace or Lab-Based Learning - 27%, Business and STEM Professionals - 10%. The researcher recommends the use of a variety of instructional strategies to best support the purpose and intent of the work. Therefore, the research identified a need for increased use of workplace or lab-based learning and the expertise of Business and STEM professionals in the classroom setting.

Greater than 50% of the research participants indicated they do not have adequate resources for STEM implementation. This includes professional development and access to STEM assets such as libraries, agencies, professionals, and museums. There was also an identified discrepancy between the perceptions of administrators and teachers regarding the availability of both professional development and STEM assets. The following recommendations can guide districts in their implementation plan for successfully incorporating STEM into classroom instruction.
Recommendations for Practice

This study found significance to a positive extent in Northeast Tennessee educators’ perceived need for STEM instruction with an average response of agree to strongly agree. However, only 36% of teachers said they were prepared for the implementation of STEM. The researcher recommends a clear vision for STEM implementation for districts, providing a pathway for necessary support and resources to guide both administrators and teachers toward STEM implementation. Within this vision professional development designed to support educators with STEM instructional strategies and the availability of STEM assets should be outlined. Support in how to better incorporate STEM assets into classroom instruction will also be beneficial for educators. Research data indicated that only 56% of teachers perceive a focus on STEM as a topic of conversations, whereas 92% of administrators indicated a focus on STEM as a topic of conversation in their school/district. This discrepancy in findings between administrators and teachers leads the researcher to believe that STEM conversations are primarily occurring at the administrative level. Therefore, it is important to involve leadership at all levels of the organization to build commitment to the purpose of the work. Instructional leaders will be critical to this work as they involve teachers in the planning for implementation. Involving all stakeholders in the STEM implementation plan will build a coherent focus and commitment to the vision.

STEM education is no longer viewed as the instruction of STEM subjects in isolation, yet the subjects of science, technology, engineering, and math are integrated with a focus on real-world problem solving (Saunders, 2009). The researcher recommends the construction of professional learning communities involving the content areas of science, English, math, and social studies to best communicate instructional objectives to develop cross-curricular units of
study. The integration of STEM subjects is standards driven and focused on application of knowledge through performance-based learning and assessment (California Center for College and Career, 2010, p. 7). STEM units are defined by the following criteria: project-based, real-world problem solving, science inquiry, self-directed inquiry. “... [I]ntegrated curriculum refers to the materials and pedagogical strategies used by multidisciplinary teams of teachers to organize their instruction so that students are encouraged to make meaningful connections across subject areas” California Center for College and Career, 2010, p. 2).

Administrators reported that they observe STEM instruction sometimes – often, while teachers reported they implement STEM instruction only sometimes. However, STEM instructional strategies of inquiry-based, problem-solving activities are reported to be used more often. This discrepancy in perception leads the researcher to believe that a clear understanding of STEM instruction is not developed for the surveyed school districts. The researcher recommends that a clarification in STEM instruction and instructional strategies would benefit educators. A clear, common definition of STEM instruction will support educators with new understandings and build commitment toward the work.

This study indicated a discrepancy in administrator versus teacher perceptions of their preparation for the implementation of STEM. 83% of administrators agree – strongly agree they are prepared for the implementation of STEM, whereas 36% of teachers feel they are prepared. “That is why systemic change – change that is simultaneously top down and bottom up and touches all the interconnected parts of the organization – is essential” (Schlechty, 2011, p. 127). Commitment is built when all stakeholders are actively involved and serve as contributing leaders in the quest to design the future (Glover, 2013). Research has found that highly effective STEM schools are defined by their positive school culture for learning. The roles of professional
capacity, community ties, instructional guidance, and student-centered approach were identified (National Research Council, 2011). An increased focus on STEM professional learning will support teachers as they work towards implementation. Focused, job-embedded support for teachers will guide individuals in meaningful professional learning experiences. Professional learning should be intensive, on-going, and connected to practice. It should be focused on student learning and address the teaching of specific curriculum content as well as align with school improvement priorities and goals. Also, awareness of availability of STEM assets and teacher involvement in resource purchasing will support teachers with classroom instruction.

To best include stakeholders and community members in a district’s STEM implementation, the researcher recommends an increased use of Business and STEM professionals. Partnerships with STEM professionals should provide students with opportunities for working alongside professionals in their STEM careers, project-based activities based upon STEM expertise, awareness of possible STEM professions, and sharing of resources to support classroom instruction. Communicating district needs with community stakeholders will greatly support this work. The Northeast Tennessee STEM Hub is an identified resource designed to provide a communication network to enhance sharing of expertise and strengthening existing collaboration while building new partnerships as well as connect regional STEM assets with the TSIN and with regional and statewide STEM initiatives (ETSU.edu, 2012, p. 2).

Recommendations for Further Research

Further research should be conducted on existing STEM identified schools and core programs to identify effective strategies that support student learning. It would also benefit school districts to analyze data from these programs to identify specific learning gains.
An analysis of instructional strategies and the implementation of project-based learning based upon the integration of science, technology, engineering, and math disciplines would likely support to districts as they implement STEM instruction across all disciplines.

Furthermore, research into community/business partner communication and relationships would benefit schools as they continue to build partnerships that support student learning.

The above recommendations will provide information to Northeast Tennessee K-8 educators as they begin and/or continue the implementation of STEM instruction.
REFERENCES


Zhao, Y. (2010). Catching up or leading the way. Alexandria, VA: ASCD.
APPENDICES

SURVEY QUESTIONS

Northeast Tennessee Educators’ Perception of STEM Education Implementation

As a requirement of the degree of Doctor of Education of Educational Leadership and Policy Analysis through East Tennessee University, I am writing a dissertation on Northeast Tennessee educators’ perceptions of Science, Technology, Engineering and Math (STEM) Education implementation. This survey is designed to provide insight into elementary and middle school teachers’ and administrators’ perceptions of STEM Education implementation. The study of current perceptions of educational professionals in Northeast Tennessee on the integration of STEM education will support schools and school districts in the implementation process. As education focuses more heavily on STEM instruction, it is essential that knowledge acquired through the study will be applicable to schools in Northeast Tennessee as our region continues to offer support for schools and school districts in the implementation process. This information will also aid schools and school districts in guiding students toward STEM related careers, as well as college and career readiness for societal success.

As a way of providing information on the topic of STEM education, I have chosen to conduct research on teachers’ and administrators’ perceptions of STEM implementation in their classroom and/or school setting. I am asking you to complete this survey to guide this research. This survey is both anonymous and voluntary and will take approximately fifteen to twenty minutes to complete.

If you have any questions you may contact Krissy Turner at kturner@k12k.com.
1. Are you employed as a/n:

2. Do you work within the elementary setting, middle school setting, or both?

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

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

5. Which school system are you employed with?

6. I perceive a need for STEM education.

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?

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?

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

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

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

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

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

15. I have adequate access to STEM assets (libraries, agencies, professionals, museums, etc).
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 utilize/observe the following instructional techniques?

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

18. In a nine week period, how often are you able to integrate discussions that help students become aware of STEM careers?

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

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.
APPENDIX B

LETTER FOR PERMISSION TO PARTICIPATE IN STUDY

March 17, 2013

Kristin Turner
Associate Principal
Robinson Middle School
1517 Jessee Street
Kingsport, TN 37664

Dear Dr. ________________,

As a requirement of the degree of Doctor of Education of Educational Leadership and Policy Analysis through East Tennessee University, I am writing a dissertation on Northeast Tennessee educators’ perceptions of Science, Technology, Engineering and Math (STEM) Education implementation. This survey is designed to provide insight into elementary and middle school teachers’ and administrators’ perceptions of STEM Education implementation. The study of current perceptions of educational professionals in Northeast Tennessee on the integration of STEM education will support schools and school districts in the implementation process. As the educational realm focuses more heavily on STEM instruction, it is essential that knowledge acquired through the study will be applicable to schools in Northeast Tennessee as our region continues to offer support for schools and school districts in the implementation process. This information will also aid schools and school districts in guiding students toward STEM related careers, as well as college and career readiness for societal success.

This letter is to request your assistance with this quantitative research which I am hopeful will be of interest to legislators, administrators, staff development coordinators, and universities with
teacher preparation programs. Your system’s participation will be in the form of an on-line anonymous survey lasting approximately fifteen minutes in length. Pending IRB approval, I anticipate the survey will occur during the month of May.

I recognize professional educators’ time is valuable and believe their input into this research is valuable and will be beneficial to Northeast Tennessee school systems.

If you agree to be a part of this study, please read carefully and sign the informed consent document. Your responses will be considered confidential. If you have questions or concerns, please contact me at 423-747-9074. Thank you for your consideration of participation in this research study. Please return the signed document by mail or scan and email to kturner@k12k.com

Sincerely,

Kristin Turner
APPENDIX C

SIGNED CONSENT TO PARTICPATE IN STUDY

PERMISSION FOR PARTICIPATION IN RESEARCH

Northeast Tennessee educators’ perception of STEM Education implementation

**Principal Investigator:** Kristin B. Turner (Graduate Student): Associate Principal, Robinson Middle School, Kingsport City schools

**Institution:** East Tennessee State University, Johnson City, TN

**Department (School, College):** Education Leadership and Policy Analysis

**Faculty Advisor:** Dr. Eric Glover, ELPA

What is the purpose of this research?

This survey is designed to provide insight into elementary and middle school teachers and administrators’ perceptions of STEM Education implementation. The study of current
perceptions of educational professionals in Northeast TN on the integration of STEM education will support schools and school districts in the implementation process. As the educational realm focuses more heavily on STEM instruction, it is essential that knowledge acquired through the study will be applicable to schools in Northeast TN as our region continues to offer support for schools and school districts in the implementation process. This information will also aid schools and school districts in guiding students toward STEM related careers, as well as college and career readiness for societal success.

What is involved in being in the research study?

The research study consists of voluntary and anonymous completion of an on-line survey developed through Survey Monkey software.

How much time will this take?

This study will take approximately fifteen to twenty minutes for participants to complete.

You will be given a copy of this information to keep for your records.

Statement of Permission for Participation in Research:

I have read the above information. I have had all my questions and concerns answered. By signing below, I indicate my permission for teachers and administrators to be in the research.
☐ Yes, I agree to have teachers and administrators participate in the research.

☐ No, I do not give permission for teachers and administrators to participate in the research.

Signature: ____________________________________________

Printed Name: __________________________________________
VITA

KRISTIN B. TURNER

Personal Data:  Date of Birth: July 21, 1975
Place of Birth: Memphis, Tennessee

Education:  Ed. D., Educational Leadership
East Tennessee State University, Johnson City, TN 2011
Masters of Science, Elementary Education
University Of Tennessee, Knoxville, TN 1998
Bachelor of Arts, Elementary Education
University Of Tennessee, Knoxville, TN, 1997

Professional Experience:  Associate Principal, Kingsport City Schools
Kingsport, TN, 2012-present
Lead District Literacy Coach. Kingsport City Schools
Kingsport, TN, 2011-2012
District Literacy Coach, Kingsport City Schools
Kingsport, TN, 2010-2012
Andrew Johnson Elementary Literacy Coach, Kingsport City Schools
Kingsport, TN, 2007-2010
Andrew Johnson Elementary Classroom Teacher
Kingsport, TN, 1999-2007