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# Case Study on the Efficacy of an Elementary STEAM Laboratory School

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STEAM Laboratory School

by

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Declaration of Originality

I do hereby declare and attest to the fact that this is an original study based solely upon my own scholarly work at Lindenwood University and that I have not submitted it for any other college or university course or degree.

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**Abstract**

A case study was conducted of an elementary STEAM laboratory program in a midwest Missouri school district, which was unique to the area, and involved risk-taking by the school officials. The delivery model for instruction in the program was inquiry-based learning with a STEAM focus. The planning of the program involved the community, as well as district personnel. The purpose of the study was to evaluate the efficacy of the program at the end of the first year to determine if the goals of the planning committee had been met and if the perceptions of the stakeholders were in favor of the decisions made to implement the program. A mixed research design was conducted which included surveys of parents and teachers involved in the program, standardized assessment scores compared to those of traditional elementary buildings in the district, and interviews with administrators involved in the planning and implementation of the program. The over-arching purpose of the study was to provide a model for future planning in the school district, as well as for other districts interested in the development of a STEAM program. Results of the mixed design were mostly positive, with survey results indicating favorable perceptions by the participants. Results of standardized testing were of mixed results as to the academic achievement of students involved in the program; however, administrator interviews indicated no expectations for increased achievement during the first year of operation. Indications were that the first year of operation of the laboratory school had met expectations, and the STEAM program would serve as a model for districts in making the choice to follow the same path toward including a STEAM curricular program in the future.

## Table of Contents

## List of Tables

## List of Figures

# Chapter One: Introduction

Jobs in the future will demand technological skills, and to be competitive in the world market, the United States needs to produce more graduates in the fields of science, technology, engineering, and mathematics (Business-Higher Education Forum [BHEF], 2011). Educational institutions, from elementary level (K-12) through post-secondary, will need to meet the needs of the 21st century by providing more opportunities for students to pursue the fields of science, technology, engineering, and mathematics (STEM), along with providing motivation for students to enter occupations that require skills in the STEM fields (Gordon, 2010). Education in the STEM areas helps prepare students for employment opportunities in an economy based on literacy of 21st century skills and improves effectiveness of the education system in grades K-16 (National Governors Association Center for Best Practices, 2015).

One Missouri school district designed and implemented an elementary-level program focused on STEM curriculum. Within this paper, the procedures are outlined that were taken in planning and involving patrons in the decision-making process and developing a laboratory school focused on science, technology, engineering, arts, and mathematics (STEAM) with an emphasis on literacy as taught through the lens of science. The literacy emphasis was implemented by means of heavy reliance on nonfiction reading. Reflections and perceptions of some of the stakeholders were evaluated to determine possibilities of direction for this district in the future. Another purpose to the study was to provide data for other school districts interested in the process of implementing a STEM curriculum at the elementary level.

Chapter One of this paper includes information related to the background of STEM and STEAM initiatives in the United States. The theoretical framework for the study is also introduced in Chapter One, with reference to research conducted on inquiry-based and project-based learning models. Chapter One includes a background of the study, with an emphasis on current mandates for STEM education. A theoretical framework is presented for inquiry-based learning, which was the framework adopted by the school district for the program. The problem of predicted employment needs for the future in STEM-related areas and the concerns for a lack of prepared applicants are stated in Chapter One. The purpose of the study was determined to address the needs for education that would prepare graduates to enter the STEM workforce or to complete higher education in the STEM areas. Research questions are outlined, and a null hypothesis is proposed for the data collected. Also, outlined are the definition of key terms, along with limitations and assumptions. A summary of the project completes the first chapter of the study.

**Background of the Study**

There is a current initiative in the United States to propel education in the areas of science, technology, engineering, and mathematics, with the acronym of STEM education (Herschbach, 2011). According to the National Center for STEM Elementary Education (2012), "Teachers *must* engage elementary and middle school children in becoming problem solvers, innovators, inventors and logical thinkers eager to master STEM subjects now and as they move into high school, college and careers" (para. 5). Tony Murphy (2011) of St. Catherine University published an article about the importance of

K-12 educators becoming trained in the STEM areas for the benefit of preparing students at these ages for pursuing STEM careers in high school and college.

School districts have invested in technology in the classrooms to varying degrees (Wolfe, 2011). It is not uncommon for school districts to invest in technology in order to focus on the areas of science, technology, engineering, arts, and mathematics (STEAM) education (NCSU, 2011). The question is whether or not technology improves students' learning in these fields and whether or not technology contributes to increased performance in science and math (Hondo & Cleveland, 2012). According to Langdon, McKittrick, Beede, Khan, and Doms (2011), "The greatest advancements in our society from medicine to mechanics have come from the minds of those interested in or studied in the areas of STEM" (para. 16).

The University of Missouri in Columbia, Missouri, was involved in the development of enhancing Missouri Instructional Technologies (eMINTs) (2011), with an emphasis on inquiry-based learning as a best practice in preparing students for 21st century learning. Also involved with the development of this program was the Missouri Department of Elementary and Secondary Education (MODESE), the Missouri Department of Higher Education, and MOREnet in Missouri (eMINTS, 2011). The first eMINTs-certified educators specializing in inquiry-based learning were from the St. Louis, Missouri, area in the late 1990s, with studies of eMINTs classrooms indicating higher achievement as based on test scores among students learning through the inquiry-based method (eMINTS, 2011). The original program in Missouri was named Multimedia Interactive Networked Technologies (MINTs); however, it was renamed eMINTs in 1999 as a state initiative to educate students through an inquiry-based model, with the use of technology as engagement and a new way of learning developed to meet the needs of the 21st century learner (eMINTS, 2011).

In this study, the reasons were examined for why district administrators and parents choose STEAM education for their students, and whether there is a perception that students who learn in technology-rich environments have an advantage over students learning in a traditional setting. The results of surveys of parents and teachers presented in Chapter Four were used to answer this question. Parental and teacher perceptions were analyzed, along with expectations and goals of the school district, which led to choosing STEAM educational opportunities in a laboratory elementary (K-6) school setting. For the purposes of this study, the school was called Unique Elementary.

**Theoretical Framework**

Inquiry-based learning is a theory on how students learn and is designed around the constructivist theories of Jean Piaget (Gillani, 2010). Piaget "viewed learning as a dynamic process where learners construct their own knowledge by interacting with the world" (Gillani, 2010, p. 5). Constructivism and inquiry-based learning form the basis of the eMINTS programs and other e-learning environments (Gillani, 2010). A significant number of the teachers chosen for the program studied in this research project were certified eMINTS teachers (MODESE, 2013). The theoretical framework of inquiry-based learning was used in answering the question in this study of whether or not students excel in academics in an inquiry-based model and a technology-rich classroom over students in the traditional setting.

The school district focused on in this study had been training teachers to obtain eMINTS certification for a decade, mainly focused on the fourth grade, and had plans to extend the training into other grade levels in the future. Every elementary building in the chosen district had a least one certified eMINTS teacher in grade four, and several of the elementary buildings had two or more staff certified in the eMINTS model. The success of the inquiry-based learning model in the eMINTS classrooms was such that when plans were developed for the STEAM laboratory program, the method of teaching/learning that was a part of the vision was based on the eMINTS classroom. This district presented the plan to the public before actively developing the goals of the laboratory STEAM-focused elementary school and based the teaching/learning delivery model on inquiry-based learning as the method of educating children chosen for enrollment in this program.

**Statement of the Problem**

Trends in the world of business are toward STEM-related employment needs (Carnevale, Smith, & Melton, 2011; Langdon et al., 2011). Government agencies have recognized a growing need to be competitive in the global market and have noted a lack of preparation in many of the nation's graduates to pursue careers in the fields of science and mathematics according to Business-Higher Education Forum (BHEF) (2011). High school students in America rank low in the areas of science and mathematics in test scores and measures of achievement, and only one-third of students in grades four through eight show proficiency in the STEM areas (Hanover Research, 2011). The STEM Education and Workforce (2014) reported only 44% of students graduating in 2013 were ready for college-level mathematics, while 36% were prepared in science, according to university entrance assessments. The report also noted students in 29 nations outperformed American students in mathematics in 2012, and students from 22 nations outperformed students from America in science (STEM Education and

Workforce, 2014). To compete globally, there is a need to make the most of STEM-related talent, as more occupations of the future will depend on qualified employees such as machinists, operators, technicians, engineering technicians, and scientists (Engler, 2012).

College enrollment of today's high school graduates is on the decline in STEM-related fields in science and technology (Fioriello, 2013). Students claim they feel under-prepared for the rigor of such programs (Fioriello, 2013). The National Science Foundation estimated 80% of the jobs created in the next decade will require training in the STEM areas, and shortages in these areas are expected if current trends continue (Fioriello, 2013).

Education is moving toward online testing (MODESE, 2013). Missouri joined a consortium of states that began assessing through an online testing system piloted in 2014, with an estimated 2,000,000 students participating (Smarter Balanced, 2014). There was a question of whether or not students would be prepared to perform at their best if not regularly taught through the use of technology in the classrooms (PRWeb, 2011). There was also research to suggest students needed to be prepared to enter a workforce built around science, mathematics, and technology (Carnevale et al., 2011). Press Release Services (PRWeb) (2011) asserted some school districts have already invested in increased opportunities for technology usage in classrooms, and others have made partial investment by providing technology to some of the students. School districts around the world are incorporating technology at varying levels through the implementation of programs to teach 21st century skills (PRWeb, 2011). The question is whether or not this creates equal learning opportunities between school programs that utilize STEM curriculum with regular use of technology and those that do not, and whether STEM schools and traditional school settings provide an equitable environment in which all students can excel.

Students need opportunities to develop 21st century skills that will be needed in the job market, and schools must determine how best to meet those objectives (Grunwald & Associates, 2010). The Unique School is designed to utilize global standards proposed by the International Society for Technology in Education (ISTE, 2011) called the National Educational Technology Standards (NETS). The NETS have been adopted by many state education departments including the MODESE, which along with 30 other states joined the Science & Math Achievement Required for Tomorrow Balanced Consortium (SBAC), founded in 2009, to move toward online testing of students (Smarter Balanced, 2014). The school district implemented a program in an attempt to best prepare students for what they will need to know to achieve on assessments using the tools that are a part of their world (Smarter Balanced, 2014; Walsh, 2009).

**Purpose of the Study**

A case study (Soy, 1997) was chosen as the method of research on a Missouri school district's implementation of the first STEAM elementary school, which was unique in focus for the geographical area. Attitudes of parents and school staff towards teaching/learning in technology-rich classrooms that focus on mathematics and science in the curriculum and emphasize literacy through the regular use of nonfiction reading and writing were evaluated (Soy, 1997). As a result, school districts could determine if a cost-benefit analysis to budget for more STEAM programs was worth considering. The analysis made by looking at the parent and teacher opinion surveys utilized in this study and through administrator interviews (Seidman, 2006), may help school districts to make informed decisions in the planning process.

The purpose of this mixed design study (Creswell & Clark, 2011) was to determine if there was any value to the increased expense of adding technology to the repertoire of teaching tools schools use to teach and prepare children as they advance in their education. One school district in Missouri was the focus of the study. The district implemented a laboratory STEAM-focused elementary school (Unique School) for the 2012-2013 school year where enrollment was a parental choice, and entry was determined by lottery. This study involved examination of the process used by the district in making the decision to create Unique School and evaluation of the expectations and experiences of some of the stakeholders during the first year of implementation of the program.

R**esearch questions and hypothesis.** The following research questions guided the study:

1. What was the purpose of the development of a STEAM laboratory school for one Missouri school district?

2. What is the difference, if any, between the achievement level of students enrolled in the STEAM program and students enrolled in traditional elementary programs as measured by the Scholastic Reading Inventory and Acuity assessments in mathematics and reading?

$H2_0$ There is no difference between the achievement level of students enrolled in the STEAM program and students enrolled in traditional elementary programs as measured by the Scholastic Reading Inventory and Acuity assessments in mathematics and reading.

3. What are the reasons parents choose to enroll their children in the STEAM-focused elementary school over a traditional elementary setting in the district?

4. What are the perceptions of parents and teachers about the experience of students attending the STEAM program?

## Definition of Key Terms

For the purposes of this study, the following terms are defined:

**Technology-rich**. A classroom where technology of various types is available for student use in the learning process is technology-rich. Computers, audio-visual equipment, and software would all be included in the learning environment (EduScapes, 2007).

**Twenty-first century skills**. Twenty-first century skills are those skills recognized as needed to fill jobs in the 21st century in science, technology, engineering, and mathematics. Emphasis is on problem-solving, collaboration, and creativity (21st Century Frameworks, 2011).

## Limitations and Assumptions

The following limitations were identified in this study:

**Sample demographics.** This research focused on a single-case study of elementary schools with similar demographics within one Missouri school district. Findings and conclusions are not necessarily applicable to school districts of differing demographics.

**Instrument.** Surveys were created by the researcher, and every attempt was made to be objective.

**Academic results.** The academic results for Unique School, were considered a limitation due to this being the first year of STEAM implementation.

**Sample growth reports.** Sample growth reports of students in the laboratory school could be biased, as all participants in the laboratory school program were there by choice.

The following assumptions were accepted:

1. The responses of the participants were offered honestly and without bias.
2. The test instruments were reliable and valid: CTB/McGraw-Hill [Acuity] (2013) and Scholastic Reading Inventory (2012).

The Scholastic Reading Inventory (2012), or SRI, was developed using the Lexile Framework to determine reading levels of participants. The construct validity of the Lexile Framework was evaluated in relationship to "other measures of reading comprehension and text difficulty" (Scholastic Reading Inventory, 2012, p. 18), using standardized reading tests to find the correlation between test scores and Lexile measures. Basal reading programs were also evaluated and compared to the standardized measures with a Lexile calibration of text comprehensibility and rank order of 0.995 (Scholastic Reading Inventory, 2012). Reliability was determined by using a standard error of measurement with a confidence interval of 90% on selected texts (Scholastic Reading Inventory, 2012).

CTB/McGraw-Hill (2013) published, "Measurement error is decreased when students and forms are appropriately matched by ability and difficulty" (para. 3). The

Acuity Predictive Tests (CTB/McGraw-Hill, 2013), when compared to the Colorado state standardized assessment, showed average correlations of scores between .75 and .80, indicating the Acuity Predictive Assessments provided "predictive information toward the end-of-year goals measured by the state NCLB assessments" (para. 4). Average reliability on state tests from Colorado and Missouri were reported in the "mid to high .80s" (CTB/McGraw-Hill, 2013, p. 3).

**Summary**

In conclusion, Chapter One focused on the appeal and effectiveness of a STEAM-focused curriculum in a K-6 elementary building. A statement of the problem was outlined, as to the need for an elementary STEM laboratory program. The theoretical framework of inquiry-based learning was developed, as was the underlying framework for the design of the Unique School. Questions were developed for the purpose of evaluating the efficacy of the Unique School laboratory program. The perceptions of the stakeholders were to be considered in evaluating the success of the first year of implementation. Another purpose of the study was to evaluate whether or not student achievement was greater as measured by growth in the Unique School over growth in academic achievement in math and reading in traditional elementary schools in the district. The intended results of the study were established and were to determine the success of a unique program implementing STEM curriculum at the elementary level. Unfamiliar terms referred to in the study were defined.

In the second chapter, a literature review is presented to include the history and timeline of the present initiative toward increased technology skills and of future employment opportunities in the fields of science, mathematics, and engineering.

Included in the 21st century skillset are those considered as the soft skills of scientific inquiry and problem-solving (Hanover Research, 2011). Also described in Chapter Two are curricular areas not normally associated with STEM, but with good argument for inclusion in developing a well-rounded citizenry, namely a social studies and arts curriculum infused into the STEM curriculum (Maguth, 2012), along with literary competency in reading, writing, and speaking (Meyrick, 2011). The underrepresentation of participants due to gender and race is also outlined, along with efforts to build equity into the opportunities afforded to students in K-16 educational programs (Hanover Research, 2011). Benefits and arguments for a national focus on STEM education are also researched and reported.

In Chapter Three, the instruments are discussed that were used to evaluate the process of developing the Unique School program, along with the survey and interview processes of gathering qualitative information from some of the stakeholders in the venture. Every attempt was made to gather and disseminate a clear understanding of the process used to create this first-in-the-area laboratory STEAM program. Participation was informed and voluntary, and quantitative data were used with discrepancy and equity. All processes used in the collection of data are outlined and presented in Chapter Three, with fairness and accuracy being a priority.

In Chapter Four, the evaluated and quantified survey results give a more objective view of the perceptions of the patrons who participated in this study. Administrative interviews are analyzed for themes, along with similarities and differences in perceptions of the progress of the first year of operation of the STEAM laboratory school. Standardized test results are evaluated for a quantitative comparison of student achievement, as determined by growth in mathematics and reading of students in the third through sixth grades, across the targeted school district.

Chapter Five includes evaluation of the study's implications and recommendations for research and decision-making about the future of STEAM elementary programs. As the formation of this particular school was the first of its kind in the area, and a laboratory program, the findings were of a unique nature. The purpose was to give as accurate a description as possible of the first year of implementation of an experimental elementary program in a particular geographical area of the country.

# Chapter Two: Review of Literature

In this chapter, literature is reviewed in relationship to the future of education. The research indicated business leaders are looking for future employees in STEM occupations, and schools are adopting or have adopted online testing methods to assess student skills in the STEM areas (Grunwald & Associates, 2010). Jobs in the STEM fields are expected to increase by 20% by 2020 (Hopkins, 2012), with 80% of new jobs in the next decade expected to require training in some of the STEM fields (Fioriello, 2013). Thus, this topic is important, and the research in this area is essential to understanding not only the problems, but possible solutions.

The literature reviewed includes analysis of the effects of technology usage on student achievement and attitudes toward learning. Research was conducted to review 21st century skills ( Rotherham & Willingham, 2010; 21st Century Frameworks, 2011), and the impact on educational reform to accommodate student learning in relationship to the standards for technology and integrated curriculum (ISTE, 2011). The need for STEM and STEAM education was an area of study, as was the theoretical framework of inquiry-based learning (Friesen & Scott, 2013). This study involved comparison of the participation of men, women, and minorities in the STEM fields of study in higher education and the workforce (Diep, 2013; Severns, 2012), and proposals to bring equity into the training of future STEM professionals (Hopkins, 2012). Teacher professional development in using effective methods of teaching STEM was also an area of research focus (Nelson & Sassi, 2005).

The State Educational Technology Directors Association (SETDA) put forth studies on the Promethean ActivClassroom showing the increased usage of technology in

America's schools is having a positive educational impact (Marzano Research Laboratory, 2009; Nagel, 2009). Students learning through the use of technology have been found to excel on standardized testing over peers in non-technology settings (Meyers & Brandt, 2010). Research also shows a correlation between student achievement and teacher training in using technology as an instructional practice (Martin, Strother, Weatherholt, & Dechaume, 2008). Such training should focus on authentic learning experiences, rather than a push to implement technology usage, in order to have the most meaning as an instructional tool (Sutton, 2011).

Matching curriculum to resources that engage students in the learning process is where technology training prepares teachers to provide those educational opportunities (Courduff, 2011). Teachers must have the tools to educate, evaluate, and assess students in 21st century methods in order to be most effective (Kumar & Vigil, 2011). Success in the STEM initiative depends not only on technological and scientific competency, but also on critical-thinking and problem-solving skills (Hanover Research, 2011).

The initiative toward education that focuses on the STEM areas is for the purpose of keeping the United States competitive in the world marketplace (Carnevale et al., 2011; Langdon et al., 2011). Technology usage prepares students for 21st century skills with a focus on the STEM areas, according to studies reported by Grunwald and Associates (2010) of Walden University; Means, Toyama, Murphy, Bakia, and Jones (2010) to the U.S. Department of Education. The current push toward integrating the STEM elements involved are listed by the STEM Initiative (Herschbach, 2011). At least one state has called for more governmental support in funding advancing STEM programs (Brett, 2007).

Literature was also reviewed on inquiry-based and project-based delivery models in adding an “A” (arts) to STEM to become a STEAM program (Moye, 2011). The introduction of the arts into a STEM-based program provides for a more well-rounded education and teaches to the whole child, according to proponents such as Robelen (2011), by unlocking “creativity and innovation” (para. 2). According to Robelen (2011), a House resolution was introduced in Rhode Island by U.S. Representative Langevin to highlight the need for inclusion of the arts into the state initiative for STEM education. Maguth (2012) proposed social studies content should also be integrated into a STEM-focused curriculum in order to promote soft skills and produce a well-rounded citizenry prepared for voting on ethical and social issues related to STEM.

**Theoretical Framework**

Constructivism recognizes that learners construct knowledge based on their own experiences, present circumstances, and individual understanding (The Center for Teaching and Learning, 2011), and that each person, as a result, constructs knowledge differently in similar situations. The ideas behind constructivist learning are not necessarily modern and have been espoused and debated by great thinkers since the 18th century (The Center for Teaching and Learning, 2011). Dewey (1916) supported child-centered pedagogy as follows:

> …learning is active. It involves reaching out of the mind. It involves organic assimilation starting from within. Literally, we must take our stand with the child and our departure from him. It is he and not the subject matter, which determines both quality and quantity of learning. (p. 9)

The Center for Teaching and Learning (2011) published a framework of constructivism and stated learners construct knowledge based on previous knowledge, current experience, and as individuals.

Piaget (1952) focused on individual ability to construct meaning and understanding of reality through experiences. According to Phillips (1997), "The individual knower or learner builds a personal understanding of the surrounding world; but bodies of knowledge (the disciplines, such as science and math) also are constructed by humans" (p. 158). The Center for Teaching and Learning (2011) noted critical thinking, or analysis, reflection, and communication, must be a part of constructing knowledge.

Inquiry-based instruction is a broad umbrella term that includes various approaches (project-based, problem-based, and design-based) that utilize inquiry as an integral component of the learning process (Stephenson, 2012). The project-based learning approach uses inquiry in basing learning activities around a central driving question integral to the curriculum and results in hands-on, real-world application and results (Thomas, 2000). Open inquiry with observable results is the foundation of inquiry-based instruction and learning (Zion & Mendelovici, 2012). Effective project-based learning relies on posing a driving question, just as the inquiry-based instructional model does, and involves students engaging in problem-solving and real-world application in order to find solutions and deeper understanding (Markham, 2012), thereby working together for improved student achievement (Thomas, 2000).

The problem-based learning model builds on prior knowledge of learners, is student-centered, and presents students with real-world challenges to solve (Gallow, 2000). Learners are asked to think critically, analyze, synthesize, and evaluate authentic problems to meta-cognitive questions, and to find reasonable solutions (Gallow, 2000). Just as other approaches to inquiry-based instruction, problem-based learning is task-oriented with the teacher as a facilitator encouraging students to explore, ask questions, and find meaning in learning (Stephenson, 2012).

Inquiry in science allows children to think like scientists, take risks, ask questions, and engage more freely in exploration (The Access Center, 2008). Students develop more in-depth reasoning ability and greater achievement in science as a result of inquiry-based learning instruction (Zion & Mendelovici, 2012). Methods used in science inquiry include structured, guided, and open inquiry, which involve differing levels of teacher participation, and the learning cycle, which includes having students work with a new concept they will later apply into a different context (Just Science Now, 2015).

Educational reform measures involve looking at the end results and forming a new conceptualized image of how to reach goals and meet the needs of the 21st century learner (Friesen & Scott, 2013). Inquiry-based learning in science is a key component of The National Science Education Standards and is operational in classrooms where hands-on, student-centered, engaged learners base understanding of concepts on looking at evidence (Zion & Mendelovici, 2012). The Galileo Educational Network in Calgary, Alberta, noted as an exemplary program by Stephenson (2012), has adopted a vision that recognizes inquiry as an integral component of the educational process and recognizes the three E’s of 21st century goals: engaged thinkers, ethical citizens, and entrepreneurial spirits (Friesen & Scott, 2013). The nature of inquiry-based learning is observation, which helps students to learn in an easier, more engaging manner than through traditional methods that rely on direct instruction (Zion & Mendelovici, 2012). Students who are more motivated toward mastering learning objectives are more engaged and goal-oriented (Thomas, 2000), resulting in greater critical thinking (Zion & Mendelovici, 2012).

The job of the teacher in an inquiry-based instructional model is to activate student interest and curiosity, while allowing for collaboration, creative and critical thinking, and trial-and-error reflection (Friesen & Scott, 2013). Teachers trained in the inquiry approach stimulate thinking skills that are of a higher order and are analytically based to meet the needs of the 21st century learner (Darling-Hammond & Richardson, 2009). Open inquiry and opportunities for exploration lead to better, more concrete knowledge of concepts (Zion & Mendelovici, 2012). Deeper understandings of real-world problem-solving are assessed differently, as students are required to solve real problems just as professionals do (Friesen & Scott, 2013), resulting in authentic experiences that have meaning and value (Thomas, 2000).

**STEM and STEAM Education**

The birth of the STEM initiative began with the launching of Sputnik, the first Russian satellite in space in 1957, which brought into awareness the Russian lead in science and technology at a time when the United States and Russia were involved in what was known as the cold war (Knight, Mappen, & Knight, 2011). In 1958, the National Defense of Education Act was passed out of concern for the competitiveness of America’s workforce, and attention was turned on the reform of educational curriculum in the United States (Knight et al., 2011). In 1983, *A Nation at Risk* was published by President Ronald Reagan’s National Commission on Excellence in Education and called for strengthening the STEM curriculum, particularly in science and mathematics

(National Commission on Excellence in Education, 1983). Enormous amounts of time, money, and policy were expended on these programs for several decades (Knight et al., 2011) in an attempt to improve America's global standing in the STEM fields. Further legislation has been passed since then, including the American Competitiveness Initiation in 2006, the Carl D. Perkins Career and Technical Education Act also in 2006, and the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act in 2007 (Knight et al., 2011). Currently, President Barack Obama has focused on expanding the Educate to Innovate campaign in mathematics and science curriculum in K-12 education (Educate to Innovate, 2009), with an emphasis on increased exposure of students through secondary school to quality STEM education with mandates and extra funding (Knight et al., 2011).

The National Science Foundation (NSF) was first credited with using the term STEM (Hanover Research, 2011), with the original program designed by Judith A. Ramsey, former director of NSF's Education and Human Resources Division (Fioriello, 2013). The acronym STEM stands for the study of science, technology, engineering, and mathematics in education (Carnevale et al., 2011) and has come to importance with a current initiative (Herschbach, 2011; Lee, 2012) toward developing a future workforce better prepared in these areas. To maintain America's strength in the global market and to raise the American standard of living, STEM education is needed, as 65% of employees with bachelor's degrees in STEM professions earn more than employees with master's degrees in non-STEM occupations (Engler, 2012). The President's Council of Advisors on Science and Technology (PCAST) (2010) outlined goals to increase competiveness on the global market in the areas of technology and science. Four goals were set forth for K-12 curriculum:

1. Ensure a STEM-capable citizenry.
2. Build a STEM-proficient workforce.
3. Cultivate future STEM experts.
4. Close the achievement and participation gap. (PCAST, 2010)

The goals set forth by PCAST were recognized as a necessary part of future preparedness of America's workforce (2010).

Preparation in the STEM employment areas is vital to keep the United States competitive in the global market (Carnevale et al., 2011; Langdon et al., 2011; National Research Council, 2011). Students in the United States underperform in comparison to peers in 14 different countries (Eberle, 2010). The importance of a STEM-qualified workforce is vital to U.S. economic growth (Studica, 2013). STEM competency is necessary for the creation of global leaders of the future and to close the performance gap between America and other industrialized countries (Fioriello, 2013).

A STEM curriculum would include in-depth study in the areas of science, technology, engineering, and mathematics in an inquiry-based or project-based forum (eMINTS, 2011; Etherington, 2011; Papanikolaou, 2010). Successful STEM education provides real-world application of the four areas of science, technology, engineering, and math, and provides sequenced learning for students in these disciplines (Eberle, 2010). Trefil and Trefil (2009) wrote, "Students live in a world increasingly dominated by science and technology," (p. 1) and, "No student should be allowed to the leave the education system without acquiring the basic knowledge of the physical world incorporated in the great ideas" (p. 2). Critical thinking and science literacy creates innovators, leading to new products and economic sustenance (Eberle, 2010). According to Trefil and Trefil (2009), only then will students be able to fully participate in a technological society. In projections of postsecondary opportunities to meet the demands of the future workforce, Science Pioneers (SP) (2014) stated, "Introducing our young children and current students to STEM opportunities and getting them engaged and excited about seeking advanced schooling in these areas is essential to meet these demands" (para. 8). Jobs of the future will require workers who can collaborate, work independently, and think critically (Fioriello, 2013), and a STEM curriculum in K-12 schools that encourages development of 21st century skills will assist in meeting these needs (Meyrick, 2011).

Hanover Research (2011) published a report by The National Governors Association Center for Best Practices that stated, "STEM literacy refers to an individual's ability to apply his or her understanding of how the world works within and across four interrelated domains" (p. 6) and defined the goals of STEM education as follows:

1. Scientific literacy – The ability to use scientific knowledge and processes to understand the natural world as well as the ability to participate in discussions that affect it.
2. Technologic literacy – Students should know how to use new technology, understand how new technologies are developed, and have the skills to analyze how new technologies affect us, our nation, and the world.
3. Engineering literacy – The understanding of how technologies are developed via the engineering design process using project-based lessons in a manner

that integrates lessons across multiple subjects.

4. Mathematical literacy – The ability of students to analyze, reason, and communicate ideas effectively as they pose, formulate, solve, and interpret solutions to mathematical problems in a variety of situations. (p. 6)

The report by Hanover Research (2011) also stated a need for the STEM subjects to become more of a focus of a K-12 curriculum. Competence in the STEM areas is critical to success in post-secondary career preparation and in the workforce (National Governors Association Center for Best Practices, 2015).

The STEM initiative was announced by President Obama in 2009, and the United Kingdom appointed a National STEM director along with initiatives in that country toward educational expectations in the areas of science, technology, engineering, and mathematics (Williams, 2011). President Obama's initiative to increase STEM education to groups underrepresented, such as women, indicates the importance of making STEM a priority over the next decade (Eberle, 2010). In addition, President Obama introduced a goal of an additional 100,000 teachers in the STEM areas, and the Educate to Innovate Initiative called for public and private sector cooperation in finding solutions to the current shortages (Engler, 2012).

While Williams (2011) recognized the benefits of skills developed by students in the STEM areas, he cautioned against the initiatives for political reasons and pointed out a disconnect that results when motives are behind educational decisions, instead of cooperation of governing bodies for the benefit of students. To develop consistency in academic success in the STEM areas, cooperation among parties is vital. Eberle (2010) stated:

> Increased commitment from businesses and other stakeholders that support STEM education is critical, now more than ever. STEM education creates the pipeline of future innovators that will move this country forward. Making STEM education a priority is important, for our nation's short and long-term future. (p. 13)

Most of the future jobs will require math and science understanding (Eberle, 2010). Cardona (2013) stated, "While the nation is expected to have more than 8.6 million STEM-related jobs available in 2018, as many as three million of those jobs might be unfilled, warns the National Math and Science Initiative" (p. 1).

STEAM is STEM education with an included focus on arts (Gritzinger, 2011; Puffenberger, 2012). A balanced STEM curriculum should include the arts (Fioriello, 2013), along with reading, writing, and speaking, which are essential for good communication skills (Meyrick, 2011). Research suggests integration of subject matter (Moye, 2011; Robelen, 2011) gives more meaning to learning and teaches to the whole child (Fioriello, 2013; 21st Century Schools, 2010). Literacy plays an essential role in an aligned curriculum and provides a clear lens with which to view the history of previous attempts at problem-solving (Meyrick, 2011). Effective collaboration is dependent on effective speaking and listening skills, along with the skill of persuasion (Meyrick, 2011).

Meyrick (2011) stated STEM content knowledge should include all subject areas, including the arts. Employers of the future will look for applicants who have, among other training, a "solid liberal arts education" (Gordon, 2010, para. 17). Citing the marginalization of social studies curriculum (sociology, psychology, economics, geography), Maguth (2012) stated funding and reduced emphasis on the social arts have been an effect of the STEM initiative and called for a renewed commitment to integrating this discipline into a balanced education for responsible civic understanding. Maguth (2012) claimed social studies are the glue that holds STEM together, and the health and prosperity of American politics could be threatened by a lack of understanding of the political process and ethics involved in increased competency with technology and science. According to Meyrick (2011), social studies allow for students to examine social issues that affect decision-making, along with an understanding of economics and politics.

Puffenberger (2012) stated, “Nationally, two organizations specifically, have launched STEM education initiatives that coincide with President Obama's *Educate to Innovate* campaign, both of which incorporate the media arts” (para. 5). Arts integration brings in personal connection and depth to the inquiry-based process of learning and teaching as published by Northwestern Illinois University (NEIU) (2014). Studies have shown arts education impacts positively on math test scores and comprehension (Puffenberger, 2012). Teachers who integrate the arts into the curriculum become more satisfied with their teaching and find themselves recommitted to the teaching profession (Arts Education Partnership, 2014). Puffenberger (2012) stated education is not keeping up with a child’s reality if not related to media and what really matters in a child’s world. According to Jolly (2014):

> A STEM program is just one part of a child’s education, focusing on math and science. But our children need a well-rounded, quality education that enables them to make informed decisions that will impact the world and the way they live (para. 16).

Arts can be incorporated into a STEM curriculum to include innovation and creativity (Ballard, 2014). As stated by Jim Price, the director of The Child's Primary School (TCPS), Albert Einstein avowed great scientists are also great artists (Ballard, 2014).

According to Lantz (2009), STEM education integrates the four traditional disciplines as "trans-disciplinary in that it offers a multi-faceted whole with greater complexities and new spheres of understanding" (para. 2). Fioriello (2013) stated, "This approach to education is designed to revolutionize the teaching of subject areas such as mathematics and science by incorporating technology and engineering into regular curriculum by creating a 'meta-discipline'" (para 1). Tarnoff (2010) stated although "STEM skills are a vital part of this country's edge, [a missing set of ] creativity-related components that are equally critical to fostering a competitive and innovative workforce" is the arts (para. 2). Tarnoff (2010) used the example of Apple products with the features of the interface design and stated without the "A" for arts, "there would be no outlet" for the science, technology, engineering, and math behind the success of the product (para. 6). Tarnoff (2010) also stated, "Companies want workers who can problem-solve, collaborate creatively and contribute/communicate new ideas" (para. 3). Employers in an innovation-driven economy are more interested in problem-solvers, critical thinkers, and good communicators (Association of American Colleges and Universities, 2013).

Fioriello stated (2013), "STEM Education attempts to transform the typical teacher-centered classroom by encouraging a curriculum that is driven by problem-solving, discovery, exploratory learning, and require students to actively engage a situation in order to find its solution" (p. 1). Application of real-world learning opportunities is provided by schools specializing in focused STEM curriculum and is critical to the economy of each state (Thomasian, 2011). A STEM learning environment is not teacher-centered, but rather driven by problem-solving, exploratory learning, discovery, and engagement in situations that require problem-solving (Fioriello, 2013).

**The Need for STEM Education**

To create a diverse workforce in the STEM fields, the education system needs to recruit STEM professionals from all sectors of the community to partner in promoting STEM education in schools, according to a report to the Washington legislature (STEM Work Group, 2010). Increased visibility of engineering and technology in curriculum for students in grades K-12 has been proposed by supporters of the STEM initiative, along with experiences in scientific inquiry and problem-solving, to produce a literate citizenry (Hanover Research, 2011). According to a study published by Grunwald & Associates (2010) for Walden University, there is overwhelming agreement of "educators and policymakers to parents and businesspeople" (para. 2) that technology needs to be a part of the education process.

The STEM Education and Workforce (2014) reported in 2013, only 42% of fourth-grade students, and 35% of eighth-grade students scored proficient or above in mathematics on standardized testing. There was very little change since 2011, when 32% of eighth-grade students scored at or above the proficient target (STEM Education and Workforce, 2014). Graduating high school seniors need to be proficient in mathematics in order to pursue STEM careers (BHEF, 2011). Engler (2012) reported in surveys conducted by Georgetown University Center on Education and the Workforce of graduating high school seniors, reasons for not entering STEM-related majors in college included the following: not knowing enough about the fields (34%), finding STEM subjects too challenging (one-third), and not feeling prepared to seek further education in the STEM areas (28%).

Businesses are currently hiring from other countries, not only because of cost, but also because talent in the STEM areas is found there (Carnevale et al., 2011). In 2008, United States' students receiving bachelor's degrees in science and engineering numbered 31%, compared to 51% in China, and 61% in Japan (STEM Education and Workforce, 2014). Training in the areas of science and mathematics is what will be needed in the future (Langdon et al., 2011), and jobs requiring computer proficiency, including programming and development, will make up the majority of STEM employment opportunities (Carnevale et al., 2011). Engineering is recognized as the application piece that completes an integrated mathematics, science, and engineering program to encourage problem-solving and innovation in students (Fioriello, 2013).

There is debate, however, over whether to embrace the new practices or continue "playing it safe" (Grunwald & Associates, 2010, para. 4) with the traditional methods of teaching. A study by Grunwald & Associates (2010) for Walden University entitled "Educators, Technology, and 21st Century Skills: Dispelling Five Myths" quoted Duncan, the U.S. Secretary of Education, in saying that in order to fully engage students, technology tools and resources are needed, along with prepared educators who acquire "new skills along with their students" (para. 5) in a collaborative learning environment.

According to the National Science Teachers Association (NSTA), elementary schools that offer STEM education are seeing a rise in educational achievement among lower socio-economic groups and are making a difference for teachers as well as students involved in the programs (Shapiro, 2013). A STEM education benefits all students and is a move from an education system traditionally tailored for female students, with an emphasis on literary concepts, which allows students to explore at greater depths for independent innovation and exploration (Fioriello, 2013). Elementary STEM programs show evidence of greater engagement in students, increasing enrollment, and an increase in reading scores from 2010 through 2012 (Shapiro, 2013).

In a report to Congress by the U.S. Department of Education, the Institute of Education Services, and the National Center for Education Evaluation and Regional Assistance, reading and mathematics software effectiveness was presented as a collaborative effort of school districts, researchers, data collection experts, and others (Dynarski et al., 2007). The study was conducted to determine the effectiveness of technology on student achievement (Dynarski et al., 2007). The studies on both mathematics and reading achievement showed no significant difference from zero in the treatment and control groups (Dynarski et al., 2007). The sample was not representative of the whole country and was area-specific (Institute of Education Sciences, 2007).

The National Governors Association Center for Best Practices (2015) called for states to develop standards for technological literacy as a part of the core curriculum. Among the indicators for 21st century literacy is competence with digital tools for global citizenship (P21 Partnership for 21st Century Learning, 2015). Technology as a component of STEM is vital to the nation's economy (National Governors Association Center for Best Practices, 2015).

Walsh (2009) gave five reasons for incorporating technology into the classroom as follows:

1. Professional Development (experience with the internet is becoming a hiring requirement in the educational field) (para. 3)
2. The Power To Engage (collaborative, hands-on, interactive) (para. 5)
3. Students Use Them Already (talking student's language) (para. 5)
4. It Isn't Going Away (it will only grow) (para. 6)
5. Businesses Want to Hire Workers Who Understand the Internet (preparation for real world careers). (para. 7)

Key findings in a national survey of business leaders indicated businesses are looking for workers who exhibit 21st century skills such as collaboration and the ability to problem-solve, think critically, and contribute to innovation (Association of American Colleges and Universities, 2013).

Gordon (2010) stated even when the numbers of unemployed were high, the vacancies in STEM-related fields were left unfilled. The skillset was not there for stepping into those positions; the employers were looking for skills not possessed by the average unemployed worker, and this, unfortunately, will continue to be the trend (Gordon, 2010). In the state of Missouri, the number of high school seniors interested in and proficient in STEM areas has been low, and very few students enrolled in Missouri's two-year college programs have been academically ready for STEM (BHEF, 2011). The STEM Education and Workforce (2014) published 38% of college students who started a STEM major of study in college did not end up graduating in those fields.

**Women and Minorities in STEM**

Gender and racial participation in the STEM fields have remained a concern, with women, along with minorities, making up a proportionally small percentage of graduates in the areas of physical sciences and engineering (Knight et al., 2011). Females are employed in one-fourth of STEM positions in the United States (Hopkins, 2012). While women account for 48% of the American workforce, they only make up 23% of the employees in STEM-related fields, and non-Hispanic, Black, and Hispanic workers who fill 25% of all jobs are only employed in 12% of STEM occupations (STEM Education and Workforce, 2014). The low percentage of women and minorities in the STEM workforce has resulted in the National Science Foundation (NSF) supporting efforts at improving equity since 1993 (NSF, 2012). Welle and Smith (2014) reported women and minorities are noticeably less visible in the technological and scientific workplace. According to Hopkins (2012), women hold 14% of engineering positions and make up only 15% of engineering students in universities.

The STEM initiative is falling short of expectation in recruiting from the underrepresented populations of women and minority students (Knight et al., 2011). The NSF (2012) reported university degree programs showed the lowest proportion in engineering, computer sciences, and physics were awarded to women, with only one-third of doctorates in economics being attained by females. The findings published by Knight et al. (2011) were that females show less interest in the fields of computer/information sciences, engineering, science, and mathematics, and that minority students entering these fields often do not have the background to complete higher education degrees in the STEM areas.

Doctoral programs in areas related to STEM completed by minority groups account for about 7% of the total, with Asian completion holding steady over the past decade, but with a drop in other minority groups (NSF, 2012). Fewer than 30% of STEM jobs in the United States are held by women or individuals of minority status (Welle & Smith, 2014). Slightly over one-fourth of doctorates awarded to women were in mathematics and statistics, as of 2012, which could account for the low number of females employed in these fields (NSF, 2012).

The NSF reported the number of doctorates (see Figure 1) awarded to the underrepresented minority population has remained below 8% since 2004, and 30% of doctorates awarded to blacks were from universities that are historically black institutions (Diep, 2013).

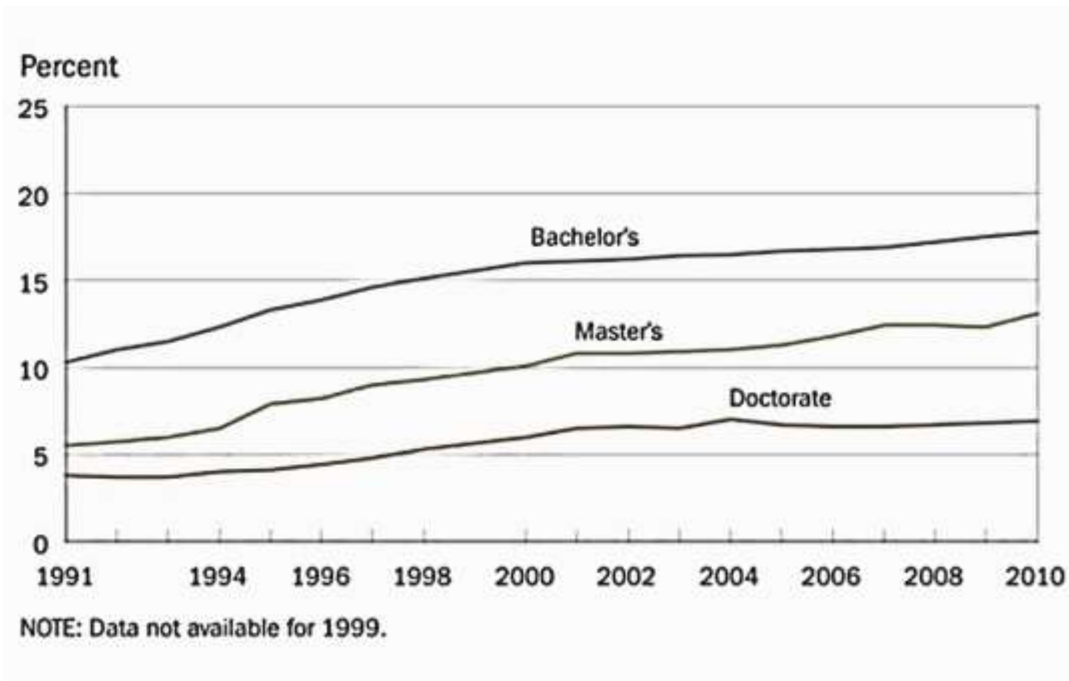


*Figure 1.* Degrees awarded to underrepresented minorities. This graph indicates the low percentage of minorities obtaining higher education degrees in the STEM fields at all levels. Published in *Popular Science* in an article on the lack of underrepresented minorities in STEM fields (Diep, 2013). Reprinted with permission of the author.

Knight et al. (2011) also purported societal stereotyping could be a factor in the lack of interest by women in pursuing STEM careers. Severns (2012) theorized children who have heard gender predictions in skills and abilities are inborn tend to fulfill those prophecies, with girls underachieving in areas such as math, due to a belief that it is too hard for them. The theory is children internalize what they hear, and often that is the reason girls do not attempt challenges in mathematics and are influenced by the stereotyping (Severns, 2012). Girls who have been told intellectual skills and abilities are a gift tend to not rise to the challenges presented in mathematics and science (Dweck, 2012). One program, "Girls Make Change through Engineering," sponsored by the Clinton Global Initiative, is using female STEM college majors as mentors for high school girls in an attempt to build support and interest in young women for entering STEM courses in higher education (Hopkins, 2012).

Stereotyping has been recognized in the lack of visibility of women and minorities in American prime-time programs and children's shows (Welle & Smith, 2014), where 15 men are depicted to each woman in STEM professions. This lack of portrayal of women and minorities in careers such as computer sciences (fewer than 21%) is recognized as a possible cause for fewer numbers of the underrepresented population (girls and students of color) pursuing careers in these fields (Welle & Smith, 2014). Although participation in university STEM programs leading to degrees has improved over the past 20 years for women and minorities, these groups continue to be underrepresented in the STEM workplace (NSF, 2012).

In 1991, women received 29.6% of the B.A. degrees nationwide in computer science, but that had decreased by 2010 to only 18.2% (STEM Education and Workforce, 2014). An increase in candidates for higher degree programs in social sciences and physical and biological sciences has been noted in the STEM underrepresented populations of women and minorities (NSF, 2012). As of 2012, less interest in STEM areas such as computer sciences, economics, mathematics, and physics was shown by females or minority groups (NSF, 2012).

**Inquiry-Based and Project-Based Learning**

The inquiry-based learning concept has been studied throughout the last seven decades since conceived by Jean Piaget, a Swiss development psychologist and philosopher (The Center for Teaching and Learning, 2011). The concept of learning by inquiry was developed in Piaget’s (1952) constructivist theory of how children learn. According to Piaget (1952), a child builds on experience and learns by hands-on activities, making meaning of the world for the self (The Center for Teaching and Learning, 2011).

The constructivist concept is closely intertwined with the inquiry-based method of learning (Thirteen Ed, 2014). John Dewey is credited with introducing this method of learning in the United States for the purpose of educational reform (Thirteen Ed, 2014). In the early 1960s, fear of losing advantages in technology and military spurred The Educational Policies Commission to determine students need to develop “ten rational powers” (Thirteen Ed, 2014, para. 2). The rational powers listed in the 1961 document (Meador, 1988) coincide with the fundamentals of inquiry learning.

Also, in the 1960s, science curriculum was evaluated for change from the traditional method of instruction to a hands-on approach in a movement called the “alphabet soup” curricula (Thirteen Ed, 2014, para. 4). Although this approach was not successful in bringing about the perceived changes necessary for science concept acquisition, attitudes of schools toward learning were recognized as not being conducive to inquiry-based thinking (Thirteen Ed, 2014). Project-based learning was noted to encourage students to engage in challenging tasks rather than to avoid them, and it was theorized girls especially benefited from this model of instruction in areas such as mathematics (Thomas, 2000). The whole language movement opened up a change in practices that would later make hands-on learning a more acceptable practice (Thirteen Ed, 2014). Given the current statistics of women entering higher education majors in mathematics (Welle & Smith, 2014), project-based learning represents a viable method of instruction (Thomas, 2000).

Piaget published findings in 1964 that constructive learning continues over a lifetime and is sequential, with the following stages; "Sensorimotor (birth to 2 years), Preoperational (2-7 years), Concrete (7- adolescence) and Formal Operational (adolescence - adult)" (Gillani, 2010, p. 3). According to Gillani (2010), the adolescent-adult phase is the stage where higher-level reasoning and problem-solving take place. Piaget theorized people assimilate new information by placing new information into existing knowledge, as in combining geometric shapes into a new shape (Gillani, 2010). The new understanding does not change the former understanding, but develops it further (Gillani, 2010). Also, according to Piaget, when a learner is unable to assimilate new knowledge into existing schema, accommodations are made in the learner by modifying former understandings or creating new ones (Gillani, 2010).

In 1962, Suchman proposed an inquiry-training model based on the theory of Piaget on how cognition develops. Suchman's model used the process of hypothesis, data collecting, and problem solving in an inquiring manner, but with discipline (Gillani, 2010). Voss conducted research and concluded inquiry-based learning is effective for all ages of learners in developing creative thinking, and in 1980, Papert theorized constructing knowledge through inquiry should become the focus of education, rather than direct instruction methods (Gillani, 2010).

In 1987, Flavell discussed what he labeled as three operations learners acquire in the Formal Operation stage as documented by Piaget. The three operations recognized by Flavell (1987) are in the areas of reasoning: Combinational, Prepositional, and Hypothetical-Deductive. Combinational reasoning allows learners to approach problem solving from an integrated approach rather than a linear one (Flavell, 1987). Prepositional reasoning results in the ability to think abstractly, while Hypothetical-Deductive reasoning allows learners to work from more than one hypothesis in order to solve problems (Flavell, 1987). These three areas result in problem solving that coincides with Piaget's research on how learners construct meaning (Gillani, 2010).

Modern research suggests students learn more effectively by being required to answer essential questions as part of a process of research inquiry (Etherington, 2011; Jun-Ming, Huan-Yu, Shian-Shyong, & Chia-Jung, 2011). The MINTS project began as collaboration among the University of Missouri, MODESE, MOREnet, and the Missouri Department of Higher Education during the 1997-1998 and 1998-1999 school years and was financed by Southwest Bell Foundation (eMINTS, 2011). The goal of the project was to determine if technology usage and changes in teaching methods would improve student performance in the classroom (eMINTS, 2011). Test performance improved, but attitudes of teachers and students were the most profound changes noted (eMINTS, 2011). The MINTS project became the eMINTS statewide initiative in the 1999-2000 school year during the term of Robert Bartman, then the Missouri Commissioner of Education (eMINTS, 2011).

Inquiry-based learning is an essential component of comprehensive eMINTS (2011) certification, and studies have shown students who learn through a curriculum that includes technology usage and inquiry-based projects, facilitated by eMINTS certified teachers, perform better on standardized tests than peers learning in a setting that does not provide the same opportunities (Martin et al., 2008). Skills in the 21st century require innovation and creative design (Meyrick, 2011), and project-based learning allows for students to show progress through a collaborative approach that allows learners to construct meaning through complex tasks and concrete artifacts (Papanikolaou & Boubouka, 2011).

Inquiry-based teaching incorporates the scientific method into students' natural tendencies for curiosity, leads to deeper understanding of concepts, and allows for teachers to facilitate student learning (Meyers & Brandt, 2010). This works with the Frameworks for 21st Century Goals and what outcomes are necessary for students to graduate (21st Century Schools, 2010). Inquiry-based teaching is seen as a natural method of combining student curiosity with critical thinking skills to better understand the world (Warner & Myers, 2011). Answers lead to more questions, which is a normal outcome in science (Warner & Myers, 2011). The inquiry-based instructional model is recommended by The National Science Education Standards for effectively teaching the sciences (Meyrick, 2011).

Inquiry-based learning is the cornerstone for teaching science and helps students to develop practical skills, where they learn to construct arguments and engage in critical discussion (Brunsell, 2011). Best practices in inquiry-based learning are based on an instructional model designed by The Biological Science Curriculum Study (BSCS) (2013), a team led by Principal Investigator Roger Bybee and are known as the five Es (NASA eClips, 2013):

1. Engage: to gain student interest and set the stage for further learning. This step in the model draws on student's prior knowledge and experience.
2. Explore: in which students are given opportunities to make their own hypothesis and draw their own conclusions with hands-on experiences, and with the teacher acting as facilitator.
3. Explain: where students communicate their findings with each other, reflect on learning, and where misconceptions and correct vocabulary usage are guided by the teacher.
4. Extend: students are allowed to use their new knowledge to apply their understanding to new and novel situations.
5. Evaluate: the diagnostic process where teachers and students determine the learning that has taken place. (paras. 3-7)

The five Es are based on the constructivist approach to learning, allowing students of all ages to build on prior knowledge to construct meaning and continually reflect on the learning process (Corporation for Public Broadcasting, 2002). Science laboratory activities should be more inquiry-based, giving students the opportunities to read, write, and critique in the process of learning (Brunsell, 2011).

In a report by Hanover Research (2011) citing The Governors Association Center for Best Practices, project-based lessons were reported as a component of developing engineering literacy, one of the essential elements of the STEM curriculum. Henderson and Dancy (2011) noted lecture-based instruction in STEM should be limited in favor of best practices that involve students in interactive learning. Learning improved when instruction moved away from traditional to researched methods and strategies, and involved faculty and students as meaningful participants (Henderson & Dancy, 2011).

Project-based learning has been noted to increase the performance and classroom participation of students who have not performed well in the traditional classroom (Thomas, 2000). A successful STEM program would include project-based learning, along with small class size, integrated curriculum, and a focus on recruiting from the underrepresented population (Robelen, 2011). Benefits of project-based learning include giving students choices, promoting interest, and creating something of perceived value (Thomas, 2000).

**21st Century Goals**

The International Society for Technology in Education (ISTE) (2011) stated, “Today’s educators must provide a learning environment that takes students beyond the walls of their classrooms and into a world of endless opportunities” (para. 3). The U.S. Department of Education is offering competitive grants for technology, and part of the criteria for accountability is that money must be used to evaluate the effectiveness of “integrating technology into the curricula and instruction” and “the impact that ed tech activities have had on student achievement” (Goldman, 2009, para. 4). Gillani (2010) published an article on “E-Learning Environments” with a training model based on the constructivist theories of Piaget (1952). In this article, Gillani (2010) discussed the precepts of constructivism and how it has become the basis for inquiry-based learning programs. The eMINTS program began implementation of technology-oriented classrooms in the 1999-2000 school year and resulted in increased test scores and positive attitudes in students toward learning (eMINTS, 2011).

Today's students need to learn the four Cs (critical thinking, collaboration, communication, creativity) along with innovation, the skills necessary for technology mastery, in addition to the traditional three Rs (reading, writing, and arithmetic) (Blair, 2012; 21st Century Frameworks, 2011). Another school district in New Jersey integrated technology into the daily instruction, along with professional development and increased opportunities for learning with the help of technology (Devine, 2012). The results documented indicated increased student performance (Devine, 2012). Moreover, STEM, when taught in K-12 curriculum, provides the opportunity needed for all students to meet 21st century goals through mastery of content and skills (Johnson, 2009; Meyrick, 2011; Partnership for 21st Century Skills, 2009).

Texley (2007) published the most important predictors for success in college and career known as 21st century competencies:

- The ability to search, find, and evaluate information on the Web.
- Web-style reading skills, which are very different from the sort of left-to-right sequential pattern that most older adults learned in school.
- Communication skills, synchronous and asynchronous.
- Multimedia production skills—the ability to integrate text, images, and video. (para. 8)

These skills need to be intrinsic and sequential for students from middle school age through high school in order to prepare for careers that increasingly require the 21st century skillset (Texley, 2007).

In an elementary classroom, the students should be involved in inquiry around an essential question, generating their own questions in the process, engaging in problem-solving, and collaborating with peers in cross-curricular study (Lange, 2014). Lange (2014) also stated life-long learning and self-advocacy are promoted with critical thinking skills. Technology plays a part in the lives of children and is a tool that when used in the classroom engages young children in learning (Murphy, DePasquale, & McNamara, 2007). Technology extends learning for young children and allows them to build proficiency towards more advanced academics (Murphy et al., 2007). Critical thinking skills and technology competency are among the 21st century skills as outlined by P21 Partnership for 21st Century Learning (2015).

Included in the goals of 21st century learning are what are referred to as "soft skills," particularly scientific inquiry and problem-solving (Hanover Research, 2011, p. 7). The social sciences also focus on these soft skills of scientific inquiry and problem-solving, essential components of an integrated curriculum focused on 21st century learning (Maguth, 2012). As more women enter disciplines in social/behavioral sciences and medical/life sciences (Knight et al., 2011), integration of the social sciences into the STEM curriculum (Maguth, 2012) could maintain interest in the STEM fields for women, who despite comparable competence in early education (Knight et al., 2011), lose interest in the STEM fields as they mature.

**Professional Development**

Teachers make a big difference in student learning, especially in mathematics, seen as the foundation of STEM subjects, and need to be able to excite and engage all students (STEM Smart Brief, 2011). Professional development for STEM teachers involves more than just learning to incorporate technology and engineering into existing math and science curriculum (NSTA, 2013). It involves integration of the content areas by showing students how each subject supports the others in STEM-based content areas (NSTA, 2013). Teachers who are highly qualified to teach in the STEM areas are in demand, particularly in elementary schools (Center for American Progress, 2011). Extensive professional development is essential to success in instruction in the STEM curriculum (Shapiro, 2013).

Unfortunately, teachers highly skilled in science and mathematics are not the norm, and most STEM educators are ill-prepared (STEM Smart Brief, 2011). Schools and educators often need to rely on support from the STEM communities in order to offer students the opportunities needed for learning in the STEM areas (IBM Corporation, 2013). Content specialization and team-teaching approaches are one way to best utilize teacher strengths (Center for American Progress, 2011). However, some precepts are recognized as essential to the success of an effective STEM learning environment, with a focus on teacher knowledge of best practices (Henderson & Dancy, 2011) and skills in utilizing materials and methods for hands-on learning (Knight et al., 2011).

Changing teaching practices to accommodate student learning relies on teacher learning, through effective professional development (Gullamhussein, 2013). Creating opportunities for teacher growth and development is a step in aiding student achievement and starts with an “assessment of strengths and weaknesses of current practice in light of new reform demands” (Gullamhussein, 2013, p. 2). Teaching critical thinking and problem-solving, according to the Center for Public Education, is an area that is weak in most classroom instruction (Gullamhussein, 2013). To be effective, teachers need deep knowledge of the content taught, as well as expertise in working with all types of learners (STEM Smart Brief, 2011).

Teacher confidence in technology usage is important for students to learn to use technology appropriately and constructively in a competitive world (Grunwald & Associates, 2010). According to the study by Grunwald & Associates (2010), teachers do not feel prepared for incorporating technology usage in the classroom in the manner in which students need to meet the goals of the 21st century, and teachers benefit from regular use of technology to build confidence in using it in the classroom. Building confidence and a feeling of competence is important for teachers to be effective with instruction in STEM (NSTA, 2013). Additionally, anxieties and concerns need to be overcome, along with understanding of integration of the STEM subjects to other subject areas, like art and social studies (NSTA, 2013). Too often, professional development in STEM is offered in short fragments and does not meet the needs of individual teachers (STEM Smart Brief, 2011).

Epstein and Miller (2011) stated improvement in STEM education depends on well-qualified and licensed teachers in the content areas. According to a publishing by STEM Smart Brief (2011), 10-20% of science and mathematics teachers are not certified, nor did they major in their subject areas, and elementary teachers typically are only required to take two math courses in their college programs. Additionally, university education programs have no curriculum standards and little oversight, adding to the state of poor preparation of new teachers for the STEM teaching environment (STEM Smart Brief, 2011).

In a study published on successful STEM programs, the recommendations from STEM Smart Brief (2011) to elicit meaningful improvement in professional development of teachers included the following:

1. Teachers need sustained science-specific training, including content, current research on how children learn science, and strategies for teaching science.
2. Initial training should be aligned with district-specific curricula so that teacher candidates are learning what they actually will be teaching.
3. Ongoing professional development must address teachers' classroom work and the problems they encounter in school settings, and then teachers need to try out new strategies in their classrooms, report on their experiences back to the training program, discuss, reflect, and learn from them.
4. On-site professional support should allow for regular interaction and collaboration with colleagues and school leaders, such as professional learning communities. Teachers need multiple and sustained opportunities for continued learning over a substantial time interval.
5. On-site professional support should allow for regular interaction and collaboration with colleagues and school leaders, such as professional learning communities.
6. Teachers need multiple and sustained opportunities for continued learning over a substantial time interval. (p. 5)

Yager and Yager (2011) published a study in which teachers were a part of an initiative for school-based leadership teams (SLBT). The study indicated positive behavior changes in teachers participating in the program, over the behavior of teachers not taking part in the initiative (Yager & Yager, 2011). Recommendations from the study were for principals to recognize the important part played in the implementation of successful professional development (Yager & Yager, 2011). The STEM Smart Brief (2011) put forth results from a study of successful STEM professional development programs that positive outcomes were achieved by focusing on content in mathematics and science, on-site follow-up in classrooms, and teacher contact time of 50 hours or more.

Teacher quality alone does not improve student outcomes, and support is needed by leadership in a positive and collaborative environment (STEM Smart Brief, 2011). Traditional teaching methods are not effective in supporting a STEM learning environment (Meyrick, 2011). Principals need to share the focus of the staff and demonstrate commitment to content knowledge in the STEM areas, supporting professional development of teachers and setting expectations for integration across the curricular areas (STEM Smart Brief, 2011). In order to effectively integrate engineering with project-based learning for problem-solving, teachers need to learn methods for doing so (Meyrick, 2011).

**Summary**

STEM education is needed for the future in order to achieve goals for 21st century skills (BHEF, 2011; ISTE, 2011). Students of today will be the workforce of tomorrow, and the technology skills required for success in technical fields need to be taught in school (Hanover Research, 2011). Studies show much more needs to be known in order to create successful STEM programs that will ensure student preparation for future employment in the areas of science and mathematics (National Research Council, 2011). STEM education as initiative appears to be the future of the global world, with major countries in competition to produce top applicants in the areas of science and mathematics (Carnevale et al., 2011). Initiatives have been in place since the Russians sent Sputnik into outer space (Knight et al., 2011). America is lagging behind other industrialized nations on assessments in mathematics and science, and high school graduates are not pursuing higher education in the STEM fields of study for various reasons, or are not completing college with STEM degrees (STEM Education and Workforce, 2014).

Women and minority groups continue to be an underrepresented group in STEM areas and in the STEM workforce (Hopkins, 2012). Employment opportunities in areas such as mathematics and science are not being pursued in great numbers by women, non-Hispanic minorities, Hispanics, or Blacks (STEM Education and Workforce, 2014), even though STEM jobs are going unfilled (Engler, 2012). Predictions were that STEM employment opportunities would expand 20% by the year 2010 (Hopkins, 2012).

Jobs in the areas of science will require the skillsets of young people trained in science inquiry (Brunsell, 2011). A well-rounded education should include integration of all content areas, including the soft skills of not only inquiry but problem-solving (Hanover Research, 2011). Effective inquiry-based learning educational models (Brunsell, 2011) support the learning of skills needed for the jobs of the future.

The STEAM programs, where the arts are incorporated into the STEM curriculum, were also researched as a viable inclusion into a program to teach to the whole child (Fioriello, 2013; Gritzinger, 2011). Technology is suggested to be the best way to engage students in learning, which could be the best reason for school districts to invest (eMINTS, 2011; Institute of Education Sciences, 2007). Inquiry-based and project-based instruction in a STEAM setting teaches to all learning levels of all children (Fioriello, 2013; Hanover Research, 2011). A STEM education is a more effective means to bring about greater achievement on standardized testing, as well as preparing students for the jobs of the 21st century, while continuing to meet the need for the United States to remain a player on the world market (Engler, 2012).

In Chapter Three, the research plan to evaluate the efforts of one school district in Missouri to implement an elementary STEAM laboratory program is introduced. The population and sample utilized for the study are outlined. Instrumentation is explained, along with the methods of data collection. Ethical considerations are explained in regard to the welfare of participants.

Presented in Chapter Four are the results of the responses of the parent and teacher surveys, standardized testing results, and administrator interviews. Data were quantified where practical, and a *t*-test was utilized to determine significance of standardized assessment scores. Interviews were coded for themes and are presented as qualitative data for a more thorough understanding of the perceptions of the various stakeholders involved. Survey results of the perceptions of the stakeholders in the program were analyzed, standardized testing results were compared, and interviews with the designers of the laboratory program were coded for similarities and differences in perception of the process used in the design planning. This provided a triangulation of data for a more thorough analysis of the case study. Methods utilized are explained, along with a plan for adding to the existing body of knowledge for other districts interested in this process.

In the fifth chapter, the findings of the qualitative and quantitative data are presented for similarities and discrepancies in stakeholder perceptions. Implications are noted, and recommendations are given based on the analysis of the triangulated data. Implications for practice are outlined, and assumptions given as to the validity of the data collected. A summary is included of the process of the case study of the laboratory STEAM school.

# Chapter Three: Methodology

Current research indicates students in the United States are not competitive with students in other industrialized countries where more educational focus is placed on science and mathematics (Carnevale et al., 2011). The initiative toward education (in preparation for employment in 21st century skills) from the United States government aims to raise the achievement level of the nation's students in key areas (Herschbach, 2011). To meet the current goals for educating students in the areas of science, technology, engineering, and mathematics (STEM), a school district in Missouri developed a plan for a laboratory elementary school, referred to in this paper as the Unique School, to focus on STEM with the addition of the arts, becoming a STEAM program.

Enrollment in Unique School was by parent choice and a lottery system. Parents who chose to enroll their students in Unique School agreed to a longer school year of an additional 20 days, along with parental involvement as an expectation. The delivery model chosen by this district for this particular building was inquiry-based learning. This study included evaluation of the process of developing the framework for the school, along with the strategy for introduction of this concept to the community. The researcher also evaluated the perceptions of parents who chose to enroll their children in the chance (as determined by lottery) to attend the laboratory program, and the perceptions of teachers in Unique School of the program during the first year of implementation. Administrator interviews were coded for perception of these stakeholders in the development of the program.

**Problem and Purpose Overview**

The introduction of the STEAM elementary laboratory school concept was unique to the area. The purpose of this study was to evaluate the process of gaining public acceptance of the concept and how well the format for this program meets the needs of 21st century learning, as determined by perception and measurement of academic growth.

**Research questions and hypothesis.** The following research questions guided this study:

1. What was the purpose of the development of a STEAM laboratory school for one Missouri school district?

2. What is the difference, if any, between the achievement level of students enrolled in the STEAM program and students enrolled in traditional elementary programs as measured by the Scholastic Reading Inventory and Acuity assessments in mathematics and reading?

$H2_0$ There is no difference between the achievement level of students enrolled in the STEAM program and students enrolled in traditional elementary programs as measured by the Scholastic Reading Inventory and Acuity assessments in mathematics and reading.

3. What are the reasons that parents choose to enroll their children in the STEAM focused elementary school over a traditional elementary setting in the district?

4. What are the perceptions of parents and teachers about the experience of students attending the STEAM program?

**Research Design**

Quantitative and qualitative data were used in a mixed design for analysis of the research questions. Mixed-method design was chosen for this study in a "convergent design" where quantitative and qualitative data were collected simultaneously, yet analyzed separately, with data merged for conclusion (Creswell & Clark, 2011, p. 73). Informed consent of participants was obtained by use of a university-approved consent form (see Appendices A & B). Surveys were developed and administered to a purposive sampling of parents whose children were enrolled in the STEAM laboratory school program to evaluate perception of outcomes of attending the school. Surveys were also administered to teachers in the program to evaluate the curriculum, delivery model, and the achievement of students in Unique School. Interviews were conducted with administrators involved in the development of the program to evaluate reasoning behind the implementation of the STEAM curriculum.

Standardized test scores were evaluated for achievement of students in grades three through six, as measured by growth in communication arts and mathematics while attending the STEAM program. Results were compared against achievement scores, as measured by growth, of traditional elementary programs (grades three through six) in the district. Random samples of 30 students' scores in each of the evaluated grade levels from the laboratory school and 30 students' scores from the other buildings in the district in each grade level were compared for growth as determined by standardized testing administered at the beginning and end of the school year. Differences were identified by means of an unpaired, two-tailed *t*-test (Bluman, 2013). Interviews were conducted with administrators to evaluate the process of designing the STEAM school, the strategy used to educate the community about the expectations for developing an elementary STEAM program, and reflections on the first year of operation of the Unique School.

**Population and Sample**

The population analyzed was from a medium-sized school district (between 5,600 and 6,000 students) in midwest Missouri. The district consisted of four elementary schools (grades K-4), one K-6 elementary, two upper elementary (grades 5-6) schools, one junior high school (grades 7-8), and one high school (grades 9-12). Student enrollment increased from approximately 5,200 in 2009 to 5,900 in December, 2012, with an average of 18 students per classroom teacher in 2012 (MODESE, 2013). The total free and reduced price meal rate for the district was 35.6%. Percentages of elementary students who qualified for free and/or reduced price meals in each building are shown in Table 1.

Table 1

*Free and Reduced Price Meal Percentages, December 2012*

| K-4 Buildings | | | | K-6 Building | 5-6 Buildings | |
|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G |
| 61.24 | 40.23 | 34.43 | 37 | 30.57 | 39.21 | 31.49 |

*Note.* Building E represents the Unique School.

Participants consisted of school administrators, teachers, and parents involved in the planning and first year of operation of the laboratory K-6 elementary school, referred to as the Unique School, focusing on science, technology, engineering, arts, and mathematics (STEAM). Emphasis of the program was on literacy taught through the lens of science by use of nonfiction reading and writing materials. The building chosen for the location of the laboratory school is the oldest elementary campus in the district, is land-locked (no more room for growth), and is centrally located in the district.

The survey sample was limited to elementary buildings in one school district, along with members of the design team for the laboratory school, which included parents, teachers, and district administrators. The sample for interviews consisted of school administrators. Comparisons of growth as measured by standardized assessments were made for a random sample of 30 attendees of the laboratory school in each grade level (third through sixth) to a random sample of 30 students from across the district in traditional educational settings at the same grade levels.

**Instrumentation**

Surveys were created to obtain quantitative data on expectations for students attending the laboratory school. The surveys were given to parents and teachers from whom permission was obtained for participation (see Appendices C & D). To ensure anonymity, the surveys taken by parents and those taken by teachers were administered digitally on a Google survey instrument, with no names required for participation. Secondary information was obtained from standardized test scores in communication arts and mathematics on tests given such as Scholastic Reading Inventory (SRI) (an online reading assessment that determines reading levels based on Lexile scores) and Acuity (an online predictive assessment given in language arts and mathematics as a formative tool to determine preparation toward state standardized testing). Lexile reading scores and predictive scores obtained from these measures were analyzed for growth from the beginning of the school year until the end of the school year. Interviews were conducted with school administrators who were involved in the design process of the STEAM program (see Appendix E).

**Data Collection**

Surveys were conducted by means of a five-point Likert scale taken online to assure anonymity during June 2013. A *t*-test was used to determine differences in the achievement as measured by growth in language arts and mathematics. Interviews took place in June 2013. One interview was an online, electronic (e-mail) format, at the request of the participant, while four were conducted in person, audio recorded for accuracy, and transcribed. Assessment data were gathered in May and June, 2013.

**Data Analysis**

Quantitative information was analyzed from the surveys on a Likert scale ("Likert Scale," 2012) in order to determine expectations of students *attending* the laboratory program from the perspectives of parents and teachers. Similar questions were utilized to evaluate perceptions of parents and teachers of student achievement *after* attendance at Unique School. The data were then compiled and analyzed for descriptive statistics.

A two-tailed *t*-test was applied for comparison of growth of the random samples on standardized assessments regularly given to all students in the district, which added another quantitative component to the study. A null hypothesis, (no difference between the traditional elementary students' levels of achievement and the levels of achievement of students in the laboratory school, as determined by growth), was tested. A confidence level (Bluman, 2013) of 0.05 was set, and *t*-test results greater than 0.05 indicated the null hypothesis could not be rejected. The assumption was made that any *t*-test results less than 0.05 indicated no statistical difference in achievement between the two samples of students (Bluman, 2013).

Interviews added a qualitative component to evaluate the process and expectations of the district employees involved in the design process of the STEAM school. Analysis of interviews was performed by coding and organizing interview data into substantive categories to evaluate for themes in order to draw conclusions (Maxwell, 2013). Triangulation was achieved by evaluating input from parents and teachers, and by evaluating student achievement data. Analysis of interview information from school officials on the process of development and implementation of the Unique School added further information to assist in determining whether expectations had been met for the first year of operation of the Unique School.

**Ethical Considerations**

Confidentiality and anonymity were of utmost importance in the data collection used in this study. Once the IRB approved the research project (see Appendix F), district permission was given for use of the standardized test scores as quantitative data. Office administrators from each of the buildings involved gathered test scores for the reading and mathematics assessments utilized, removed any identifying information, and submitted the data to the researcher. Test results were sorted into two groups, the Unique School and a compilation from the other elementary schools in the district, at each grade level. The scores from each test were numbered and randomized by use of an online tool created by Randomness and Integrity Services, Ltd. (2015). The first 30 randomly selected scores from each group were used for the *t*-test. This identical process was used for each grade level (third through sixth) and for each assessment (Acuity and SRI) used in the study. No submitted data were excluded for randomizing.

For the surveys given to parents and teachers, a neutral employee with access to all e-mails sent a description of the research project and an informed consent. Anonymity was assured, and the consent form was worded in such a way that consent was given by following a link to the survey tool (Google Surveys, 2013) with an explanation the participant need only respond to what he/she was comfortable with answering. The identities of participants were at no time known to the researcher. All results were tabulated via Google Surveys (2013).

Interview participants were contacted by e-mail initially with an explanation of the project and a request for participation. Informed consent was then provided in person and by school mail, along with a list of questions to be used in the interviews. After obtaining signed consent, which assured anonymity, interviews were scheduled. Four of the interviews were conducted face-to-face, and one was completed by e-mail at the request of the participant. Interviews were recorded with permission of the interviewees and later transcribed by the researcher. Each participant was labeled with a letter A-E, for the purpose of sharing in this study, thereby assuring anonymity.

**Summary**

Data gathered through research were used to evaluate the decision made by one Missouri K-6 elementary school to become a STEAM (science, technology, engineering, arts, and mathematics) laboratory school with voluntary enrollment. The study evaluated parental choice in enrolling students into the program, educators' perceptions on the efficacy of the model, and administrative expectations of the STEAM curriculum.

Administrators who were involved in the design and implementation of the STEAM program were interviewed for perceptions of the success of the unique program.

Responses to interviews were coded and compared to evaluate similarities and differences in reflections on the process for design of the Unique School. This information was analyzed to determine if this district, or other school districts, should consider investing in additional technology and professional development needed to undertake the process of implementing further STEAM programs. The triangulated data collected were qualitative and quantitative in an attempt to determine if improvement in student achievement was indicated that would meet the growing need for education in the areas of science and mathematics, and if further laboratory programs should be created in this particular district.

Described in Chapter Four is the process used to elicit stakeholder input about perceptions of the program. The methods utilized for data collection are explained and summarized for consideration. Survey responses of participants are outlined, and the results are quantified for a more complete picture of the perceptions of parents and teachers of students in the laboratory program.

Quantifiable data were collected from standardized assessment results and compared by means of a *t*-test, and the results are included. Interview questions asked of administrators involved with the planning process behind the implementation of the STEAM laboratory school are shared and responses provided. An analysis of the results of the triangulated data is given at the end of Chapter Four.

In Chapter Five implications for practice, based on the research and data analysis, are presented. Recommendations for the future of this district and others interested in this process are offered for consideration. A summary of the process undertaken in this study is shared for an overview of the project, the purpose behind the study, and the perceptions of those involved in the first year of operation of the STEAM laboratory school. All data collected are included for an objective consideration of the results of the case study.

# Chapter Four: Analysis of Data

The purpose of the study was to determine the efficacy of the first year of operation of the STEAM laboratory school and perceptions of the stakeholders in the program. Data were collected from standardized testing utilized by the district which included Acuity Mathematics (CTB/McGraw-Hill, 2013), Acuity English Language Arts (CTB/McGraw-Hill, 2013), and Scholastic Reading Inventory (2012). A random sample of 30 students' scores from each grade level from the laboratory school were compared to a random sample of 30 students' scores from other schools in the district for growth in mathematics and reading in grades three through six.

Parents were contacted by means of a neutral staff member of the school who had permission to access the e-mail addresses of prospective participants. An introductory e-mail was sent to all parents of students in grades three through six in the STEAM laboratory school. A link to the online survey was included in the introductory e-mail, and an explanation was given that accessing the link and participating in the survey constituted informed consent by the participants.

Surveys taken by parents and teachers were completed by use of Google Surveys (2013), using a Likert scale of 1-5, where 1 was a rating of *strongly disagree* and 5 was a rating of *strongly agree*. Responses were compared for similarities in perceptions among parents and staff. Descriptive accounts of various components of the program were given in the survey statements to parents and teachers. The statements were rated by the participants in an attempt to elicit perceptions about the efficacy of the STEAM laboratory program.

The parent surveys were completed by 75 parents.  Staff surveys were completed by 17 teachers (classroom teachers, special area teachers, and special education teachers).  All surveys were conducted anonymously with no contact between the participants and the researcher.  All responses from parents and teachers were graphed and tabled and are included in this chapter.

Interviews were conducted with administrators who were instrumental in the design and development of the laboratory school program, and who continued to be major participants in the operations and decisions of the school.  All interviewees were given the questions in advance of interviews, and participation in all questions was completely voluntary.  Five questions were asked in an open-ended design, and the answers to each question were compared for similarities and discrepancies in responses.  The face-to-face interviews were recorded with participant permission and were later transcribed by the examiner.  All five administrators were asked identical questions.  Four of the five administrator interviews were conducted in person.  One interview was completed in an online format at the request of the interviewee, based upon time constraints in the schedule and difficulty in participating in a face-to-face interview.  Interviews were coded into substantive categories.

Data from standardized testing samples were subjected to a *t*-test with a margin of error at 0.05, and a null hypothesis was posed (there would be no difference in the academic rate of growth in students at the laboratory school and students in the traditional elementary schools in the district).  Standardized testing data were collected through the administrative office and were randomized by the researcher by means of an online tool.  No student names were known to the researcher, and all data were included.

**Parent Survey Statements**

Parents of students in grades 3-6 were invited to respond anonymously to a survey to evaluate their perceptions of the STEAM program. Participation in the survey was voluntary.

**Parent survey statement 1. I feel that having my student attend the STEAM laboratory school program improved his/her performance in mathematics.**

The percentage of parents who responded their child's performance in math was improved by attendance at the STEAM school was 59% (with ratings of 4 and 5). Neutral responses on the question were given by 26% of the participants, and 15% responded with a negative perception to this question (1 and 2) (see Table 2).

Table 2

*Summary of Parent Responses to Survey Statement 1*

| | Rating | Responses | Percentage |
|---|---|---|---|
| SD | 1 | 0 | 0% |
| D | 2 | 11 | 15% |
| N | 3 | 19 | 26% |
| A | 4 | 22 | 31% |
| SA | 5 | 20 | 28% |

*Note.* Percentage of parent responses go survey statement 1 on a 1-5 scale.

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

**Parent survey statement 2. It is important to me that my student attends the STEAM laboratory school program again next year.** Parents were asked to rate the importance of their children continuing in the laboratory school program for the following year with 68% responding favorably (derived by adding the number of 4 and 5 responses). Neutral responses were provided by 22% of participants, and 10% responded with negative ratings of 1 or 2 (see Table 3).

Table 3

*Summary of Parent Responses to Survey Statement 2*

| | Rating | Responses | Percentage |
|---|---|---|---|
| SD | 1 | 3 | 4% |
| D | 2 | 4 | 6% |
| N | 3 | 16 | 22% |
| A | 4 | 11 | 15% |
| SA | 5 | 38 | 53% |

*Note.* Percentage of parent responses to survey statement 2 on a 1-5 scale.

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

**Parent survey statement 3. I feel that it has been important for my student to use technology on a daily basis in order to be the most successful academically.** When asked about the importance of students using technology on a daily basis in order to be successful academically, 64% of the parents responded favorably (combined ratings of 4 and 5). Neutral responses were provided by 21% of respondents, and less favorable responses were given by 15% of respondents (derived by adding the number of ratings of 1 and 2) (see Table 4).

Table 4

*Summary of Parent Responses to Survey Statement 3*

| | Rating | Responses | Percentage |
|---|---|---|---|
| SD | 1 | 3 | 4% |
| D | 2 | 8 | 11% |
| N | 3 | 15 | 21% |
| A | 4 | 21 | 29% |
| SA | 5 | 25 | 35% |

*Note.* Percentage of parent responses to survey statement 3 on a 1-5 scale.

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

**Parent survey statement 4. My student's achievement in the area of mathematics was not greatly affected by attendance at the laboratory STEAM school.** When parents were asked if their students' performance in math was not greatly affected by attendance in the STEAM laboratory school, 25% responded either *agree* or *strongly agree*. Neutral responses were given by 33% of participants, and 41% responded as either *disagree* or *strongly disagree* (see Table 5).

Table 5

*Summary of Parent Responses to Survey Statement 4*

| | Rating | Responses | Percentage |
|---|---|---|---|
| SD | 1 | 11 | 15% |
| D | 2 | 19 | 26% |
| N | 3 | 24 | 33% |
| A | 4 | 11 | 15% |
| SA | 5 | 7 | 10% |

*Note.* Percentage of parent responses to survey statement 4 on a 1-5 scale.

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

**Parent survey statement 5. I would not have been disappointed if my student had not been chosen through the lottery for attendance at the laboratory STEAM school.** Parents were asked if they would not have been disappointed if their child had not been chosen for the laboratory school, and 71% responded as *disagree* or *strongly disagree.* There were 19% neutral responses, and 9% responded *agree* or *strongly agree* (see Table 6).

Table 6

*Summary of Parent Responses to Survey Statement 5*

| | Rating | Responses | Percentage |
|---|---|---|---|
| SD | 1 | 28 | 39% |
| D | 2 | 23 | 32% |
| N | 3 | 14 | 19% |
| A | 4 | 4 | 5% |
| SA | 5 | 3 | 4% |

*Note.* Percentage of parent responses to survey statement 5 on a 1-5 scale.

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

**Parent survey statement 6. I feel that my student would have been just as successful in any elementary program in the district, even without daily technology.** The final question to parents was to rate whether their children would have been just as successful in any elementary program in the district, even without technology; 39% responded favorably, with 29% neutral responses, and 32% responded *disagree* or *strongly disagree* (see Table 7).

Table 7

*Summary of Parent Responses to Survey Statement 6*

| | Rating | Responses | Percentage |
|---|---|---|---|
| SD | 1 | 7 | 10% |
| D | 2 | 16 | 22% |
| N | 3 | 21 | 29% |
| A | 4 | 22 | 31% |
| SA | 5 | 6 | 8% |

*Note.* Percentage of parent responses to survey statement 6 on a 1-5 scale.

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

**Teacher Survey Statements**

Participating staff who completed the survey were recruited by e-mail by a neutral party within the building. An explanation of the research project was offered, and informed consent was given by those willing to participate in the survey. At no time were the identities of the participants known to the researcher. The questions were similar to those used in the parent surveys, but were designed to be appropriate for teachers within the school.

**Teacher survey statement 1. I feel that students attending the STEAM laboratory school program improved their performance in mathematics.** When staff were asked to respond to statement 1, about student performance in math in the laboratory school, 76% responded there was an improvement in performance. Neutral responses were given by 24% of teachers. There were no ratings below 3 (see Table 8).

Table 8

*Summary of Responses to Teacher Survey Statement 1*

| | Rating | Responses | Percentage |
|---|---|---|---|
| SD | 1 | 0 | 0% |
| D | 2 | 0 | 0% |
| N | 3 | 4 | 24% |
| A | 4 | 8 | 47% |
| SA | 5 | 5 | 29% |

*Note.* Percentage of teacher responses to survey statement 1 on a 1-5 scale.

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

**Teacher survey statement 2. It is important to me that I continue to teach in the STEAM laboratory school program.** Teachers were asked to rate the importance of continuing to work in the laboratory school environment for the upcoming year, all responses were 4 and 5 (see Table 9).

Table 9

*Summary of Responses to Teacher Survey Statement 2*

| | Rating | Responses | Percentage |
|---|---|---|---|
| SD | 1 | 0 | 0% |
| D | 2 | 0 | 0% |
| N | 3 | 0 | 0% |
| A | 4 | 3 | 18% |
| SA | 5 | 14 | 82% |

*Note.* Percentage of teacher responses to survey statement 2 on a 1-5 scale.

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

**Teacher survey statement 3. I feel that it is important for students to use technology on a daily basis in order to be the most successful academically.** Teachers were asked to respond to whether or not they thought daily use of technology was important in their students' success, and no responses were given in *disagree* or *strongly disagree* categories of 1 or 2. Neutral responses measured 12%, while 88% of respondents agreed technology usage was important (ratings of 4 or 5) (see Table 10).

Table 10

*Summary of Responses to Teacher Survey Statement 3*

| | Rating | Responses | Percentage |
|---|---|---|---|
| SD | 1 | 0 | 0% |
| D | 2 | 0 | 0% |
| N | 3 | 2 | 12% |
| A | 4 | 6 | 35% |
| SA | 5 | 9 | 53% |

*Note.* Percentage of teacher responses to survey statement 3 on a 1-5 scale.

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

**Teacher survey statement 4. Student's achievement in the area of mathematics was not greatly affected by attendance at the laboratory STEAM school.** Teachers were asked to respond to student achievement not being greatly affected by attendance in the laboratory school, and 59% responded as *disagree* or *strongly disagree* (ratings of 1 and 2), while 24% were neutral, and 18% responded as *agree* or *strongly agree* (ratings of 4 and 5) (see Table 11).

Table 11

*Summary of Responses to Teacher Survey Statement 4*

| | Rating | Responses | Percentage |
|---|---|---|---|
| SD | 1 | 3 | 18% |
| D | 2 | 7 | 41% |
| N | 3 | 4 | 24% |
| A | 4 | 2 | 12% |
| SA | 5 | 1 | 6% |

*Note.* Percentage of teacher responses to survey statement 4 on a 1-5 scale.

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

**Teacher survey statement 5. I would not have been disappointed if I had not been chosen to teach at the laboratory STEAM school.** When teachers were asked to respond if they would not have been disappointed by not being chosen to teach in the laboratory school, 65% responded as *disagree* or *strongly disagree* (ratings of 1 and 2), while 0% were neutral, and 35% responded with a rating of 4 or 5 (see Table 12).

Table 12

*Summary of Responses to Teacher Survey Statement 5*

| | Rating | Responses | Percentage |
|---|---|---|---|
| SD | 1 | 10 | 59% |
| D | 2 | 1 | 6% |
| N | 3 | 0 | 0% |
| A | 4 | 5 | 29% |
| SA | 5 | 1 | 6% |

*Note.* Percentage of teacher responses to survey statement 5 on a 1-5 scale.

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

**Teacher survey statement 6. I feel that students would be just as successful in any elementary program in the district, even without daily technology.** Teachers were asked to respond if they felt students would be just as successful in any elementary program in the district, even without daily technology, with 82% as *disagree* or *strongly disagree*, 12% as *neutra*l, and 6% of the responses as *agree*. There were no ratings of 1 in this category (see Table 13).

Table 13

*Summary of Responses to Teacher Survey Statement 6*

| | Rating | Responses | Percentage |
|---|---|---|---|
| SD | 1 | 7 | 41% |
| D | 2 | 7 | 41% |
| N | 3 | 2 | 12% |
| A | 4 | 1 | 6% |
| SA | 5 | 0 | 0% |

*Note.* Percentage of teacher responses to survey statement 6 on a 1-5 scale.

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

A comparison of responses reported by parents and teachers are illustrated in the following graphs (see Figures 2 through 7). Some noted differences existed in the perceptions of the participants to the statements as presented through the survey. The questions were worded similarly with respect to the positions of the patrons who consented to participate in the study. The statements were ordered on a Likert scale for a 1-5 response, with 1 as *strongly disagree*, 3 as *neutral*, and 5 as *strongly agree*.

In Figure 2, the responses to the statement concerning improved performance in mathematics are graphed. The trend in the results indicated a large percentage of parents, and all teachers surveyed, responded *neutral*, *agree,* and *strongly agree* to that particular statement. There was an indication, however, some parents did not feel attendance at the STEAM school would be particularly important to performance.

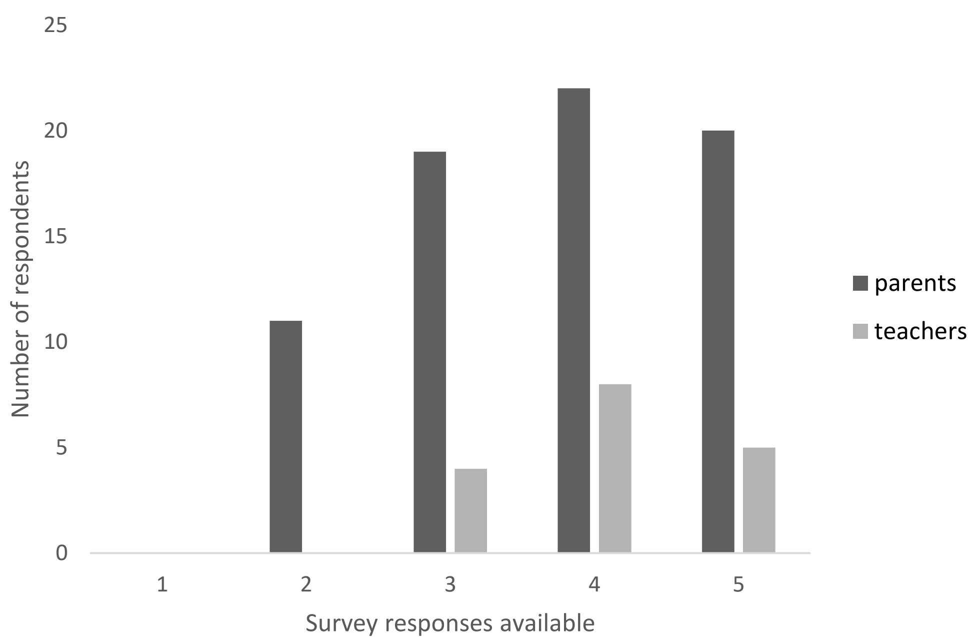


*Figure 2.* Comparison of parent and teacher responses to survey statement 1. A side-by-side comparison was made to determine perception of mathematics performance as the result of attendance at the laboratory school. (1= Strongly Disagree, 2= Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

In Figure 3, the responses to the statement concerning the importance of the students attending the laboratory school in the following year are graphed. The results indicated that a large percentage of parents responded *agree* or *strongly agree* to that particular statement, compared to highly favorable teacher responses. There was an indication, however, some parents did not feel attendance during the following year would be particularly important for their student. This indicated teachers had an overall more optimistic perception of the future of the program than the parents during the first year of operation of the program.

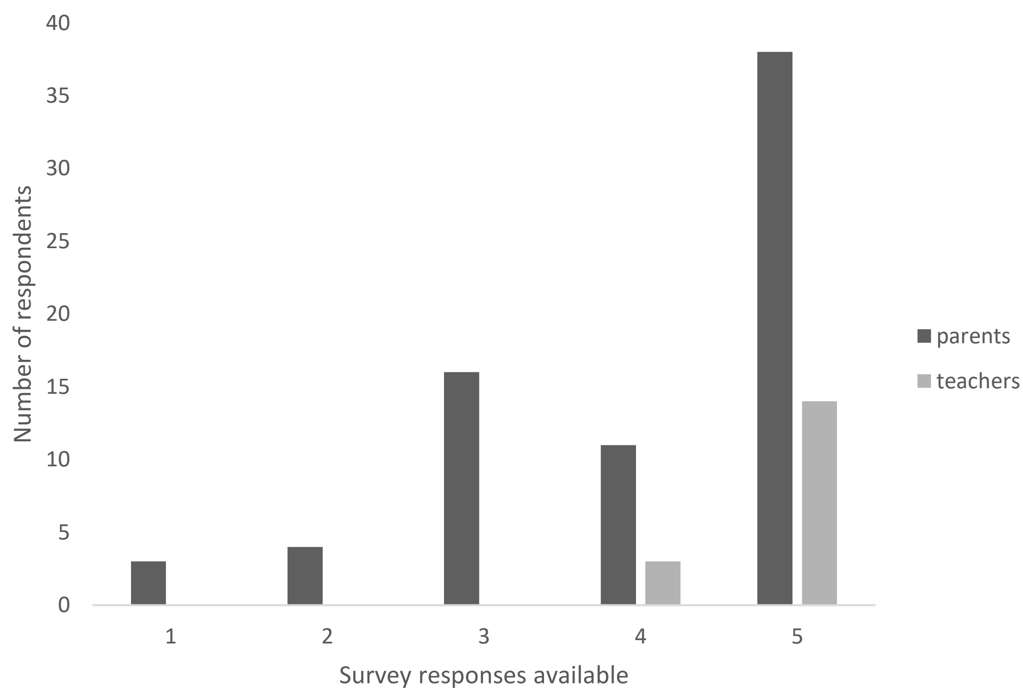


*Figure 3.* Comparison of parent and teacher responses to survey statement 2. Parent and teacher responses to whether or not attendance in the laboratory school was of importance in the subsequent year. (1= *Strongly Disagree*, 2= *Disagree*, 3 = *Neutral*, 4 = *Agree*, 5 = *Strongly Agree*)

Figure 4 displays the differences in perceptions between parents and teachers as reported on Statement 3 about the daily use of technology as an intergral part of a successful academic program. While the majority of responses from both groups of participants were favorable to the statement, there were parents who clearly did not see the importance of the use of technology as a tool for academic success.

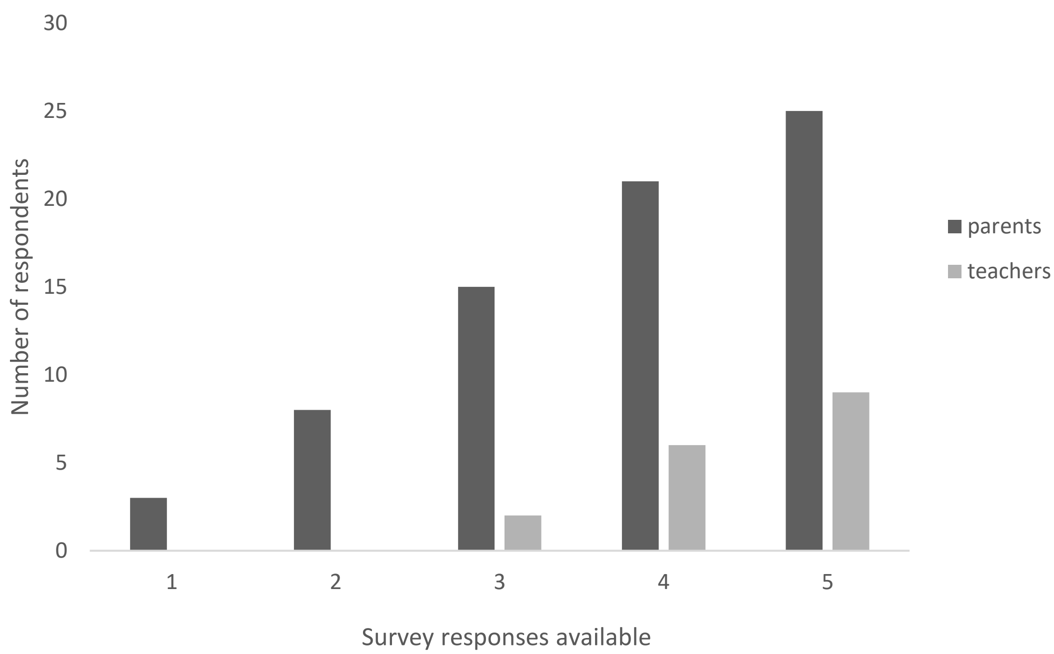


*Figure 4.* Comparison of parent and teacher responses to survey statement 3. Parent and teacher perceptions of regular technology usage as an important component of a successful academic program. (1= *Strongly Disagree*, 2= *Disagree*, 3 = *Neutral*, 4 = *Agree*, 5 = *Strongly Agree*)

The responses as indicated by survey results to a negatively-worded statement about the STEAM program not affecting mathematics performance are shown in the following graph. These were the responses to statement 4. Again, the majority of responses appeared to be favorable toward the program's effect on academic performance in mathematics. However, there were responses from both groups that indicated there was not agreement on this topic.

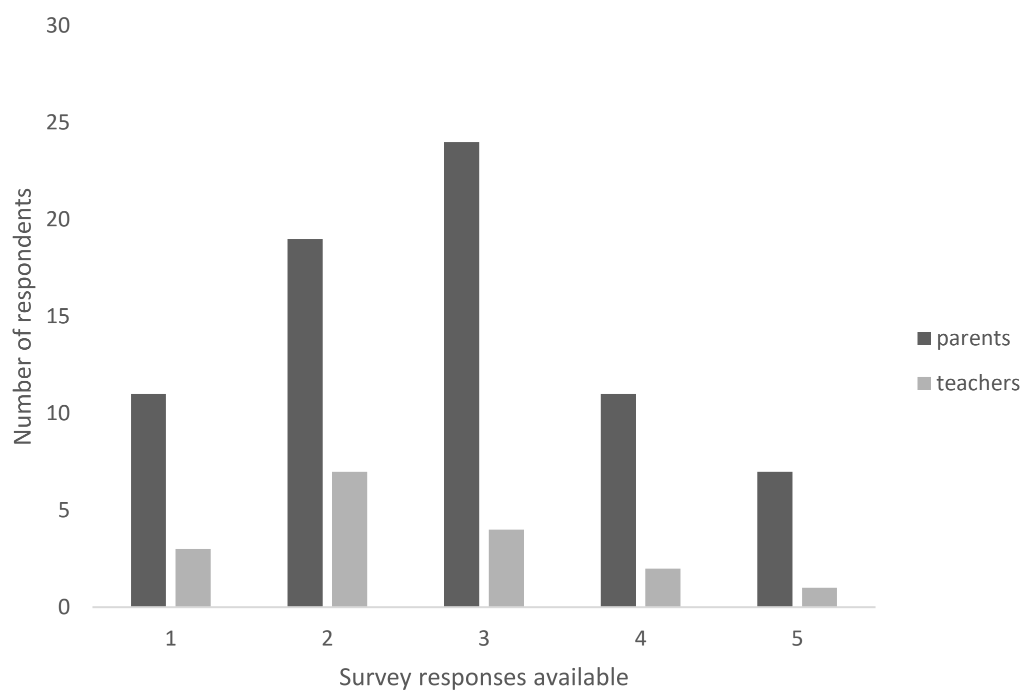


*Figure 5.* Comparison of parent and teacher responses to survey statement 4. Responses are compared to a negatively-worded question on the effect of the STEAM laboratory program on mathematics performance. (1= *Strongly Disagree*, 2= *Disagree*, 3 = *Neutral*, 4 = *Agree*, 5 = *Strongly Agree*)

In Figure 6, the responses are denoted to statement 5. The statement was worded in the negative and focused on the importance of students being chosen for the program through the lottery process. Responses of parents indicated they would have been disappointed if their children had not been chosen. Teacher responses indicated how disappointed they would have been to have not been chosen to teach in the program. From both groups there was an indication that disappointment would have been high for many of the respondents.

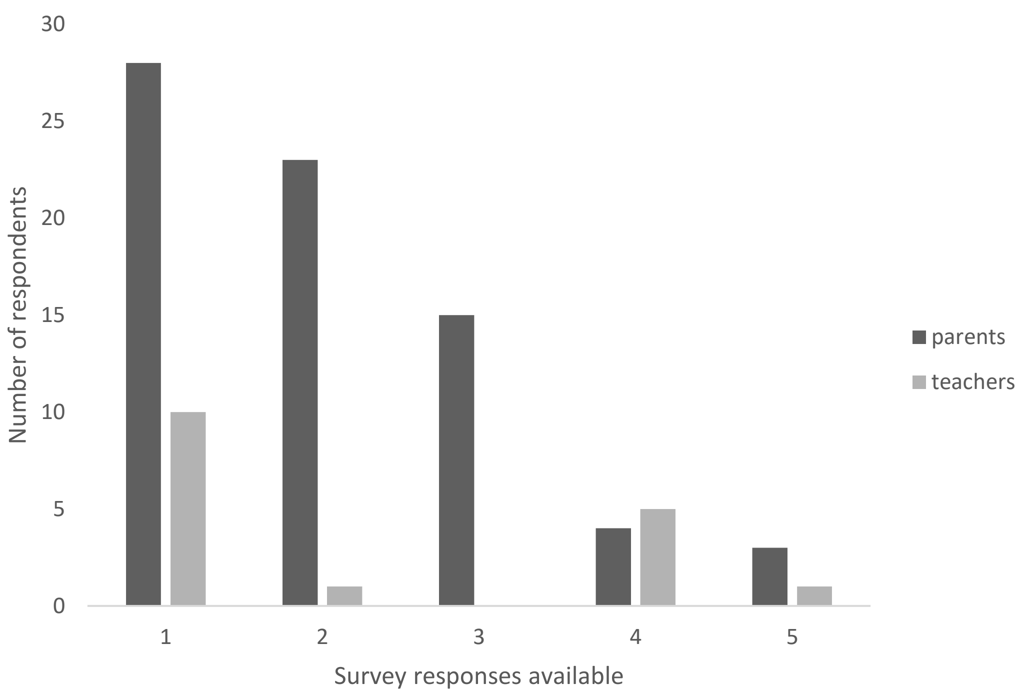


*Figure 6.* Comparison of parent and teacher responses to survey statement 5. This statement was worded as to “not being disappointed” if not chosen to participate through the lottery for the program. (1= *Strongly Disagree*, 2= *Disagree*, 3 = *Neutral*, 4 = *Agree*, 5 = *Strongly Agree*)

In the final statement of the survey, the perception of whether or not students would have been just as successful in any elementary program in the district was posed. The results, as seen in Figure 7, indicated an overwhelming majority of parents would have been just as confident with any school in the district. Teachers, on the other hand, appeared to disagree with that statement.

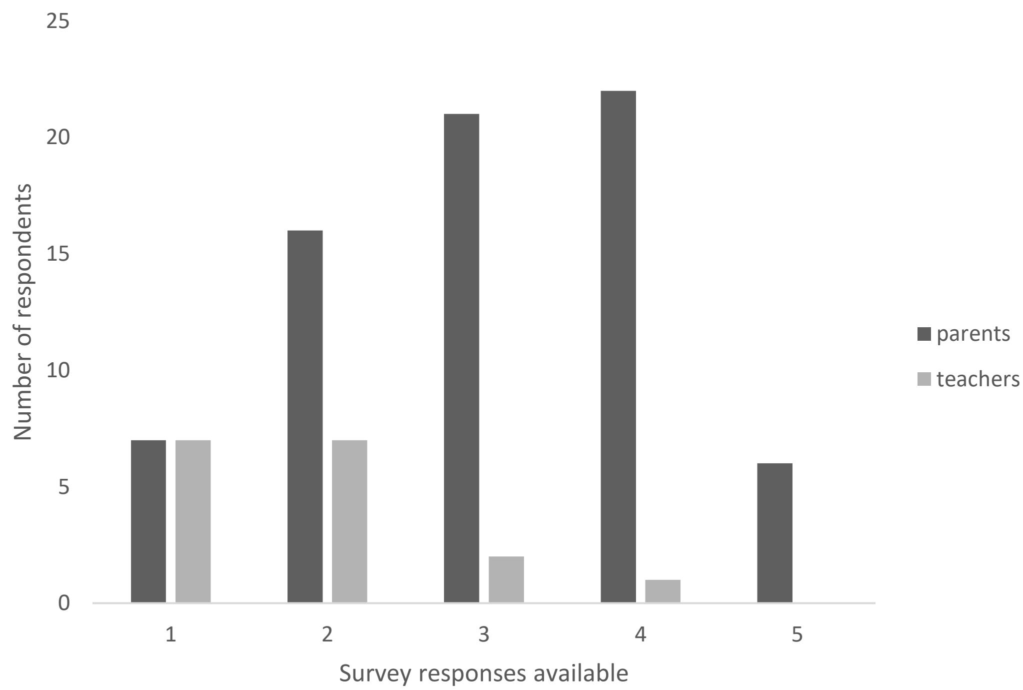


*Figure 7.* Comparison of parent and teacher responses to survey statement 6. Parent degree of confidence in any elementary program in the district was much higher than teacher perception that other programs would not be as effective for performance.

(1= *Strongly Disagree*, 2= *Disagree*, 3 = *Neutral*, 4 = *Agree*, 5 = *Strongly Agree*)

**Standardized Testing Data**

The *t*-test results in Acuity mathematics growth indicated the null hypothesis could not be rejected in any of the grade levels. In third grade, the *t*-test score was 0.13, and in fourth grade the *t*-test score was 0.97. In fifth grade, the *t*-test score was 0.37, and in sixth grade the score was 0.33. All *t*-test scores in mathematics achievement growth of students in the laboratory school compared to students in the same grade levels in traditional elementary schools in the district were > 0.05 and would not allow rejection of the null hypothesis of no difference between growth rates (see Table 14).

Table 14

*t-test Scores for Growth in Mathematics*

| Grade Level | **t*-test score |
|---|---|
| 3 | 0.13 |
| 4 | 0.97 |
| 5 | 0.37 |
| 6 | 0.33 |

*Note.* **t*-test scores derived by comparing growth rate of student samples in STEAM laboratory school to traditional elementary student samples by means of Acuity Mathematics Predictive Tests.

The Acuity English Language Arts scores included the following: third grade .79, fourth grade .26, and fifth grade .26. Only in sixth grade was the null hypothesis of no difference between growth rates rejected with a *t*-test score of .03 < 0.05 (see Table 15).

Table 15

*t-test Scores for Growth in English Language Arts*

| Grade Level | **t*-test score |
|---|---|
| 3 | 0.79 |
| 4 | 0.26 |
| 5 | 0.26 |
| 6 | 0.03 |

*Note.* **t*-test scores derived by comparing growth rate of student samples in STEAM laboratory school to traditional elementary student samples by means of Acuity ELA Predictive Tests.

A random sample of 30 students' scores from each of grades three through six were collected and compared to a random sample of 30 students' scores from the same grades comprised of students from the non-STEAM elementary schools in the district. The scores were subjected to a *t*-test and compared for growth in reading as assessed by the SRI. In grades three and six, the null hypothesis was not rejected with scores of 0.80 and 0.93, respectively. The *t*-test scores indicated for grades four allowed for rejection of the null hypothesis with 0.02, while in grade five the null hypothesis could not be confidently rejected with 0.06, a difference of 0.01 (see Table 16).

Table 16

*t-test Scores for Growth in Reading*

| Grade Level | **t*-test score |
|---|---|
| 3 | 0.80 |
| 4 | 0.02 |
| 5 | 0.06 |
| 6 | 0.93 |

*Note.* **t*-test scores derived by comparing growth rate of student samples in STEAM laboratory school to traditional elementary student samples by means of Scholastic Reading Inventory.

**Interview Results**

Five district administrators, who were directly involved in the design and implementation of the STEAM laboratory school and who continued to be major participants in the school's operation, were interviewed about the design process. Perceptions of the efficacy of the program in the first year of operation were the focus of the interviews. For the purpose of anonymity, the administrators were referred to as Administrators A, B, C, D, and E. All administrators were asked the same set of questions in an open-ended session. One interviewee provided answers by e-mail, due to scheduling restraints. All others were conducted face-to-face, recorded, and later transcribed by the researcher. Interview questions were coded into substantive categories for similarities and differences.

**Administrator interview question 1. What factors did you consider before proposing/becoming a design team member of the STEAM laboratory school in this district? Why?** Administrator B and Administrator D both responded families already in the district, and those new to the district, were interested in having choice in the opportunities offered for their students' education. A longer school year, service work performed by students, and an opportunity for more involvement by parents were cited by Administrator A as a reason for moving in this direction. Both administrators discussed the unique approach this program would offer to the area.

The unusual concept of the STEAM elementary school in midwest Missouri was discussed as ground-breaking by Administrator C, who responded the value seen in the program was the motivation for becoming a part of the design team for the laboratory school in this district. Research support for this type of program was cited by

Administrator B as a "best practice" for educating students. Administrator E also responded that being a part of designing this program, with a specific focus on STEAM education, was in the best interest of children and was motivated by being instrumental in bridging the gap in technology for students and teachers. Administrator A stated an interest in being a part of the design and planning team, as the science and technology focus would impact teachers.

**Administrator interview question 2. Reflecting back on the process, is there anything that you would do differently if faced with the same decisions today? Why or why not?** Three of the administrators interviewed responded the timing of implementation of the STEAM program was appropriate. Administrator E stated the process was not rushed and would have been drawn out if more time had been spent on planning and decision-making, while Administrator B responded nothing should have been done any differently, and the district had hit a "home run" with this decision. Administrator D responded the "buy-in" from the community went well, and Administrator A stated the district had done a good job on the timing and planning of the STEAM program; however, Administrator A admitted some elements had not been well planned for, particularly in the area of transportation during the extended four weeks of the school year. Some "hang-ups" involving transportation had surfaced, according to Administrator A, in spite of planning, and more time could have been spent on that particular issue.

Another area cited by Administrator A and Administrator D that needed more forethought was professional development. Both of these administrators responded technology issues had not been thought through as well as possible (new equipment and new operating system), and time spent on planning for professional development for teachers would have been beneficial for a smoother transition, if the planning process could be done over again.

**Administrator interview question 3. As we near the end of the first year of operation of this program, what is your perspective on the program? Are you seeing the success that you had hoped for, and in what ways?** The five administrators interviewed expressed positive perceptions of the program in the first year. Administrator B stated all indications, as of the date of the interview, reinforced the belief the STEAM program "hit a homerun," while Administrator D expressed although success was achieved, the pressure of high expectations was felt by teachers. Also, according to Administrator D, this first year was a necessary team-building year for teachers, and in the next couple of years expectations of greater success would be realized. Administrator A stated the first year goal was just "to maintain" in achievement, and the second year would see greater success in this area by way of standardized test scores.

According to Administrator C, teachers jumped in with a "can do" attitude and did a "terrific job of learning on the fly." More training in the way of professional development, particularly in the areas of science and technology usage before the school year started, would probably have made the first year transition easier, according to Administrator E and Administrator C. Administrator E stated success had been achieved by a focus on solutions to the problems that arose, and attitudes toward the environment had been very positive.

**Administrator interview question 4. How does the first year of operation of the STEAM laboratory school change the outlook for the future in this district? Are**

**there any more plans to expand this concept, and in what way?** The administrators interviewed all expressed there is interest and discussion in the idea of another laboratory school. Several of the interviewees expressed a possible next laboratory school might specialize in arts or foreign language, and the success of the STEAM school has shown the community and the board of education a school of choice for parents and students is desirable. Administrator B stated formal discussions have begun with the board on a future laboratory school, but it may not be STEM-focused, and the community could put pressure on the board to go that route.

Administrators C and D stated the focus may be on the arts, while Administrator D expressed a possibility of foreign language as the focus. All of the administrators stated the success of the STEAM laboratory school has resulted in discussion of another such school in the future. Administrator A also responded the present laboratory school would have an effect on an emphasis in science in the other elementary buildings in the district and would put more pressure on the junior high school to prepare for students moving up from the STEAM program.

**Administrator interview question 5. Is there anything else that you would like to add about the STEAM laboratory school?** The open-ended design of this question allowed for a variety of responses from the participants, which are summarized individually. According to Administrator A, a key to the success of the STEAM laboratory school was the choice for teachers in teaching in this type of environment, and an attempt to do otherwise would not work. Also stated was a concern for the students as they leave this environment and move up to another building. This administrator said changes needed to be made in preparation for these students at the upper levels.

Administrator B stated evaluating the components of the STEAM program, such as service work by students and parent participation, will be important for future planning. Continued growth for the students and teachers was stated by Administrator C as "exciting," and in spite of the best planning, a lot of things happen you just do not expect. Examples were given such as transportation and a different schedule for the STEAM school. This administrator said no one can expect all of the things that can happen, and "you don't know until you do it."

Administrator D expressed the extended school year was a good decision, and results will show that. This administrator also said in time (two or three years), the longer school year will result in better achievement for students, parents will probably prefer this for their children, and this is a "real plus for the kids." Seeing the one-to-one technology piloted in the STEAM laboratory school was expressed as a good model for future technology one-to-one implementation in the district by Administrator E. This administrator stated the program was a model for the future of the district, and restated the need for effective professional development in the future. Year two of implementation was, in the opinion of this administrator, going to be exponentially better than year one. A common theme of the responses on question five was that even though year one was successful, real growth in achievement of students was expected in the following years.

**Summary of Data Collection**

Parent and teacher interviews were conducted by an anonymous online survey instrument and were compared for similarities and differences in responses on similar questions. Results were obtained via a Likert scale of 1 to 5, with 1 as *strongly disagree* and 5 as *strongly agree*. Standardized testing data using the SRI (2012), Acuity Math Predictive Tests (2013), and Acuity Language Arts Predictive Tests (2013) were compared from random samples of 30 students' scores in grades three through six in the STEAM laboratory school and 30 random samples of students' scores in the same grades in the other elementary schools in the district by means of a *t*-test. Growth was measured from the beginning of the school year to the end of the school year in math and reading. A confidence interval of $< 0.05$ was used to indicate whether a null hypothesis could be rejected. In most grade levels, in both subject areas, no substantial growth was indicated during the first year of implementation of the STEAM program; however, results were mixed with rejection of the null in grade six in English Language Arts and grade four in reading indicating a possible difference.

Administrator interviews were conducted with key people in the planning and implementation of the STEAM program. Responses were coded into substantive categories for similarities and differences in responses to identical open-ended questions. Triangulation was achieved by the use of standardized test scores, parent and teacher surveys, and interviews. The research design was mixed with qualitative and quantitative data collected and analyzed.

**Summary**

In Chapter Four, the results of the triangulated data were outlined and discussed. Tables of data were created for statement responses from parents and teachers with percentages of each response given. Graphs were also created to compare the responses of parents and teachers to similar statements, for the perceptions of the different stakeholders to the questions asked.

Standardized test scores from the samples utilized for study were subjected to a *t*-test to determine the significance of the findings. Each grade level analyzed was treated to an individual *t*-test. The findings were inserted into tables for ease of understanding. Interviews conducted with administrators who were partially responsible for the design process and the implementation of the program were coded and compared for similarities and differences in perspectives. A detailed description of the processes was described.

Chapter Five offers the findings from the surveys, interviews, and standardized tests. Conclusions, implications for practice, and recommendations for the future of the STEAM program in this particular district are presented. Suggestions are made for other districts interested in the process used in the creation of this particular elementary program.

# Chapter Five: Summary and Conclusions

This case study was conducted after the first year of implementation of a laboratory elementary school specializing in science, technology, engineering, arts, and mathematics (STEAM) in a school district in Missouri. The current national initiative for STEM education (Herschbach, 2011) was behind the design of the program with an inclusion of the arts, based on research for development of the whole child (Arts Education Partnership, 2014; Fioriello, 2013; 21st Century Schools, 2010). Surveys were conducted with parents of students attending the program and teachers working within the school and were analyzed for perceptions of six different statements related to the first year of operation of the STEAM school. Administrators involved in the design and implementation of the program were interviewed with open-ended questions that were coded for similarities and differences in perceptions. Standardized testing results were gathered in the areas of mathematics and reading from students in grades three through six and were compared to testing scores from the other elementary schools in the district in the same grade levels by means of a *t*-test. The results of analysis are summarized in this chapter.

## Findings

The findings of the qualitative and quantitative data are discussed in the next section. The results of parent and teacher surveys were quantified and compared for similarities and discrepancies in the perceptions to statements individualized to the position of the participants. Interview responses from administrators were coded for themes, with similarities and differences noted, and individual perceptions to interview question number six were reported.

**Parent and Teacher Surveys**

Parent and elementary teacher surveys consisted of six statements rated on a scale of 1-5, with 1 rated as *strongly disagree* and 5 rated as *strongly agree*, by parents and teachers willing to participate by way of an online survey. The statements addressed the same areas from the perspectives of the two different groups. Responses were recorded for 75 parents of students in grades three through six, and 17 teachers of the same grade levels. Classroom teachers, special education teachers, and special area teachers were included in the survey. No questions were asked about the survey by the participants, and so it is assumed they understood the numerical values of their answers.

Statement 1 referenced the perception of whether or not students attending the STEAM laboratory school program improved their performance in mathematics. Parents (59%) responded with ratings of 4 and 5, while teacher responses were 76% favorable with responses of 4 or 5. This indicated both the parent group and the teacher group had a majority of favorable perceptions about the success of students in mathematics in the STEAM program. Some parents (19%) were neutral in their responses, and only 11% did not feel the program had improved their child's mathematics achievement.

Statement 2 rated the importance of students attending the STEAM laboratory school again the following year for parents, and for continued employment in the program for teachers. Parent perception was favorable with 68% rating 4 or 5, and teacher perceptions were 100% favorable in the 4 and 5 categories. This indicated a majority of parents and all of the teachers surveyed wanted to continue to be a part of the program. Perception appeared to be positive in regard to this question. Only 7% of responding parents rated the importance of future attendance as unfavorable, and 16% were neutral on this statement.

Statement 3 referenced the perception by parents and teachers that daily technology usage was important for academic success by students. Parents responded favorably with 64% in the 4 and 5 categories, and teacher responses were 88% favorable with 4 and 5 chosen on the survey. Indications were that technology was an important piece of student academic success in the program, in the perceptions of the respondents. Neutral responses were 15%, and 11% of the parents did not feel technology was important for student success.

Statement 4 was posed in the negative, and was about student achievement in mathematics not being greatly affected by attendance at the STEAM laboratory school. Parents responded 41% as *disagree* or strongly *disagree*, and 33% *neutral*. Teacher responses were 59% as *disagree* or *strongly disagree*, and 24% *neutral*. Indications were that parents were not as sure about this statement as teachers; a majority of the teachers felt the program was important for success in mathematics. Wording of the statement might have been confusing, as this statement was worded in the negative. Of the parent responses, a high percentage (24%) answered neutrally on that question.

On both parent and teacher surveys, Statement 5 was written negatively to determine parent perceptions about how disappointed they would have been to not have had their child chosen for the program, and for teachers, how disappointed they would have been to have not been chosen to teach in the STEAM laboratory program. While 71% of parents responded *disagree* and *strongly disagree,* 65% of the teachers responded *disagree* and *strongly disagree*. Only 7% of the teachers responded they would not have been disappointed if not chosen for attendance. Indications of the perceptions of both the parent and teacher groups were disappointment would have been great if not having been chosen to participate in the program.

In the last statement (6), parents and teachers were asked to rate whether students would have been just as successful in any elementary program in the district, even without daily technology, and 39% of the parents responded *agree* and *strongly agree.* Conversely, only 6% of the teachers responded *agree* and no teachers responded *strongly agree.* Indications were that a majority of parents felt any elementary program in the district would have been a successful placement for their children, and teacher perceptions were that the STEAM program was a better learning opportunity for students. It is important to note teacher participation in the program was a choice, and parents had to enter a lottery for inclusion of their students in the laboratory program with no guarantee of enrollment before the drawing. This could have influenced parent responses, as they would have been prepared for non-acceptance in the STEAM school.

**Summary of Results of Parent and Teacher Surveys**

While parents and teachers who were surveyed perceived that being a part of the STEAM laboratory school was important to them and remaining in the program was important, results were mixed on the success rate of students in mathematics in the STEAM laboratory school over other elementary programs in the district. The results of the survey indicated some possibilities:

1. The statements written in the negative using the word “not” could have confused the participants.

2. Parents have confidence in the quality of education offered by the school district in any of the elementary schools.

3. Teacher bias cannot be ruled out, as all participants in the study were employed by their choice in the program, and many had participated in the design process of the laboratory school.

4. Teachers who work with technology on a daily basis, and regularly attend professional development in that area, may have perceived more value in the use of technology than some of the parents.

Further study would be beneficial to determine if any of these scenarios are likely. A study of the second year of operation of the laboratory school could be indicated. The perceptions of teachers working in the program appear to be in the majority that the STEAM laboratory school is the best academic placement for students. It is important to note teachers working in this elementary school setting made a choice to be there, which could have biased their opinions.

**Results of Standardized Testing Used in Study**

Quantitative data were collected by using a random sample of 30 student test scores from the Scholastic Reading Inventory (2012), Acuity Mathematics (CTB/McGraw-Hill, 2013), and Acuity Language Arts (CTB/McGraw-Hill, 2013) from the STEAM school and a random sample of 30 student scores from each of the other elementary schools in the district by means of a *t*-test to determine growth. The school district assesses students in grades three through six at the beginning of the academic year, in the middle of the year, and again at the end of the school year. A growth model was used to determine academic success as indicated by these standardized test scores.

Only the first and last test scores were used to determine growth rate. The level assumed for statistical difference was $< 0.05$, with a null hypothesis of $> 0.05$ indicating no statistical difference in the growth of students in reading and mathematics.

In grade three, the null hypothesis was not rejected in the results of the Scholastic Inventory (2012) with a *t*-test score of 0.80, and in the results of Acuity Language Arts (2013) with a *t*-test score of 0.79. In Acuity Mathematics (CTB/McGraw-Hill, 2013), the *t*-test score obtained was 0.13. Indications were that no difference was observed between the growth rate of the two sample groups (Unique School and combined scores from all other elementary schools in the district), and that the null hypothesis could not be rejected.

Results of a *t*-test score in grade four in Scholastic Reading Inventory (2012) was 0.02, which was assumed to show a possible difference in growth rate, while the *t*-test score in Acuity Language Arts (CTB/McGraw-Hill, 2013) was 0.26, which did not allow for rejection of the null hypothesis for growth in language arts achievement. In Acuity Mathematics (CTB/McGraw-Hill, 2013), the *t*-test score was 0.97, which also did not allow for rejection of the null hypothesis. Indications were mixed for growth in reading and showed no difference in growth in mathematics between the two sample groups.

In grade five, the Scholastic Reading Inventory (2012) *t*-test score was 0.06, and in Acuity English Language Arts (2013) was 0.26, neither of which allowed for rejection of the null hypothesis. In Acuity Mathematics (2013), the result of the *t*-test was 0.37, and the null hypothesis could not be rejected for a difference in growth rate between the two sample groups. Indications were there was no difference in the growth rate of students in grade five in reading or mathematics achievement.

The result in grade six from the Scholastic Reading Inventory (2012) was a *t*-test score of 0.93, and in Acuity English Language Arts (2013) 0.03. In Acuity Mathematics (2013), the *t*-test score was 0.33. The results were mixed in reading growth, with a possible difference noted in Acuity English Language Arts (2013) results; however, the Scholastic Reading Inventory (2012) score would not allow for rejection of the null hypothesis. The null hypothesis could also not be rejected for a difference in growth rate in the area of mathematics as indicated in the Acuity Mathematics (2013) test results.

**Summary of Results of *t*-test Scores on Standardized Tests**

Results of standardized testing results, as indicated by a growth model subjected to a *t*-test, were mixed. In most areas, no statistical difference was indicated in reading or mathematics growth in grades three through six. Mixed results were obtained in reading growth in grades four and six. Further study was indicated in order to obtain additional standardized comparison, and a second year of operation of the STEAM laboratory school in comparison to other elementary schools in this district could be beneficial.

**Summary of Administrative Interviews**

The five administrators who were interviewed in this study expressed satisfaction with the process followed for design and implementation of the STEAM laboratory school. A common theme emerged. The interviewees, for the most part, felt if the district could do the process over, better planning for professional development of teachers would be have been beneficial; however, all administrators expressed satisfaction with how teachers had risen to the challenge, and how perceptions of the public and staff had been a positive factor in the success of the first year of implementation of the program. The future of laboratory schools in the district was seen as a possibility; however, with a different emphasis to meet the needs of the patrons.

**Triangulation of Data**

This study utilized data from standardized testing administrated in the district by means of a *t*-test. Surveys of parents and teachers involved in the program were conducted by means of a rating scale to determine perceptions, and interviews were conducted with administrators involved in the planning and implementation of the STEAM laboratory program. Analysis of the separate pieces of data indicated that while test results did not show any conclusive evidence of greater achievement in students involved in the program over other students of the same age in the district, expectations were for seeing significant differences in subsequent years, with positive perceptions of patrons, staff, and administration toward the program.

Based on the data analyzed, the STEAM laboratory school appeared to be successful in meeting the goals of the design team in the first year of implementation. The majority of participating respondents indicated favorable perceptions of the program. Further study is suggested to determine if expected goals are met in successive years of this program, with more data available for analysis.

**Conclusions**

This study indicated the first year of operation was successful in terms of the perceptions of the stakeholders who participated in the surveys and interview processes. The results of the surveys given to parents and to teachers indicated a majority of participants perceived the first year of operation favorably. Implementation of a STEAM laboratory program appears, according to the research, to have been a positive move for this school district, after the first year of operation.

The interviews with five administrators in the district also indicated favorable perceptions of the first year of operation of the STEAM laboratory school. Themes emerged as substantive categories among the responses. Areas of concern were recognized, particularly in the lack of preparation for effective professional development and technology usage of under-developed teachers. Administrators also voiced the importance of the teachers' enthusiasm as a component for success in that first year.

Standardized test scores did not show significant difference between the growth rate of students in this building and students in other elementary buildings in the school district, although interviews with administrators indicated that had been expected in the first year, was not a cause for concern, and was common in the development of a new program. Positive perception among administrators was that the second year of implementation would be more accurate in the area of student achievement.

Administrators voiced the perception the first year was one of adjustment and maintaining status quo with student test scores. All administrators interviewed indicated a favorable perception to having been a part of the planning and implementation of the STEAM laboratory school. They felt the STEAM school had been a much sought-after change on the part of patrons, and the ability to offer choice had been important to the success of the program. There was an indication the district would be willing to consider another laboratory school in the future, with a different focus to allow for more parental choice.

## Implications for Practice

Research indicates best practice in instruction should include inquiry-based learning strategies for effective achievement of students at all levels (P21 Partnership for 21st Century Learning, 2015). A focus on a STEAM curriculum would be an area where an investment in professional development of teachers could be beneficial. Time and money used for quality training of teachers in the use of the technology and learning strategies would be indicated for the benefit of working with students in a STEAM setting.

The most successful STEM programs utilize teachers well-trained in their content areas. As most elementary teachers are not well-trained to teach science and math at the level of a STEM program, training and ongoing support would be most beneficial to student success. Competency in content areas, as well as in inquiry-based teaching models, would give teachers confidence in their ability to step out of comfort zones in teaching and allow them to become greater risk-takers in trying something as new as a STEAM program. Therefore, content competency, pedagogy, and integrative technology training would be indicated as a major part of the process for planning implementation of a new program, whether STEM, STEAM, or another 21st century-aligned curriculum.

## Recommendations for Future Research

Further research would be of benefit, to follow the achievement and growth rate of students involved in this type of program over subsequent years to determine if the projections of the design team for this laboratory elementary are correct as far as the improved achievement level of the students over time. Recommendations are for the district involved in this study to address the areas seen in hindsight as needed for improvement, and for action be taken to correct those weaknesses. This was particularly recognized in the area of professional development. This study also indicated before another laboratory school was designed, those areas need to be emphasized in the planning and preparation of teachers.

A further recommendation for other school districts planning to take a step in the direction of a STEAM laboratory elementary school would be to study the strengths and weaknesses of this program in the first year of implementation, in order to benefit from the lessons learned by this district in this undertaking. Quality professional development and ongoing support for teachers would be indicated, particularly with new technology and methods of integrating content taught in a STEM or STEAM-focused setting.

Quality training in inquiry-based learning would be recommended, as research indicates inquiry-based learning as best practice in teaching science particularly, but also in integration of the STEM content. Any change in scheduling or calendar should also be addressed for a smoother transition. Public input is recommended, as stakeholders have a large impact on the perception of any new program and the positive attitudes of students.

Another recommendation would be to involve teachers in the planning process as much as possible. If practical, voluntary participation of teachers in the implementation of a new program such as a laboratory school would build a cohesive front in facing the challenges of such an undertaking.

**Summary**

A STEAM laboratory school was the subject of this study, in a midwestern school district of about 6,000 students. The program was the first of its kind in this particular area of the country and resulted in some risk-taking by one school district. Literature was reviewed on the need and initiative for more rigorous curriculum in America's schools in science, technology, engineering, and mathematics (STEM) and the inclusion of the arts (STEAM). Statistics indicated the United States is scoring below other industrialized countries in the STEM areas, and with the current and predicted future requirement for a well-trained workforce in STEM disciplines, the need is for early exposure of students to curriculum that will prepare them for the jobs of the future.

Inquiry-based instruction was also researched as a best practice, as it was the chosen delivery model of the school in this study. The focus of the district involved was to introduce STEM content to elementary students from kindergarten through sixth grade. Some risk-taking was involved, and a program that included the arts in STEM to become a STEAM laboratory school was chosen.

Attendance in the laboratory school was voluntary and decided on a lottery basis. The process of designing the program included input from the community, parents, and school staff. Public opinion was in favor of the venture, and this case study was chosen to determine the perceptions of some of the stakeholders involved in the program after the first year of implementation.

Parents of students attending the program, as well as teachers in the building and administrators personally involved in the planning and implementation of the program, were surveyed and interviewed for perceptions of the success of the first year of the STEAM laboratory school. Some weaknesses in planning were noted in interviews, particularly in the area of professional development for teachers before the start of the school year in working with new content and new technology and in scheduling for the longer school year; however, reflections of administrators indicate the lessons learned will be beneficial in future decision making.

Quantitative data were used to determine the growth rate of students in the first year of operation, and although the results showed no statistical difference by attendance in the program to students in other buildings, the expectations of the stakeholders indicated this was to be expected in the first year. Attitudes were positive that subsequent years would prove the program to be advantageous for student achievement. The majority of those who participated in the program indicated positive perceptions of the STEAM program. Some weaknesses were noted in the planning process, and reflections were shared as to how to make future programs of this nature run more smoothly.

Overall, the implementation of a STEAM laboratory elementary school for this district appears to have been the success that was hoped for by the designers of the program. There was an indication future laboratory schools may be on the horizon for this school district, and public support is in favor of such an effort. The next few years will bear watching to determine if perceptions of the program prove correct, and if this elementary laboratory STEAM school will become a model for other districts in moving into STEM or STEAM and 21st century learning.

**Appendix A**

LINDENWOOD

**INFORMED CONSENT FOR PARTICIPATION IN RESEARCH ACTIVITIES**

"Case Study on the Efficacy of an Elementary Science, Technology, Engineering, Arts, Mathematics (STEAM) Elementary School"

Principal Investigator Mary Paula Armknecht

Telephone: [redacted] E-mail: paulaarmknecht@_____________ net

1. You are invited to participate in a research study conducted by (Mary Paula Armknecht) under the guidance of (Dr. Sherry DeVore). The purpose of this research is to evaluate the effectiveness of the STEAM elementary program implemented by the school district after the first year of operation in terms of student achievement and perception of some of the parents and teaching staff.

2. a) Your participation will involve a brief online survey.
   b) The amount of time involved in your participation will be approximately 2 minutes.

   Approximately 120-260 participants will be involved in this research. [Participants in the survey will be teachers and parents of students in the STEAM program surveyed anonymously.]

3. There are no anticipated risks involved in this research.

4. There are no direct benefits for you participating in this study. However, your participation will contribute to the knowledge about the STEAM elementary program and may help the district with future planning.

5. Your participation is voluntary and you may choose not to participate in this research study or to withdraw your consent at any time. You may choose not to answer any questions that you do not want to answer. You will NOT be penalized in any way should you choose not to participate or to withdraw.

6. We will do everything we can to protect your privacy. Surveys will be conducted online and your identity will be unknown to the researcher and staff of the school.

7. If you have any questions or concerns regarding this study, or if any problems arise, you may call the Investigator, Mary Paula Armknecht, (417-[redacted]) or the Supervising Faculty, Dr. Sherry DeVore (417-881-0009). You may also ask questions of or state concerns regarding your participation to the Lindenwood

Institutional Review Board (IRB) through contacting Dr. Jann Weitzel, Vice President for Academic Affairs at 636-949-4846.

**I have read this consent form and have been given the opportunity to ask questions. I may retain a copy of this consent form for my records. I consent to my participation in the research described above.**

**By completing the survey, you consent to participate in this study.**

Thank you for your time,
Mary Paula Armknecht 4/25/13
Doctoral Student
Lindenwood University

**Please check here <hyperlink> to complete the survey**

**Appendix B**

LINDENWOOD

**INFORMED CONSENT FOR PARTICIPATION IN RESEARCH ACTIVITIES**

"Case Study on the Efficacy of an Elementary Science, Technology, Engineering, Arts, Mathematics (STEAM) Elementary School"

Principal Investigator: Mary Paula Armknecht

Telephone: [redacted] E-mail: paulaarmknecht@[redacted]

Participant ____________________________Contact info _________________________

________________________________________________________________________

1. You are invited to participate in a research study conducted by (Mary Paula Armknecht) under the guidance of (Dr. Sherry DeVore). The purpose of this research is to evaluate the efficacy of the STEAM elementary program implemented by the school district after the first year of operation in terms of student achievement and perception of some of the major stake holders.

2. a) Your participation will involve
   - A brief interview (see questions attached).
   - Interview will be conducted in person at a location that is convenient for you (or by phone at your preference), and will be audio recorded for transcription.

   b) The amount of time involved in your participation will be approximately 15-20 minutes.

   Approximately 120-260 participants will be involved in this research. [Approximately five administrators will be interviewed, and the remainder of the participants will be teachers and parents of students in the STEAM program surveyed anonymously.]

3. There are no anticipated risks involved in this research.

4. There are no direct benefits for you participating in this study. However, your participation will contribute to the knowledge about the STEAM elementary program and may help the district with future planning.

5. Your participation is voluntary and you may choose not to participate in this research study or to withdraw your consent at any time. You may choose not to answer any questions that you do not want to answer. You will NOT be penalized in any way should you choose not to participate or to withdraw.

6. We will do everything we can to protect your privacy. As part of this effort, your identity will not be revealed in any publication or presentation that may result from

this study and the information collected will remain in the possession of the investigator in a safe location to be destroyed at the end of the study.

7. If you have any questions or concerns regarding this study, or if any problems arise, you may call the Investigator, Mary Paula Armknecht, (417-[redacted]) or the Supervising Faculty, Dr. Sherry DeVore (417-881-0009). You may also ask questions of or state concerns regarding your participation to the Lindenwood Institutional Review Board (IRB) through contacting Dr. Jann Weitzel, Vice President for Academic Affairs at 636-949-4846.

**I have read this consent form and have been given the opportunity to ask questions. I will also be given a copy of this consent form for my records. I consent to my participation in the research described above.**

| | | |
|---|---|---|
| ___________________ | | ___________________ |
| Participant's Signature | Date | Participant's Printed Name |
| ___________________ | | ___________________ |
| Signature of Principal Investigator | Date | Investigator Printed Name |

**Appendix C**

Parent Survey

*Please check the appropriate box to indicate your agreement or disagreement with the statements below, where the number 1 has the least value (strongly disagree) and the number 5 has the greatest value (strongly agree).*

| strongly disagree | disagree | no opinion | agree | strongly agree |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

1. I feel that having my student attend the STEAM laboratory school program improved his/her performance in mathematics.

○ ○ ○ ○ ○

2. It is important to me that my student attends the STEAM laboratory school program again next year.

○ ○ ○ ○ ○

3. I feel that it has been important for my student to use technology on a daily basis in order to be the most successful academically.

○ ○ ○ ○ ○

4. My student's achievement in the area of mathematics was not greatly affected by attendance at the laboratory STEAM school.

○ ○ ○ ○ ○

5. I would not have been disappointed if my student had not been chosen through the lottery for attendance at the laboratory STEAM school.

○ ○ ○ ○ ○

6. I feel that my student would have been just as successful in any elementary program in the district, even without daily technology.

○ ○ ○ ○ ○

# Appendix D

Staff Survey

*Please check the appropriate box to indicate your agreement or disagreement with the statements below, where the number 1 has the least value (strongly disagree) and the number 5 has the greatest value (strongly agree).*

| strongly disagree | disagree | no opinion | agree | strongly agree |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

1. I feel that students attending the STEAM laboratory school program improved their performance in mathematics.

○ ○ ○ ○ ○

2. It is important to me that I continue to teach in the STEAM laboratory school program.

○ ○ ○ ○ ○

3. I feel that it is important for students to use technology on a daily basis in order to be the most successful academically.

○ ○ ○ ○ ○

4. Students' achievement in the area of mathematics was not greatly affected by attendance at the laboratory STEAM school.

○ ○ ○ ○ ○

5. I would not have been disappointed if I had not been chosen to teach at the laboratory STEAM school

○ ○ ○ ○ ○

6. I feel that students would be just as successful in any elementary program in the district, even without daily technology.

○ ○ ○ ○ ○

# Appendix E

Interview Questions

1. What factors did you consider before proposing/becoming a design team member of STEAM laboratory school in this district?
2. Reflecting back on the process, is there anything that you would do differently if faced with the same decisions today?
3. As we near the end of the first year of operation of this program, what is your perspective on the program? Are you seeing the success that you had hoped for?
4. How does the first year of operation of the STEAM laboratory school change the outlook for the future in this district? Any more plans to expand this concept?
5. Is there anything else that you would like to add about the STEAM laboratory school?

**Appendix F**

LINDENWOOD

LINDENWOOD UNIVERSITY ST. CHARLES, MISSOURI

| | |
|---|---|
| DATE: | May 13, 2013 |
| TO: | Mary Paula Armknecht |
| FROM: | Lindenwood University Institutional Review Board |
| STUDY TITLE: | [459515-1] Case Study on the Efficacy of an Elementary Science, Technology, Engineering, Arts, Mathematics (STEAM) Laboratory School |
| IRB REFERENCE #: | |
| SUBMISSION TYPE: | New Project |
| ACTION: | APPROVED |
| APPROVAL DATE: | May 13, 2013 |
| EXPIRATION DATE: | May 13, 2014 |
| REVIEW TYPE: | Expedited Review |

Thank you for your submission of New Project materials for this research project. Lindenwood University Institutional Review Board has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission. Suggestions and comments follow:

- For the unpaired t-test, a hypothesis statement should be included.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to the IRB.

This project has been determined to be a Minimal Risk project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the completion/amendment form for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of May 13, 2014.

Please note that all research records must be retained for a minimum of three years.

If you have any questions, please send them to IRB@lindenwood.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Lindenwood University Institutional Review Board's records.

# References


American Psychological Association. (2010). *Publication manual of the American psychological association* (6th ed.). Washington DC: American Psychological Association.

Arts Education Partnership. (2014). Common core and the arts. Retrieved from http://www.aep-arts.org/resources-2/common-core-and-the-arts/

Association of American Colleges and Universities. (2013). Employers more interested in critical thinking and problem solving than college major. Retrieved from https://www.aacu.org/press/press-releases/employers-more-interested-critical-thinking-and-problem-solving-college-major

Ballard, A. (2014). TCPS continues to support STEAM over STEM. Retrieved from http://tcps.org/whats-new-at-tcps/tcps-continues-support-steam-stem/

Biological Science Curriculum Study. (2013). NASA eClips. Retrieved from http://www.nasa.gov/audience/foreducators/nasaeclips/5eteachingmodels/

Blair, N. (2012, January/February). Technology integration for the new 21st century learner. *Principal, 91*(3), 8-11. Retrieved from http://www.naesp.org/principal-januaryfebruary-2012-technology/technology-integration-new-21st-century-learner

Bluman, A. G. (2013). *Elementary statistics: A step by step approach* (6th ed.). New York, NY: McGraw-Hill.

Brett, J. T. (2007). Toward a STEM policy. *New England Journal of Higher Education, 22*(1), 30. Retrieved from http://www.eric.ed.gov/PDFS/EJ793922.pdf

Brunsell, E. (2011, January 3). The five features of science inquiry: How do you know? [Web log post]. Retrieved from http://www.edutopia.org/blog/teaching-science-inquiry-based

Business-Higher Education Forum. (2011). Meeting the STEM workforce demand: Accelerating math learning. *BHEF Research Brief*. Retrieved from http://www.eric.ed.gov/ PDFS/ED527258.PDF

Cardona, M. (2013, May 28). Why the national STEM education fund is so important [Web log post]. Retrieved from http://www.huffingtonpost.com/maria-cardona/investing-in-tomorrows- le_b_3314124.html

Carnevale, A. P., Smith, N., & Melton, M. (2011). STEM: Science, technology, engineering, mathematics. Georgetown University Center on Education and the Workforce: Washington, DC. Retrieved from http://www9.georgetown.edu/grad/gppi/hpi/cew/pdfs/stem-complete.pdf

Center for American Progress. (2011, May 5). Idea of the day: We need to improve STEM education in elementary schools. Retrieved from https://www.americanprogress.org/ issues/general/news/2011/05/05/9616/idea-of-the-day-we-need-to-improve-stem-

Corporation for Public Broadcasting. (2002). Enhancing education: The 5 e's. Retrieved from http://enhancinged.wgbh.org/research/eeeee.html

Courduff, J. (2011). One size never fits all: Tech integration for special needs. *Learning and Leading with Technology*, *38*(8), 16-19.

Creswell, J., & Clark, V. (2011). *Designing and conducting mixed methods research.* Thousand Oaks, CA: Sage Publications.

CTB/McGraw-Hill. (2013). Acuity predictive assessments. Retrieved from https://www.ctb.com/img/pdfs/wpAcuityEfficacy.pdf

Darling-Hammond, L. & Richardson, N. (2009). Research review/teacher learning: What matters? *ASCD, 66*(5), 46-53. Retrieved from http://www.ascd.org/publications/educational-leadership/feb09/vol66/num05/Teacher-Learning@-What-Matters%C2%A2.aspx

Devine, S. (2012). Coursesmart launches beta program for coursesmart analytics at Educause 2012. *Virtual-Strategy Magazine*. Retrieved from http://www.virtual-strategy.com/2012/11/07/coursesmart-launches-beta-program-coursesmart-analytics-educause-2012?page=0,0#axzz3TM5ZJ34x

Dewey, J. (1916). *Democracy and education*. New York, NY: Macmillan.

Diep, F. (2013). Minority scientists are less likely to find jobs [Web log post]. Retrieved from http://www.popsci.com/science/article/2013-03/minority-scientists-are-more-likely-be-unemployed-and-other-stats

Dweck, C. S. (2012). Is math a gift? Beliefs that put females at risk. Retrieved from https://web.stanford.edu/dept/psychology/cgi-bin/drupalm/system/files/cdweckmathgift.pdf

Dynarski, M., Agodini, R., Heaviside, S., Novak, T., Carey, N., Campuzano, L., & Means, B. (2007). Effectiveness of reading and mathematics software products: Findings from the first student cohort. Retrieved from U.S. Department of Education website: http://ies.ed.gov/ncee/pdf/20074005.pdf

Eberle, F. (2010). Why STEM education is important? Retrieved from https://www.isa.org/standards-and-publications/isa-publications/intech-magazine/2010/september/why-stem-education-is-important/

Educate to Innovate. (2009). Education knowledge and skills for the jobs of the future. Retrieved from http://www.whitehouse.gov/issues/education/k-12/educate-innovate

EduScapes. (2007). Technology-rich learning: An overview. Retrieved from http://eduscapes.com/tap/tap100.htmlhttp://eduscapes.com/tap/tap100.html

eMINTS National Center. (2011, January). About eMINTS: Compelling results. Retrieved from http://emints.org/about/index.shtml

Engler, J. (2012). STEM education is the key to the U.S.'s economic future. Retrieved from http://www.usnews.com/opinion/articles/2012/06/15/stem-education-is-the-key-to-the-uss-economic-future

Epstein, D., & Miller, R. (2011). Slow off the mark: Elementary school teachers and the crisis is STEM education. Center for American Progress. Retrieved from https://www.americanprogress.org/wp-content/uploads/issues/2011/04/pdf/stem_paper.pdf

Etherington, M. B. (2011). Investigative primary science: A problem-based learning approach. *Australian Journal of Teacher Education, 36*(9), 36-57.

Fioriello, P. (2013). Understanding the basics of STEM education: What is STEM education? Retrieved from http://drpfconsults.com/understanding-the-basics-of-stem-education/

Flavell, J. H. (1987). Speculation about the nature and development of metacognition. In F. Weinert & R. Kluwe (Eds.*), Metacognition, motivation, and understanding* (pp. 21-29). Hillsdale, NJ: Lawrence Erlbaum. Retrieved from http://www.lifecircles-inc.com/Learningtheories/constructivism/ flavell.html

Friesen, S., & Scott, D. (2013, June). *Inquiry-based learning: A review of the research literature.* Paper prepared for the Alberta Ministry of Education, Alberta, Canada.

Gallow, D. (2000). What is problem-based learning? Retrieved from http://www.pbl.uci.edu/whatispbl.html

Gillani, B. (2010). Inquiry-based training model and the design of e-learning environments. *Issues in Informing Science and Information Technology, 7*, 1-9. Retrieved from http://iisit.org/Vol7/IISITv7p001-009Gillani721.pdf

Goldman, H. (2009, July). Department of Education releases ed tech guidance race to the top notice for comment and other ARRA items [Blog comment cached]. Retrieved from http://www.iste-community.org/profiles/blogs/department-of-education

Google Surveys. (2013). Retrieved from http://www.google.com/insights/consumersurveys/home

Gordon, E. (2010). Employment for today and tomorrow. *Emerging Careers.* Retrieved from http://www.eric.ed.gov/PDFS/EJ909604.pdf
www.acteonline

Gritzinger. (2011). STEM and STEAM education - White house. Retrieved from http://steammanifesto.com/stem-and-steam-education-white-house/

Grunwald & Associates. (2010). Educators, technology and 21st century skills: Dispelling five myths. Retrieved from www.WaldenU.edu/fivemyths

Gullamhussein, A. (2013). *Case study report.* Center for Public Education. Retrieved from http://www.centerforpubliceducation.org/Main-Menu/Staffingstudents/Teaching-the-Teachers-Effective-Professional-Development-in-an-Era-of-High-Stakes-Accountability/Teaching-the- Teachers-Full-Report.pdf

Hanover Research. (2011). Building a science, technology, engineering, and math agenda. Retrieved from http://www.hanoverresearch.com/wp-content/uploads/2011/12/K-12-STEM-Education-Overview-Membership.pdf

Henderson, C., & Dancy, M. H. (2011, February). *Increasing the impact and diffusion of STEM education innovations.* A White Paper commissioned for the Characterizing the Impact of Engineering Education Innovations Forum, New Orleans, LA. Retrieved from https://www.nae.edu/File.aspx?id=36304

Herschbach, D. R. (2011). The STEM initiative: Constraints and challenges. *Journal of STEM Teacher Education, 48*(1), 96-122. Retrieved from http://www.eric.ed.gov/PDFS/EJ952045.pdf

Hondo, M., & Cleveland, P. (2012). Congressman proposes STEM education office-STEM education. Retrieved from http://www.usnews.com/news/blogs/stem-education /2012/01/20/congressman-proposes-ste

Hopkins, K. (2012). College mentors key to prospective female STEM majors. Retrieved from http://www.usnews.com/education/high-schools/articles /2012/05/31/college-mentors-key-to-prospective-female-stem-majors

IBM Corporation. (2013). IBM and P-TECH. Retrieved from https://www-03.ibm.com/press/us/en/presskit/42300.wss

Institute of Education Sciences. (2007). Developmental summer bridge programs. Retrieved from http://ies.ed.gov/ncee/wwc /interventionreport.aspx?sid=632

ISTE: International Society for Technology in Education. (2011). Transforming learning environments with technology. Retrieved from http://www.iste.org /standards.aspx

Johnson, P. (September, 2009). The 21st century skills movement. *Educational Leadership, 67*(1), 11.

Jolly, A. (2014). STEM vs. STEAM: Do the arts belong? Retrieved from http://www.edweek.org/tm/articles/2014/11/18/ctq-jolly-stem-vs-steam.html

Jun-Ming, S. U., Huan-Yu, L., Shian-Shyong, T., & Chia-Jung, L. U. (2011). Opass: An online portfolio assessment and diagnosis scheme to support web-based scientific inquiry experiments. *The Turkish Online Journal of Educational Technology, 10*(2), 151.

Just Science Now. (2015). What is inquiry? Retrieved from http://www.justsciencenow.com/inquiry/

Knight, D. B., Mappen, E. F., & Knight, S. L. (2011). A review of the literature on increasing the representation of women undergraduates in STEM disciplines through civic engagement pedagogies. *Science Education & Civic Engagement: An International Journal, 3*(1), 36-47. Retrieved from http://seceij.net/seceij/winter11/women_undergrad.html

Kumar, S., & Vigil, K. (2011). The new generation as preservice teachers: Transferring familiarity with new technologies to educational environments. *Journal of Digital Learning in Teacher Education, 27*(4), 153. Retrieved from http://www.eric.ed.gov/PDFS/EJ936543.pdf

Langdon, D., McKittrick, G., Beede, D., Khan, B., & Doms, M. (2011, July). STEM: Good jobs now and for the future. U.S. Department of Commerce: Washington, DC. Retrieved from http://www.esa.doc.gov/sites/default/files/reports/documents/stemfinalyjuly14_1.pdf

Lange, S. (2014, June 12). Strategies to promote critical thinking in the elementary classroom [Web log post]. Retrieved from http://www.p21.org/news-events/p21blog/1435-strategies-to-promote-critical-thinking-in-the-elementary-classroom

Lantz, H. B. (2009). Science, technology, engineering, and mathematics (STEM*).* Retrieved from http://www.currtechintegrations.com/pdf/STEM EducationArticle.pdf

Lee, J. (2012, February 14). Obama's budget shuffles STEM education deck. *Science Insider*. Retrieved from http://news.sciencemag.org/scienceinsider/2012/02/obamas-budget-shuffles-stem.html

Lexile Format. (2013). The Lexile framework for reading. Retrieved from https://lexile.com/about-lexile/lexile-overview/lexile-infographic/

Maguth, B. M. (2012). In defense of the social studies: Social studies programs in STEM education. *Social Studies Research and Practice, 7*(2), 65-90. Retrieved from http://www.socstrpr.org/wp-content/uploads/2012/08/MS06393-5.pdf

Markham, T., (2012, February 21). Project-based learning and common core standards. *The Whole Child: Blog Post.* [Web log post]. Retrieved from http://www.whole child education.org/ blog/project-based-learning- and-common- core-standards

Martin, W., Strother, S., Weatherholt, T., & Dechaume, M. (2008). An investigation of program fidelity and mastery and student achievement. Retrieved from http://cct.edc.org/admin/publications/report /eMINTS%20rpt08_final_short.pdf

Marzano Research Laboratory. (2009). Evaluation study of the effects of promethean activclassroom. *Promethean, Ltd.* Retrieved from http://www.scribd.com/doc/14646326/Marzano-Preliminary-Report-

Maxwell, J. A. (2013). *Qualitative research design: An interactive approach* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Meador, G. (1988). Relating the nature of science and the central purpose of the American education to the learning cycle. Retrieved from http://www.bps-ok.org/physics/papers/learned.pdf

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2010, September). Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies. U.S. Department of Education. Office of Planning, Evaluation, and Policy Development. Retrieved from http://www2.ed.gov/rschstat/eval/tech/evidence-based-/finalreport.pdf

Meyers, C., & Brandt, C. (2010). Findings for the eMINTS (enhancing Missouri's instructional networked teaching strategies) program from 1999-2009. Retrieved from http://www.emints.org/wp-content/uploads/2011/07/

summary_emints_research.pdf

Meyrick, K. M. (2011). How STEM education improves student learning. *Meridian K-12 School Computer Technologies Journal, 14*(1). Retrieved from http://www.ncsu.edu/meridian/summer2011/meyrick/print.html

Missouri Department of Secondary and Elementary Education. (2013). Missouri education technology strategic plan: 2007-2011. Retrieved from http://www.dese.mo.gov/ divimprove/instrtech/techplan/documents/2007-11METSP-Oct2009.pdf

Moye, J. (2011). Putting core academics into context, CTE courses provide an excellent platform for students to learn the relevance of science, technology, engineering, and mathematics (STEM) as well as literature, arts, and social studies. Retrieved from http://www.eric.ed.gov/PDFS/EJ926077.pdf

Murphy, L. M., DePasquale, R., & McNamara, E. (2007). Meaningful connections: Using technology in primary classrooms. *Beyond the Journal: Young Children on the Web.* Retrieved from https://www.naeyc.org/files/yc/file /200311/TechInPrimaryClassrooms.pdf

Murphy, T. (2011, August 29). STEM education--it's elementary. *US News*. Retrieved from http://www.usnews.com/news/articles/2011/08/29/stem-education--its-elementary

Nagel, D. (2009, April). Study ties student achievement to technology integration. *The Journal.* Retrieved from http://thejournal.com/articles/2009/04/02/study-ties-student-achievement-to-technology-integration.aspx

NASA eClips. (2013). 5Es Overview: "The 5Es instructional model." Retrieved from http://www.nasa.gov/audience/foreducators/nasaeclips/5eteachingmodels/

National Center for STEM Elementary Education. (2012). What is STEM? Retrieved from https://www2.stkate.edu/ncsee/what-is-stem

National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for educational reform: A report to the nation and the secretary of education, United States Department of Education*. Retrieved from http://datacenter.spps.org/uploads/sotw_a_nation_at_risk_1983.pdf

National Governors Association Center for Best Practices. (2015). Science, technology, engineering & math (STEM) education. *NGA Center for Best Practices.* Retrieved from http://www.nga.org/cms/stem

National Research Council. (2011). Successful K-12 STEM education. Retrieved from http://www.stemreports.com/wp-content/uploads/2011/06/NRC_STEM_2.pdf

National Science Foundation. (2012). *Report to congress: Broadening participation in America's STEM workforce* Retrieved from http://www.nsf.gov/od/iia/activities/ceose/reports/Full_2011-2012_CEOSE_Report_to_Congress_Final_03-04-2014.pdf

National Science Teachers Association (NSTA). (2013). STEM pathways for underserved students. Retrieved from http://www.nsta.org/docs/201310Reports.pdf

Nelson, B. S., & Sassi, A. (2005). *The effective principal: Instructional leadership for high-quality learning.* New York, NY: Teachers College Press.

NCSU. (2010, October 3). NCSU researchers build “STEM teams” for rural areas. *WRALtechwire*. [Web log post]. Retrieved from http://wraltechwire.com business/tech_wire/biotech/blogpost/8392501/

Northwestern Illinois University (NEIU). (2014). Inquiry based learning. Retrieved from http://www.neiu.edu/~middle/Modules/science%20mods/amazon%20 components/AmazonComponents2.html

Papanikolaou, K. (2010). Introducing robotics to teachers and schools: Experiences from the terecop project. *Constructivism: Paris.* Retrieved from http://hermes.di.uoa.gr/frangou/papers/eurologo%202010.pdf

Papanikolaou, K., & Boubouka, M. (2011). Promoting collaboration in a project-based e-learning context. *JRTE, 43*(2), 135-155. Retrieved from http://news.yahoo.com/mendon-illinois-school-tdistrict-announces-one-one-student-144607374.html.

Partnership for 21st Century Skills. (2009). P21 framework definitions. Retrieved from http://www.p21.org/storage/documents/P21_Framework_Definitions.pdf

Phillips, D. (1997). How, why, what, when, and where: Perspectives on constructivism and education. *Issues in Education: Contributions from Educational Psychology, 3*(2), 151-194.

Piaget, J. (1952). *Psychology and Epistemology*. New York: Gotham/Penguin University Books.

President’s Council of Advisors on Science and Technology. (2010). [Letter written September, 2014, to B. Obama]. Retrieved from ttps://www.whitehouse.gov/ sites/default/files/microsites/ostp/PCAST/PCAST_worforce_edIT_Oct-2014.pdf

PRWeb. (2011, July). Ohio budget expands digital learning opportunities for students: National digital learning experts, former governors Bush and Wise laud state action. *Press Release Services.* Retrieved from http://new.yahoo.com/ohio-budget-expands-digital-learning-opportunities-students-national-215609013.html

P21 Partnership for 21st Century Learning. (2015). Framework for 21st century learning. Retrieved from http://www.p21.org/our-work/p21-framework

Puffenberger, A. (2012, January 19). The STEAM movement: It's about more than hot air [Web log post]. Retrieved from https://artofthestem.wordpress.com/author/skeelsd/page/21/

Randomness and Integrity Services, Ltd. (2015). *Random.org.* Retrieved from https://www.random.org/

Robelen, E. (2011). STEAM: Experts make case for adding arts to STEM. *Education Week*, *31*(13), 8. Retrieved from http://www.edweek.org/ew/articles/2011/12/01/13steam_ep.h31.html?tkn=SOUF33yOAK2IkI%20CvYbeMsKPUWP0STvHXAtn&cmp=ENL-EU-NEWS1&preview=1&r=1230672781

Rotherham, A. J., & Willingham, D. (2010). 21st century skills: The challenges ahead. *Educational Leadership, 67*(1), 16-21.

Scholastic Reading Inventory. (2012). SRI. Retrieved from http://teacher.scholastic. Com/products/srireadingassessment/index.htm

Science Pioneers. (2014). Why STEM education is important for everyone. Retrieved from http://www.sciencepioneers.org/parents/why-stem-is-important-to-everyone

Seidman, I. (2006). *Interviewing as qualitative research: A guide for researchers in education and the social sciences* (3rd ed.). New York, NY: Teachers College Press.

Severns, M. (2012). Study offers possible explanation for the huge gender gap in science and math. Retrieved from http://www.slate.com/blogs/future_tense/2012/06/14/stemgender_gap_research_on_telling_girls_they_re_bad_at_math_.html

Shapiro, D. (2013). The attractions of STEM magnet schools. *NSTA Reports. Webnews Digest.* Retrieved from http://www.nsta.org/publications/news/story.aspx?id=59800

Smarter Balanced Assessment Consortium. (2014). Retrieved from http://www.smarterbalanced.org/about/

Soy, S. K. (1997). *The case study as a research method* (Unpublished paper). University of Texas at Austin. Retrieved from http://www.ischool.utexas.edu/~ssoy/usesusers/l391d1b.htm

STEM Education and Workforce. (2014). National math and science initiative: Elementary and secondary education. Retrieved from http://www.nga.org/files/live/sites/NGA/files/pdf/0702INNOVATIONSTEM.PDF;jsessionid=A5822A26DDCFC8509D5CFBDE02CA 143E

STEM Smart Brief. (2011). Preparing and supporting STEM educators. Retrieved from http://successfulstemeducation.org/sites/successfulstemeducation.org/files/Preparing%20Supporting%20STEM%20Educators_FINAL.pdf

STEM Work Group. (2010). Recommendations for science, technology, engineering, and mathematics education. Report to Christine Gregoire, Governor, and the Washington State Legislature. Retrieved from http://www.k12.wa.us/LegisGov/2010documents/STEMWorkgroupReport2010.pdf

Stephenson, N. (2012). Introduction to inquiry-based learning. Retrieved from http://www.teachinquiry.com/index/Introduction.html

Studica. (2013). What is STEM and why is it important. Retrieved from http://www.studica.com/what-is-stem-education-project-base-learning STEM education programs

Suchman, J. R. (1962). *The elementary school training program in scientific inquiry*. Urbana, IL: University of Illinois.

Sutton, S. R. (2011). The preservice technology training experiences of novice teachers. *Journal of Digital Learning in Teacher Education, 28*(1), 44. Retrieved from http://www.teachinquiry.com/index/Introduction.html

Tarnoff, J. (2010). STEM to STEAM—Recognizing the value of creative skills in the competitiveness debate. Retrieved from http://stematehs.pbworks.com/w/file/fetch/46306554 /STEM2STEAM_Creativity.pdf

Texley, J. (2007). Twenty-first-century skills for tomorrow's leaders. *Peer Review, 9*(1).

The Access Center. (2008). Science inquiry: The link to accessing the general education curriculum. The American Institutes for Research. Retrieved from https://www.asdk12.org/depts/science/ESCARGOtweb/documents/ScienceInquiry.pdf

The Center for Teaching and Learning. (2011). The conceptual framework. Retrieved from http://www.cwu.edu/teaching-learning/sites/cts.cwu.edu.teaching-learning/files/documents/CF_2011.pdf

Thirteen Ed. (2014). How has inquiry-based learning developed since it first became popular? Retrieved from http://www.thirteen.org/edonline/concept2class/inquiry/index_sub4.html

Thomas, J. W. (2000). A review of research on project-based learning. Retrieved from http://www.newtechnetwork.org.590elmp01.blackmesh.com/sites/default/files/dr/pblresearch2.pdf

Thomasian, J. (2011). Building a science, technology, engineering, and math education agenda: An update of state actions. Washington, DC: National Governors Association (NGA), Center for Best Practices. Retrieved from http://www.nga.org/files/live/sites/NGA/files/pdf/1112STEMGUIDE.PDF

Trefil, J., & Trefil, W. (September, 2009). Teaching for the 21st century. *Educational Leadership, 67*(1), 28-33.

Twenty-first Century (21st) Frameworks. (2011). Retrieved from http://www.p21.org/our-work/p21-framework

Twenty-first Century (21st) Schools. (2010). Education in the 21st century. Retrieved from http://www.21stcenturyschools.com/what_is_21st_century_education.htm

Walsh, K. (2009). 5 reasons why educators need to embrace internet technologies. *EmergingEdTech.* Retrieved from http://www.emergingtech.com/2009/05/5-reasons-why-educators-need-to-embrace-internet-technologies/

Warner, A., & Myers, B. (2011). Agricultural education and communication. Retrieved from http://edis.ifas.ufl.edu/wc075

Welle, B., & Smith, M. (2014). Time to raise the profile of women and minorities in science. Retrieved from http://www.nsf.gov/statistics/2015/nsf15311/digest/theme3.cfm#asiandegrees

Williams, J. (2011). STEM education: Proceed with caution. *Design and Technology Education: An International Journal*, *16*(1), 26-35.

Wolfe, T. J. (2011). Middle school and technology usage: A case study. *Meridian K-12 School Computer Technologies Journal*, *14*(1). Retrieved from www.ncsu.edu/meridian/summer2011/wolfe/print.html

Yager, S., & Yager, R. (2011). Impact of school based leadership teams for implementing a successful professional development initiative. Retrieved from http://files.eric.ed.gov/fulltext/EJ972970.pdf

Zion, M., & Mendelovici, R. (2012). Moving from structured to open inquiry: Challenges and limits. *Science Education International, 23*(4), 385. Retrieved from http://files.eric.ed.gov/fulltext/EJ1001631.pdf

# Vita

Mary "Paula" Armknecht is a native of Springfield, Missouri, and has lived most of her life in the Missouri Ozark region. She attended parochial school through the sixth grade and continued a public school education in Springfield Public Schools. While raising her family, Paula entered Southwest Missouri State University (now Missouri State University) and earned her bachelor's degree in elementary education, with a minor in special education. She received certifications in 1-8 elementary, K-12 special education, and 5-8 social studies and language arts.

Paula began her career as a special education teacher and returned to Southwest Missouri State University to complete her master's degree in Elementary Administration. After five years in special education, she made a change into general classroom teaching. She taught third grade for five years and fourth grade for eight years. In her career, Paula has worked with students from first grade through eighth grade. She earned certification in eMints through the Missouri Department of Elementary and Secondary Education and completed certification through her school district as a Tech Academy Leader. She currently holds certification in STEM (science, technology, engineering, and mathematics) and is a fourth-grade teacher in a Missouri public elementary school in the Springfield area.