DETERMINING FACTORS THAT SERVE AS BARRIERS TO INTEGRATIVE STEM METHODOLOGY IMPLEMENTATION IN K-12 SCHOOLS

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DOCTOR OF PHILOSOPHY

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ABSTRACT

The purpose of the correlational study was to determine factors that served as barriers to integrative science, technology, engineering and mathematics (iSTEM) implementation in K-12 schools. The sample studied ($N = 153$) was drawn from classroom teachers and administrators with training in iSTEM methodology or experience in iSTEM methods and subsequent experience regarding implementation barriers.

The researcher developed the Integrative STEM Implementation Barriers Instrument (iSTEMIBI). The iSTEMIBI included a six-point Likert scale measuring levels of agreement to statements regarding implementation barriers. The research utilized the Embedded Design correlational model as detailed by Creswell and Plano Clark (2007). Likert items were developed from identified barriers in the literature and from unpublished research by the researcher regarding barriers identified by K-12 teachers completing iSTEM workshops. The research design allowed open-ended response from participants to support the predominately quantitative data.

Qualitative analysis of the literature review indicated issues and benefits common to the current iSTEM movement and earlier curricular movements. ANOVA and post hoc Tukey analysis methods were utilized to determine paired differences between groups by *Implementation Level*, *Content Area*, and *Grade Level* within 12 researcher-developed barriers constructs and identified factors ($p \leq .05$). Eleven factors impacting implementation were identified through principal component analysis and a subsequent path model was developed.

A minimum mean score ($\bar{x} \geq 4.0$ = *Slightly Agree*) was established to compare mean scores within the factor by the implementation levels reported. As participants indicated higher levels of implementation, especially at the *Partial Implementation* and *Full Implementation* levels, the number of items meeting the minimum mean score criteria decreased. Two factors, *Teacher Education Gap in iSTEM* and *No Child Left Behind* (NCLB) were consistently among the highest ranked factors regarding impact on implementation levels. The path analysis also supported the strength of impact of the *Teacher Education Gap* and *NCLB*.

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To complete a project of this magnitude, one encounters a host of people and organizations making important contributions to the success of the research. The support, encouragement, and direction were appreciated.

Several organizations provided access to K-12 educators with integrative science, technology, engineering and mathematics (iSTEM) training and experience in implementation of content and methodology. The organizations included: Center for Innovation in Engineering and Science Education (CIESE); National Center for Technological Literacy (NCTL); Great Plains STEM Education Center (GPSEC); International Technology and Engineering Educators Association (ITEEA); Maryland State Department of Education; Missouri River Education Cooperative; Ohio Technology and Engineering Educators Association (OTEEA).

It was my good fortune to have a group of integrative STEM experts available at Valley City State University. James Boe, David Demuth, Lana Fornes, Don Fischer, Gary Ketterling, Don Mugan, and Roger Skophammer were all integral to crafting Likert statements or giving input on implementation level definitions, and providing input and feedback on the overall design that was critical to the success of the research instrument.

I am indebted to my committee members—Dr. Ericka Offerdahl, who provided important direction regarding science-based perspective on integrated STEM; Dr. Brent Hill, whose assistance was critical in the final phases of the statistical analysis; Dr. Don Mugan, my mentor when I first studied as an undergrad at Valley City State University and whose signature I value the most on this project. I can only hope my career can reach a fraction of what you have accomplished and meant to the Technology and Engineering and iSTEM fields. You are a visionary who saw the big picture long before it was on the radar for most educators and

stakeholders; Dr. Myron Eighmy, as an advisor you supported me, pushed me to places I didn't want to go, and helped me grow. I took my first class in the NDSU doctoral program from you and in that first class meeting I realized you understood the importance of technology and engineering education.

And finally to my wife Gail—this degree is just as much yours as it is mine. Thank you for the support, hugs, reality checks and sarcasm along the way that were needed to keep me grounded. I can't imagine this journey or life without you.

DEDICATION

This dissertation is dedicated in memory of my parents, Leiv Klare Gjøvik and Anna Serene (Knaben) Gjøvik—two Norwegian immigrants to the United States who understood the value of education and passed that value on to their children. I had the good fortune of traveling with them to Norway as a child. As a result of that visit, I always wondered why they left such an incredible country. Years later I asked *far* (father) why he uprooted his family, loaded what items they could in trunks, boarded a converted troop ship, and moved to the United States in 1947. The simple answer was not what I expected—"All our children will have college degrees". Apparently my siblings and I received the message about the value of education—we all became educators.

Takk, far og mor.

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CHAPTER 1. INTRODUCTION

Numerous authors (Augustine, 2007; Bybee & Starkweather, 2006; Miaoulis, 2009;) noted the United States was losing its competitive economic ranking due to progressing foreign economies and a world containing substantial numbers of highly motivated workers, who were becoming more educated and willing to work for less pay. Augustine (2007) further indicated 16 major reports extolling the competitiveness issues facing the United States. Early on, offshoring of manufacturing jobs outside the United States was limited to assembly line and factory-type jobs. According to Augustine, the problem spread to other areas such as software development, administrative work, and professional pursuits.

In response to the United States economic decline, leaders turned to supporting educational reform efforts designed to address the following: (a) falling rankings in United States high school achievement scores in relationship to scores from other industrialized countries (Cavanagh, 2008); (b) a perceived loss of the United States economic competitive edge due to a decrease in domestically trained engineers—considered key to economic resurgence through innovation of new technologies and processes (Bybee & Starkweather, 2006; Peterson, 2009); and (c) concerns about the skill sets of United States high school graduates, calling for improvement in areas such as communication, critical thinking, collaboration, and problem solving (Atkinson & Mayo, 2010).

In response to several national reports regarding the state of education in the United States, methods of teaching evolved to change how mathematics and science were taught in schools across the United States. A methodology that evolved was the teaching of Science, Technology, Engineering and Mathematics (STEM) in K-12 education (Augustine, 2008; Dugger, 2010a; Pearson & Young, 2002). Pearson and Young (2002) indicated the methodology was developed to add technological literacy to the standard curriculum found in K-12 schools. According to Katehi (2009) the STEM initiative called for a paradigm shift in education, to include technological literacy and engineering as inclusive and interdisciplinary core curricular concepts, along with classic content such as science, math, and social studies in comprehensive and integrated curriculum.

Authors (Ashida & Hunter, 2009 a-f; Hunter, 2010; Lantz, 2009; Miaoulis, 2009; Sandlin, 2009) indicated adoption of STEM methodology was relatively slow in regards to implementation. In many cases where STEM curriculum was implemented, a very narrow view focusing only on science and/or math was commonplace. Literature on the subject indicated various barriers to STEM implementation.

Augustine (2007) indicated the United States (U.S.) struggled in a newly defined global economy. In this economy, aviation and telecommunications made distance irrelevant. Where U.S. citizens once competed with their neighbors for jobs, job seekers found themselves competing with candidates from around the world. With the economic downturn, the ability to restore the economy through innovation and invention became even more critical. Augustine further noted that 4% of jobs in the U.S. were in engineering but the remaining 96% of jobs relied heavily on the knowledge and innovation produced by these engineers that consequently are the core of new company starts in the U.S.

Disconcerting to national leaders was the outlook of no quick economic recovery. Friedman (2006) indicated development of a scientist or engineer took up to 15 years. An eSchool News report (2008a) cited House Speaker Jon Husted who indicated that in 1970 approximately 50% of those gaining engineering and science degrees were Americans. At the time of the article it was estimated only 15% of those gaining those same degrees would be

Americans. Dugger (2010a) detailed a more sobering estimate for political and business leaders in the U.S. acknowledging that by 2010, 90% of the world's engineers would be living in Asia. For the United States to climb out of the economic crisis, including reversing the trend of outsourcing many manufacturing jobs and innovative processes overseas, a new cadre of domestically grown and educated engineers and technicians were needed.

Regarding U.S. complacency Friedman (2006) stated:

> …the United States was an island—an island of innovation and safety and growing incomes. And therefore it became a magnet for the world's capital and the world's talent. When your currency is the world's currency and every brain wants to come over and work in your backyard, you start to take things for granted. (p. 343)

Cavanagh (2007) indicated major funding in the STEM fields from the federal and state governments was intended. Also key to the concept was infusion of applied mathematics and inquiry-based science to STEM methodology. Bray (2003) called for a change in the standard K-12 curriculum to be more integrated and comprehensive, a transdisciplinary methodology for all students relying on technological literacy to bring applied components to traditional academic studies.

Selling the benefits of an education including STEM as part of the standard K-12 curriculum was a critical part of workshops and training for teachers and teacher candidates. The importance of making STEM methodology training available to teachers was highlighted by Pines (2009) noting the following on pacing and training of teachers:

> For proper pacing to occur, those of us in the Clark School and other university programs must do a better job of educating high school and middle school teachers about the field of engineering, the academic capabilities their students must develop to enter the field,

> and the right level of engineering concepts teachers can include in their lessons. By providing such support, we can show students, parents, teachers, counselors, and administrators that introducing engineering in K through 12 education is both feasible and of great benefit to the students themselves and to progress in our nation and our world. (p. 2)

Statement of the Problem

The purpose of the study was to determine factors that served as barriers to STEM implementation K-12 schools. The sample studied was drawn from classroom teachers and administrators with training in STEM methodology or experience in STEM methods and subsequent experience regarding integrative STEM (iSTEM) implementation barriers. The participants, through the completion of the researcher-designed Integrative STEM Implementation Barriers Instrument (iSTEMIBI), gave specific insight regarding implementation barriers from the perspective of teachers and administrators with understanding and/or experience in implementing STEM methodology.

Research Questions

A review of related literature and survey of STEM-based workshop participants was completed to answer the following research questions:

1. In what ways is the iSTEM movement similar to previous educational reform movements in the United States?
2. What do stakeholders perceive to be barriers to implementation?
3. Do barriers and factors that affect iSTEM adoption vary between groups?
4. What factors contribute to iSTEM implementation?
5. What barriers and contributing factors have the greatest impact on implementation?

The identification of factors that serve as barriers to iSTEM implementation in the K-12 setting may assist school officials and administrators contemplating inclusion of iSTEM curriculum. While government and industry leaders supported the concept with increased funding, schools were slow to implement or, in some instances, implemented limited versions of the STEM concept by only placing emphasis in science and mathematics, prompting discussion among STEM leaders regarding the missing "T and E" in STEM (Cavanagh, 2008; Katehi, Pearson, & Feder, 2009; Miaoulis, 2009).

Intent of the research was to provide knowledge and identification of the factors that influence iSTEM implementation and to serve to assist iSTEM leaders, school officials and individual teachers considering iSTEM inclusion in the local curriculum. The results of the research may shorten the time required to execute a comprehensive iSTEM program locally.

Definition of Terms

The following terms were used throughout the study and were defined by cited references or intended meaning of the author of this study.

Educational Technology: Is defined as the use of "…technology as a tool to enhance the teaching and learning process" (ITEA, 2007, p. 3).

Engineering Design: An engineering process of designing or devising a system, component or process to meet a need. The process is also known as technological design and is defined as "…the engineering design process demands critical thinking, the application of technical knowledge, creativity, and an appreciation of the effects of a design on society and the environment" (ITEA, 2007, p. 99).

Inclusive: Regarding curriculum—for all students, whether university, technical school or trade bound, female or male, challenged or excelling.

Interdisciplinary: Utilizing knowledge taken from two or more disciplines to solve a problem or develop a product solution.

Integrative STEM (iSTEM): A student-centered methodology that provides students with content, procedures and abilities to research and solve complex problems requiring integration of disciplines resulting in applied understanding.

Manual Training: A concept prevalent in the early 1900s with the intent of not educating for a trade, but to educate for and understanding of basics of all trades (Bennett, 1937).

STEM: Acronym for Science, Technology, Engineering and Mathematics.

Technology: The ITEA/ITEEA defines technology as "…the modification of the natural environment in order to satisfy perceived human needs and wants" (ITEA, 2007, p 9).

Technological Literacy: Technological literacy according to the ITEA/ITEEA is "…the ability to use, manage, assess, and understand technology" (ITEA, 2007, p. 9).

Technology Education: "A study of technology, which provides an opportunity to learn about processes needed to solve problems and extend human capabilities" (ITEA, 2007, p 242).

Limitations of the Study

Due to the unique sample of the study, results may not be generalizable beyond the specific population from which the sample was drawn. The heterogeneity purposive nonprobability sampling method was chosen to provide an opportunity for all respondents to provide data of a diverse nature.

Delimitations of the Study

The study was limited to participants solicited from several organizations with membership experienced in STEM methods in the K-12 setting. Organizations providing invitations to participate were: Center for Innovation in Engineering and Science Education (CIESE); Great Plains STEM Education Center (GPSEC); International Technology and Engineering Educators Association (ITEEA); Missouri River Educational Cooperative; and Maryland State Department of Education. The study utilized a Likert-based questionnaire with additional open-ended responses following the Embedded Design correlation variant model as outlined in Creswell and Plano Clark (2007).

Assumptions

The following assumptions guided the development and administration of the study:

- Cooperating organizations provided access to individuals with training and/or experience in STEM content and methodology.
- Cooperating organizations provided a cross-section of potential participants from the entire K-12 setting.
- It was assumed cooperating organizations provided access to educators with varying implementation levels from (a) *No Implementation,* (b) *Preparation*, (c) *Partial Implementation*, and (d) *Full Implementation.*
- Respondent’s answers in the instrument were accurate and honest.
- The heterogeneity purposive nonprobability sampling method provided a diverse data set regarding barriers to STEM implementation in the K-12 setting.

Organization of the Study

Chapter 1 provided an introduction to the problem, purpose of the study, significance, research questions and definitions that guided the study. Chapter 2 contains a review of relevant literature pertaining to STEM methodology including: (a) applied, interdisciplinary, and comprehensive education movements and the ties to industry and economy; (b) philosophical roots and practices of STEM methodology; (c) impetus behind the STEM movement; (d) identified barriers to STEM adoption; and (e) barriers research, scale and instrument development. Chapter 3 includes the outline of methodology and processes utilized to complete the study. Data will be presented along with analysis in Chapter 4. Chapter 5 will contain a summary of the findings, conclusions of the study, and provide recommendations for further study.

CHAPTER 2. LITERATURE REVIEW

The review of literature focused on areas of interest to the research project. The areas of interest were: (a) applied, interdisciplinary, and comprehensive education movements and the ties to industry and economy; (b) philosophical roots and practices of STEM methodology; (c) impetus behind the STEM movement; (d) identified barriers to STEM adoption; and (e) barriers research, scale and instrument development.

To gain a better understanding of the changing educational landscape, the literature review focused on earlier practices and current methodologies that evolved in the integrative STEM (iSTEM) movement.

Applied, Interdisciplinary and Comprehensive Education Movements

Politics and Public Attitude

To better comprehend the current status of the iSTEM movement in the U.S., a review of historical roots of applied, interdisciplinary, and comprehensive education movements in the US was undertaken. Pulliam (1991) noted education, since the colonial days in the US, was an evolving system driven by "…the whims of politics and public attitudes" (p. 57).

As the modern U.S. system of education had ties to ancient Greek educational tradition, the roots of the acceptance issue for applied practice curriculum may be traced back to this tradition and practice. Bennett (1926) defined the early Greek term "banausic" which translates as "merely mechanical". The term exhibited "contempt towards the manual arts" (pp. 15-16). In ancient Greek society, menial work was performed by slave or hired labor and simply was not suitable for a free citizen.

Bennett (1926) identified early leaders in concepts of handiwork training. The text outlined the changes in educational thought regarding education and training post Revolutionary

War, French Revolution and the introduction of the steam engine, which ushered in the Industrial Revolution. Apprenticeship training in the trades until the 19th Century was the only form of education for the majority of the middle class in the U.S.

Bennett (1937) detailed from the point in approximately "…1870 when the manual arts were subjected to analysis and organized in pedagogical form comparable to the older subjects in the school curriculum" (p. 157). Key was the provision of education at low cost to the working classes. The concept involved one teacher to instruct a large number of students and Pestalozzi's concept of utilizing output of student labor to fund the institution. Also, growth of recognition of value of education by governments led to funding by public and private entities.

Theory and Practice: Roots of Manual and Applied Education

The influence of Pestalozzi and Fellenberg. Early educational leaders and philosophers were influenced by the work of Pestalozzi and Fellenberg (Bennett, 1926; Pulliam, 1991). Prominent officials visited from other countries to study Pestalozzi's methods, and Fellenberg's work received great interest from government leaders and educators from numerous European countries and the United States. As a matter of these observations, manual labor and skilled trades work became central to education as new educational practices evolved on both sides of the North Atlantic.

Bennett (1926) and Pulliam (1991) noted Froebel was a follower Pestalozzi's work and methodologies. Froebel left Germany after religious persecution and moved to Switzerland, eventually opening the first *Kindergarten* school in 1837. The Kindergarten stressed the importance of active sensory learning. According to Bennett (1926) Froebel's methods included the concept of "gifts" and "occupations" for his Kindergarten. Gifts were playthings of shape and for playing with and building. These included balls, cubes, blocks, wooden tablets, lines, points (beans, seeds, leaves, pebbles) for arranging activities. The occupations were basic materials for transforming, modifying and essentially creating activities (clay, cardboard, wood, paper, paint, etc.). “The gift gives insight; the occupation, power”. In this environment gifts were key to elements of discovery and the occupations allowed invention (pp. 161-166).

The concept of education regardless of social class, according to Pulliam (1991), was at the core of efforts by Johann Basedow in Germany and the resulting curriculum included “…health, sex education, vocational training…” (p. 76).

The New Harmony experiment in Indiana. Bennett (1926) outlined background on Owen and his influence on education in the United States. Owen came to the United States in 1825 to begin a “new moral world” following persecution in Britain. Owen had a well-to-do retired associate named Maclure who had spent seven summers in Switzerland including time at the Pestalozzi and Fellenberg schools. The goal of Owen’s new moral world societal obligations would be to create a place to “rationally educate and employ everybody” (p. 176). Although not met with great success, the experiment had future influence on American education in that it (a) became a center for educational scientists, (b) emphasized equal educational opportunity for both boys and girls, and (c) brought the ideas of Pestalozzi and Fellenberg regarding manual arts as an important part of education to the United States.

Mechanic’s institutes. Bennett (1926), in detailing background of the Mechanic’s Institutes, indicated the educational concept developed as “industrial and agricultural populations” desired to improve economic and social status through education. National leaders and business strove to create an intelligent citizenry and workforce. (p. 317). Institutes started in New York and in Boston in the early 1820s. The New York school originated as a school only for children of mechanics, but eventually allowed others to attend. The New York school was successful and self-supporting until its closure in 1858, two years after the adoption of the public school system in New York City.

In 1824 the Franklin Institute began in Philadelphia and included applied sciences in agriculture and mechanics. An inherent issue was mechanics attending lacked the level of education to learn properly through the scientific lectures. Thus the Franklin Institute high school had four areas of study (a) English, (b) classical studies, (c) modern languages, and (d) mathematics and practical sciences (Bennett, 1926, p. 321).

Manual labor movement. The Manual Labor Movement in America was influenced by Fellenberg's Academy (Bennett, 1926; Pulliam, 1991). Bennett (1926) further outlined the importance of manual labor training to future manual and comprehensive education in the United States as manual training was broaching into instruction of secondary and technical subjects. The concept began in 1825-1830 and by the 1840s had lost momentum due to cost of implementation. Remnants of the concepts took hold in some schools and eventually became permanent. While Fellenberg's academy was for the affluent, manual labor was for physical training. But, in the farm and trade school, manual arts were crucial for a student of less financial means to pay for instruction and living expenses, in addition to gaining skills. In America, the two were combined. Supporters of manual labor derived a positive of maintaining health of students, but also as a means of getting an education for those of lower economic status.

Bennett (1926) also detailed how theological seminaries, due to the nature of needs of students and churches in particular, grasped this concept of education and hence were leaders in the movement to include manual labor as a system of exercise for students.

Industrial schools. In recounting background of industrial schools, Bennett (1926) iterated these types of schools evolved in America to include publicly funded education (initially provided by the local community) for orphans, poor, disabled, African Americans following the Civil War, and Native Americans. The first reform school started in the United States in 1824 in New York, followed by one in Boston in 1827 and Philadelphia in 1828. The goal was to provide industrial training to make students productive members of society. An issue was these reformatory education programs were basically workhouses promoting a form of slavery. Bennett indicated: "The occupation he learned, as a rule, could not be called a trade and it was not the one he was likely to follow as a means of livelihood after leaving the institution" (p. 248). Training was focused on habits of industry, not trades.

Bennett (1926) detailed early support for a comprehensive education system by the effect on other classical subject areas noted in industrial schools:

> To a few progressive schoolmasters who had given the industrial work a fair trial in their schools, it had a value in school beyond enabling a child to earn money, beyond teaching him an industrial occupation, more important than preventing idleness. They saw in it, when utilized at its best, a means of strengthening the instruction in other subjects. (p. 237)

The issue at the time was a lack of evidence of pedagogical analysis and organization of industrial schooling according to Bennett (1926). Much is the same today as authors bemoan the lack of research-based assessment pertaining to the results of technology and engineering curriculum on the larger classical school curriculum (Katehi, 2009; Katehi et al, 2009; Peterson, 2009).

Early schools of applied science and engineering. Bennett (1926) noted the driving force behind Mechanics' and Lyceum Movements were science and mathematics as they applied to agriculture, mechanics and manufacturing. A new type of higher learning institution was on the horizon—colleges with the intent of training with "…curriculum preparing students for higher careers in agriculture, the mechanic arts, and engineering" (p. 348). The Gardiner Lyceum founded at Gardiner, Maine in 1823 offered short-term classes in specialized content, but was on a liberal scale meaning students were working for a college-level grade. Funding for Gardiner came from gifts, tuition and state appropriations. Gardiner was highly reliant on state support and after 10 years financial support ceased and Gardiner closed.

Bennett (1926) also noted a second important school, started in 1824, was the Rensselaer School located in Troy, New York (now known as Rensselaer Polytechnic Institute). Rensselaer strove to benefit the children of "farmers and mechanics" by giving students applied experiences in experimental chemistry, philosophy, and natural history as they applied to agriculture, domestic economy, the arts, and manufactures (p. 350). Work at Rensselaer was considered so progressive that a considerable number of college graduates attended making Rensselaer the first graduate school and eventually the first engineering college in the United States.

Land Grant Act of 1862. Early on, according to Bennett (1926), agricultural college degrees were looked at with disdain as farmers considered professors book taught with little or no practical farm experience. Professors who considered applied science content as inferior to classic content exacerbated the issue regarding negative perceptions of college degrees. On a similar note in recent times, Kelley (2010) noted the technology and engineering components of STEM as being a relative newcomer when compared to the classical curriculum areas of math and science and therefore somewhat lacking in "stature and acceptance" (p. 3). Bennett (1926) further noted in 1850 Jonathan Baldwin Turner, president of Illinois State Teacher's Institute, called for a state industrial university with emphasis in agricultural and industrial applied sciences. Turner's work was the driving force behind the movement that established state land-grant universities.

Bennett (1926) and Pulliam (1991) outlined the timeline of the Act. Resolutions from the Illinois Legislature regarding the land-grant idea were compiled and House member Justin S. Morrill of Vermont was persuaded to bring the proposed bill forward in 1857. The bill passed the House of Representatives but was defeated in the US Senate. Again it was introduced in 1859, passed both houses of Congress but was eventually vetoed by President Buchanan. During the presidential election of 1860, both Lincoln and Douglas had promised Turner they would support the bill if passed again. Lincoln signed the Act into law on July 2, 1862.

The Act, as noted by Bennett (1926), provided 30,000 acres of public land per senator for support of agriculture and mechanic arts. The Land Grant Act resulted in many of the state colleges of agriculture, mechanical arts, and state universities in operation today. The Civil War delayed several states in implementation of the Act, but eventually 13 states benefited. Workshops in these land grant engineering schools were for learning the best practices, not for pay as had been done in the past to support one's expenses or to gain physical exercise.

Bennett (1937) noted that although the Land Grant Act of 1862 began the public support of applied science agriculture and mechanic arts colleges and universities, there was still a void for providing engineering education.

Manual training in elementary education. Bennett (1937) detailed an experiment during the 1870s in Boston that eventually lead to elementary schools incorporating training into the classroom. This educational change was driven by the desire of religious groups and social workers to include more practical instruction in the public schools. Tool instruction as per the Russian system and Swedish sloyd greatly influenced the incorporation of manual training in elementary schools in the United States. Practical application of knowledge eventually morphed from these education models and coupled with the American concept of crafts and ideals of educational process. The inherent issue perplexing the leaders of the time was how to incorporate the best of the different methods into coursework. The growth of the American system of manual training in grammar school was attributed to the melding of three manual arts conceptual areas:

> It was recognized that by accepting some of the so-called principles of the Swedish sloyd while continuing to apply some fundamental practices of the Russian system and harmonizing these with the best American practice in the use of woodworking tools, Boston had produced an American system of manual training that was pedagogically sound and practical. (p. 434)

Bennett (1937) credited John Dewey, who proposed the importance of including industrial aspects of life as critical to core elementary curriculum. Bennett indicated Dewey supported manual training concepts in elementary schools that became supporting content for other curricular areas by being "…so broad and rich in related content that they would very readily and naturally become the basis for instruction in the so-called other subjects" (p. 451).

Applied Practices Versus Classical General Education

Bennett (1937) posed that during the period from 1880-1890 much discussion was heard regarding support of manual training and classical general education. Conventions of the National Education Association served as a sounding board for the debate. Some supported the manual training concept in general education but only as a separate independent school for manual training. The concept led to the development of vocational schools. The concept in manual training was to not educate for a trade, but to educate basics of all trades. Also, some of the schools of the time provided instruction in practical courses for young women.

The Committee of Ten. Helton (n.d.) stated during a time following the Civil War there had been no curricular direction on a national level and the number of subjects taught had grown as education demands were being met. Helton further indicated strong growth had happened in the sciences and in coursework designed for students on a non-college attending track. Hence applied subjects such as commercial arithmetic, typewriting, business correspondence, to name a few, were also delivered. Curriculum in high schools typically included classical or practical coursework referred to as "manual training" or "commercial" (Pulliam, 1991, p. 91). Pulliam further noted the perceived problem was little consistency in length or terms of courses. A course designed for one semester or one year might well be a four-year course in another high school. The need for standardization of the curriculum led to the National Education Association (NEA) establishing the Committee of Ten (C10), with the expressed intent of standardizing delivery across the United States.

Weidner (n.d.) and the Center for the Study of Mathematics Curriculum (Center for the Study of Mathematics Curriculum [CSMC], 2004) gave additional background of conditions leading up to the establishment of the C10 in 1892. There were two educational camps at the time, traditional educators viewing high school strictly for college preparation—in effect a conduit for college preparation, and another philosophy called for education of all students dependent on a student's intended track for future employment. The NEA appointed Charles Elliot of Harvard University to chair the C10 with the charge to determine a standard curricular path for public schools. Because of these differing philosophies, a diverse list of curricular subjects developed leading to a preponderance of nearly 40 different subjects with little consistently across the U.S.

In discussing the standards movement, Sewall (1994) commented on the efforts of the C10, to set standards for secondary school content, objectives, and methodology for high schools in the U.S. that affect curriculum to this day. The result established a curriculum designed for all students, whether college bound or not, effectively leaving little or no room for manual or applied coursework.

Sewell (1994) also indicated the C10 recommended a curriculum, although not removing the classical Greek and Latin languages, that allowed the classical languages to be studied as electives. Sewell indicated the change gave more credence to the classical languages, geography and math, and gave less emphasis to English, history, sciences, and other modern languages such as German and French. Wiedner (n.d.) and the CSMC (2004) also noted other recommendations proposed by the C10. The first was exposing students to some of the subjects at an earlier age, in effect suggesting an eight-year elementary and a four-year secondary plan. The second was to offer the same curriculum to college or university-bound students as well as non-college or university-bound terminal students.

According to Weidner (n.d.) the C10 contributed to the liberalization of education by allowing additional paths outside of Latin and Greek track. Suggested tracks were (a) Classical, (b) Latin-scientific, (c) Modern Language, and (d) English. The recommendations were grounded in the belief the common curriculum options (a) would be of benefit to both terminal and college/university bound students by allowing a goal of all students doing well in life, (b) would give student abilities to contribute to their own well-being and the benefit of society, and (c) would prepare some students for advanced college/university education. Helton (n.d.) indicated the recommendation of the Committee resulted in a curriculum for all students, regardless of college/university track or terminal completion of high school. Helton also stated

"By and large, the report of the Committee of Ten established college domination over the high school curriculum…" (para. 2).

Pulliam (1991) indicated the issue with the recommendations of the C10 being influenced by "vested interests" and further stated "…vocational and commercial courses were largely ignored" (p. 92). The work of the C10 lead to the unit of credit still in use today for high schools known as the Carnegie unit and Pulliam noted a requirement of 15 Carnegie units for graduation including three units of English and a minimum of two units of mathematics.

Fallout of recommendations issued by the Committee of Ten. The CSMC (2004) reported the type of mathematics proposed in the General Statement of Conclusions of the Committee of Ten. Item 1-d called for "High school mathematics courses should have the same expectations for all students". Also in item 2-c, from the Special Report on Arithmetic, the Committee recommended the following: "Some topics should be curtailed or omitted, including the greater part of commercial arithmetic and examples 'not intelligible to the pupil should be omitted' " (p. 3), effectively eliminating applied practical mathematics for students of that time.

The 1895 *Committee of 15*, as noted by Feldmann (2005), completed its work 2 years after the C10 with the expressed focus to make recommendations regarding elementary school curriculum. Two years later another committee was convened in 1897 and was named the *Committee of Twelve on the Rural School Problem* (C12). The C12's goal was to address inequalities in education in rural/agrarian schools in the nation. There were difficulties in rural schools regarding implementation of the C12's recommendations, and little change ensued.

Sewell (1994) noted issues with implementation of recommendations proposed by the C12 eventually lead to the release of the *Cardinal Principles of Education,* published in 1918. Sewell recounted the Progressivism movement had issues with the recommendations of the C10.

The movement took hold in the 1920s and Sewell indicated Dewey's *Democracy and Education* had great effect on education:

> Written at the peak of progressive confidence, when educators were flushed with faith in the new social sciences, this wide-ranging book stressed activity, experience, and utility, human growth and potential. With confidence in reason and human goodness, dazzled by the redemptive power of general education, Dewey looked upon the educational goals published a generation before as hopelessly inadequate for a democratic people. (p. 23)

Sewell (1994) noted the theoretical differences caused a change in the 1894 standards when the *Cardinal Principles* were published, again under the auspices of the NEA. Hofstadter was reported by Bohan (2003) to be a critic of progressive education, and further, Hofstader was cited by Sewell (1994) stating educators of the time "militantly proclaimed that such education was archaic and futile and that the noblest end of a truly democratic system of education was to meet the child's immediate interests by offering him a series of immediate utilities" (p. 24). Hofstader further made a negative implication of the *Principles* as "…a crusade to exalt the academically uninterested or ungifted child into a kind of culture-hero" (as cited by Sewell, 1994, p. 24). The change in philosophy of the *Principles* once again recognized the need for applied and practical forms of education for students not on a college/university track. Although the Progressive Education movement gained prominence in the 1920s, Bohan (2003) noted the roots of the Progressive Era were found in the recommendations of the C10 from the 1890s and predated formation of the Progressive Education Association in 1919. The movement was predicated on citizenship education.

Feldmann (2005) indicated the change to educate focusing on individual skills, later referred to as people skills, with the following: "By 1918, concentration of studies in American schools had turned more away from subject matter—and to personal growth and development—than had ever been witnessed before" (p. 41).

According to Feldmann (2005) schooling of the time was based on education as a "socializing agent" (p. 42). The "…Cardinal Principles called on American secondary schools to hone the skills of students in several general 'personal development' areas: Health, Command of Fundamental Processes, Worthy Home Membership, Vocation, Leisure Pursuits, Citizenship, and Ethical Character" (p. 43).

Feldmann (2005) reported Frederick Taylor published his manifesto *The Principles of Scientific Management* and the concept of "social efficiency" gained popularity and was supported by Charters and Snedden, two educational curriculum reformers. The concept "…sought to apply the reason and operation of the manufacturing world to that of public schooling" (p. 44), and conceptually was in alignment with behaviorists of the time.

Feldmann (2005) further explained the stock market crash of 1929, and the Great Depression that followed, once again left fertile ground for education reformers and leaders to question concepts being taught in schools. "Reconstructionists" were the next reform group to have an effect in education. The group questioned the social purpose of the curriculum (p. 47).

According to Feldmann (2005) during the 1940s Ralph Tyler's *Basic Principles of Curriculum and Instruction* was a popular curricular framework well embraced by behaviorists. Feldmann (2005) stated: "Tyler stressed that it was what the student did in the classroom—not the teacher—that was important" (p. 48). Tyler's framework relied on identifying objectives, developing learning units based on the objectives, organization of learning units and a final evaluation of the process. The process was about imparting skills to the student through the education process. Feldmann indicated the behaviorist reformers had direct ties to the earlier social efficiency reformers.

The vocational education movement. Pulliam (1991) noted following the Civil War to Woodrow Wilson's presidency there was little support for educational reform, as the Republican Party dominated the period and the party was "Distinctly the party of business, industrial, and commercial interests, …" (p. 88). Bennett (1937) confirmed this noting by 1885 general consensus was public funds should not be used for special trades or vocational training.

Bennett (1937) intimated the case of manual/applied practices in training supporting and enhancing general education was supported when a manual training school official indicated "The boys taking manual training were said to make 'more rapid progress and do much better work in all branches of mathematics" (p. 390).

Bennett (1937) outlined background about the vocational education movement and the ensuing support on the national level. Prior to 1906 various types of trade schools were started in New York, Philadelphia, and San Francisco. Pulliam (1991) indicated free public education for all was a concept that gained momentum following the Civil War. In 1905 a commission was started to determine vocational training needs for the Commonwealth of Massachusetts. Of interest to this research were the following determinations: (a) public institutions were not meeting the needs of industry as they were too literary; (b) technical schools of the time were not able to fulfill the needs of industry; and (c) support was growing for public funding of industrial/vocational training.

Bennett (1937) indicated two recommendations came out of the commission: elementary schools should be modified to introduce students to elements of industry; and, high school curriculum should be adjusted to include mathematics, science and drawing instruction using applied practices, with a reference to industry of the time. This allowed students' understanding the subjects were not merely for academic pursuits, but also had relevance in practical life.

According to Bennett (1937) the National Society for the Promotion of Industrial Education formed in 1906. Two important results of the work of the Society were surveys of major cities across the United States regarding vocational education needs and the eventual passage of the Vocational Education Act of 1917. Bennett also indicated the Smith-Hughes Act enabled federal direction and reimbursement law to various types of vocational training and the hence the Act ushered in a "…new era in manual and industrial education in the United States and therefor the end of the era…" (p. 550). In addition, Bennett further identified three continuing and remaining issues that had to be dealt with:

- Issues between manufacturers and labor unions regarding each having the desire to control the labor market.
- Disagreements between those supporting practical education in public schools and those who felt vocational education would lower the standards of the classical public school of the time.
- Some believed the vocational school needed to be separated from the general education components of the public school while others could not support the concept of a dual system.

Prior to the Act being voted into law, several types of vocational education schools evolved: (a) the pre-vocational or industrial school, (b) the continuation school, (c) the part-time cooperative school, (d) the day vocational or trade school, and (e) the apprenticeship or corporation school (p. 528).

Industrial Education: Change on the Horizon

Foster (1997) noted during the 20th Century "…practical, vocational, and career-oriented education…" (para. 2) were key elements of movements in education in the U.S. resulting in three distinct occupational movements. The manual training concept of the late 19th century evolved to public funding of vocational education during WWI. The second was a career education movement in the early to mid 1970s and at the time industrial education had evolved along two different paths—as a general education concept and as career-oriented curriculum. In the third iteration, Foster indicated in the change from industrial arts to technology education, there existed a field with potential positive results as an inclusive curriculum for all students.

Era of industrial education transition. Foster (1997) noted the educational roots of technology education in the U.S. were traced back to the manual training and manual arts movements of the late 1800s and early 1900s and the eventual evolution of manual arts to the industrial arts concept that was prevalent through most of the 1900s. In the mid 1980s, technology education became latest iteration of industrial education. Although the emphasis changed to technology education in the mid 1980s, as indicated by Clark (1989), industrial arts content and methodology remained as vestiges of an earlier time under the technology education umbrella.

Foster (1997) insinuated a persistent question pervaded the field. There was, and continued to be, discussion among factions whether industrial education should be considered general or vocational education. Both industrial and vocational factions pointed to Bonser and Mossman as "providing significant philosophical direction" (para. 24) in various industrial education fields.

Manual training to industrial education. Snyder (2004) noted issues for industrial educators when dealing with the evolving definitions of the various curricular areas during the progression from manual arts. For the purpose of this research the following helped define the fields' evolution. Snyder (2004) cited definitions of manual training, manual arts and industrial arts as defined by Crawshaw and Varnum:

> *Manual training* … refers to the method by which industrial work is developed under school control. It signifies a plan by which hand, tool and machine work is made educative through a series of progressively developmental problems.
>
> *Manual arts* … indicates the content of the several subjects which are included in a division of the school dealing with industrial work.
>
> *Industrial education* … refers to the study of all or a branch of industry (a manual art) by means of the most approved pedagogical and industrial methods. It includes both information about and practice in industry. (p. 5)

Snyder (2004) further described the evolution to industrial arts and attributed the background to Collicott and Skinner. The authors noted manual training predominately utilized woodworking to give students learning and knowledge through tactile processing. Further the manual arts, still placing importance on skill development, were expanded to insure products were useful and well designed. Finally, industrial arts was described as an attempt to utilize pedagogical practices from the past that still had value but to expand the skills desired to include a more student-centered view including "child's interests and environment" (p. 22) with further involvement of additional subject areas.

Bennett (1937) also helped define the differences with the following: "In the term industrial arts, the 'industrial' is emphasized; while in manual arts, the 'arts' is historically the distinctive word and, in the term manual training, 'manual' is the important word" (p. 455).

Manual arts to industrial arts. Foster (1997) credited Frederick Gordon Bonser and Lois Coffey Mossman with developing manual training as a concept and eventually defining the industrial arts concept in the 1920s. Further noted was the curricular idea became a core concept in industrial education in the U.S. for 70 years. Foster (1999) further wrote:

> Bonser and Mossman (1923) were still using the term 'manual training' to identify the prevailing interpretation of industrial education in the 1920s. In *Industrial Arts for Elementary Schools* they drew a sharp distinction between manual training and their program of industrial arts, which could generally be considered an attempt at reconciling cultural industrial education and object teaching. (para. 24)

According to Foster, the Bonser and Mossman view regarding the place of industrial arts in the curriculum "…as ideally being completely integrated with the rest of the school curriculum. Seventy-five years later, these are tenets of technology education at all levels" (para. 31).

Foster (1999) saw a clear connection within the Bonser and Mossman philosophy of industrial arts serving as a connecting activity for other school subjects versus simply learning manual skills and tool usage. Foster (1995) referred to the development of industrial arts as borrowing from several practical education roots: "lt seems clear that the founding of industrial arts in the U.S. was less an extension of any one of those roots than it was a philosophical convergence of them" (para. 1). This assimilation was also noted by Bennett (1937) as industrial arts could trace its form and lineage back to numerous movements and training systems:

"…handwork instruction in the primary and intermediate schools, whether known as manual training or sloyd or manual arts or construction work or handwork or by any other name" (p. 445).

Progressivism became dominant just after WWI and focused on a child-centered concept. Industrial arts according to Bonser and Mossman was a product of the progressive movement (as cited in Foster, 1997). Foster further credited Anderson who noted industrial arts was not an outgrowth of manual training according to some historians, but a cycling trend in education for hundreds of years, going back to early influences in Europe.

Foster (1997) characterized the philosophical differences of the two "As politically right-of-center as the goals of social efficiency had been, so had progressive education been viewed as left-of-center. Now the tide had turned" (para. 30). The Cold War and the Russian launch of Sputnik lead to the demise of progressivism at the time. Although industrial arts was a product of the progressive era, it still was successful during a more conservative political time. Early on, post WWII industrial arts was acceptable as it promoted industry and self-efficiency, concepts supported in a capitalistic society. But after Sputnik and the adoption of the National Defense Education Act, industrial arts was no longer a critical component of education politically, and numbers began to fade.

Foster further characterized the pendulum swing as the progressive era concepts of student-centered curriculum and career and competency-based education were once again important in the 1990s. Also noted were issues identified in the 1990s were also issues in the 1960s. Foster cited Barlow, who indicated in 1973 "…criticism of education in 1912, in relation to the lack of vocational education, reads much like the criticism of the 1970s, in relation to the lack of career education" (p. 31).

Industrial arts to technology education. Snyder (2004) summed the ties of earlier programs to technology education stating "learning by doing" served as core to the paradigms, but in all there was a tie to technology. Hence "Technology education evolved from, but is not limited to, this strong tradition of hands-on learning" (p. 23). Atkinson and Mayo (2010) reported the positive results of problem-based activities. Student interest was maintained as they acquired and applied knowledge to real-world problems. The authors indicated a lack of educational research in STEM subjects in the U.S., but referred to research in the United Kingdom and Israel with very positive results attributed to project-based learning methods.

In discussing the heritage of the technology education field, Snyder (2004) defined the various "technics" paradigm names beginning with manual arts and progressing through technology education, and indicated the wide variety of labels regarding technical forms of education was a hindrance.

Foster (1995) credited the influence of Bonser and Mossman regarding social-industrial theory on technology education. Their issues with the manual training movement were the inability to meet individual needs of children, motivational issues, and a strong emphasis on efficient production of products with little or no adherence to the needs of the student.

Foster (1995) identified three distinct movements regarding industrial education curriculum and further indicated some histories of industrial education and/or technology education blend the movements into a single curricular movement. Foster listed object teaching of Pestalozzi, tool instruction for both children and adolescents from the manual training era, and cultural industrial education. Kirkwood, Foster and Bartow (1994) conducted research tracing historical roots of industrial arts to technology education. The results confirmed the lineage, based the authors' contention that several leaders were identified as critical contributors in both the industrial arts and technology education era.

Foster (1995) credited Bonser and Mossman as core contributors to the theory of technology education. In fact, Foster also intimated Bonser was the fortunate recipient of much of the credit for the work he and Mossman co-authored. Foster noted Bonser had no published works in elementary industrial arts before his association with Mossman. This may be supported by a reference to Bonser's contributions in 1913 to the expansion of industrial arts in the elementary curriculum, as noted in Bennett (1937), without any mention of Mossman. Foster (1995) further indicated Mossman was a supporter of integrating (interdisciplinary) activities to bring practical application to content areas. Additionally, Mossman felt it important that students should design their own projects, an important concept found technology and STEM education today.

Foster (1995) also alluded to leaders, who purportedly followed the Bonser and Mossman concepts of industrial arts, supporting a separation of industrial arts and vocational education. In fact, Bonser and Mossman supported vocational education for students as long as they had experienced industrial arts in the elementary school. The segregation of the two areas continues to this day. Foster further stated:

> Bonser and Mossman had a sound plan for industrial arts. Many plans since-such as the Industrial Arts Curriculum Project, the Jackson's Mill Industrial Arts Curriculum Theory, and the current Technology for All Americans project-have also been the results of collaborative efforts among educators. But whereas historically the profession has recognized these group efforts as such, it has yet to acknowledge Lois Coffey Mossman

> as a primary contributor not only to industrial arts, but also to modern technology education. (para. 57)

Industrial Arts Curriculum Project. Snyder (2004) indicated the *New Industrial Arts Curriculum* was introduced as a concept to the 1947 convention of the American Industrial Arts Association (AIAA) by a group consisting of: Warner, Gary, Gerbracht, Gilbert, Lisack, Kleintjes, and Phillips. The curriculum emphasized people not only as consumers, but also as producers and recreational users of technology. The concept was considered ahead of its time and lacked strong implementation, but according to Olson did impact future industrial arts practices (as cited in Snyder, 2004). There was an evolution of the Warner et al, concept as a new project entitled *A Curriculum to Reflect Technology* with additional emphasis on socio-economic aspects of technology within the following areas: "power, transportation, manufacturing, construction, communication and management" (p. 23). Snyder noted the curriculum never gained any national traction, probably due to a lack of funding.

Jackson's Mill Industrial Arts Curriculum Theory. Wicklein (2006), while indicating the lineage of industrial arts curriculum projects following WWII, credited the Jackson's Mills project as consolidating and bringing consensus in the industrial arts paradigm and its eventual further evolution to technology education:

> I consider the publication of the Jackson's Mill Industrial Arts Curriculum Theory document as the starting point of the modern era of technology education. Of course there were other significant contributions that helped to set the stage for this document. William E. Warner's *A Curriculum to Reflect Technology* (1947), Delmar Olson's *Technology and Industrial Arts: A Derivation of Subject Matter from Technology with Implications for Industrial Arts Programs* (1957), Paul DeVore's *Technology: An*

> *Intellectual Discipline* (1964) and the development and implementation of the *Industrial Arts Curriculum Project* (lACP), the *American Industry Project*, and the *Maryland Plan* (1960s and 1970s) all created a progressive stimulus that paved the way for the field of technology education. However, it was the Jackson's Mill document that provided the needed systemic refocus of the curriculum formerly known as industrial arts. (p. 25)

Lauda (2002), one of the participants in the Jackson's Mills Industrial Arts Curriculum Theory, outlined background to the gathering of 21 leaders in industrial arts education. Lauda pointed to issues in industrial arts stemming from an overall failure to adapt needed changes within the industrial arts paradigm. The result of the project was a theoretical base studying the following technological systems: (a) manufacturing, (b) construction, (c) transportation, and (d) communications. Two distinct philosophical differences emerged regarding whether industrial arts should be based on study of industry or study of technology.

Technology for All Americans Project (TfAAP). According to Snyder (2004), the need for technological literacy appeared in literature as early as 1948 when Williams, vice president of the AIAA penned *Industrial Arts Faces a New Era.* Over 50 years later, technological literacy stood as a major tenet of the *Standards for Technological Literacy* (*STL*), published by the International Technology Education Association (ITEA, 2007). Snyder (2004) indicated before the *STL* were produced, a major research concept entitled the Technology for All Americans Project (TfAAP) occurred that eventually became the source of content for the *STL*.

William E. Dugger, Jr. served as the Director of the TfAAP. Dugger (2010b) referred to TfAAP and indicated how the project's resulting publication (ITEA, 1996) "provided the research necessary to identify the content to be later used in the creation of *STL* standards" (p. 2). The project ran from 1994 to 1996 and was later revised in 2006. Dugger further outlined the timeline of the further development of assessment, professional development and program standards *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards* (AETL) published by the ITEA (2003). The AETL had three sets of standards to address that were accomplished by further publication of three addenda (ITEA, 2004; ITEA, 2005a; ITEA, 2005b).

Dugger (2010b) noted these publications provided "assistance for developing and implementing standards-based technology programs, student assessment, professional development, and curriculum. They feature practical suggestions and processes, multiple forms and worksheets, and concrete examples for implementing exemplary technology education programs and curriculum in grades K-12" (p. 4).

The Standards for Technological Literacy. Pearson (2004) was a Program Officer at the National Academy of Engineering (NAE) directing technological literacy and public understanding of engineering activities. He referred back to the development of the *STL* as a "…critical point in the history of technology education" (p. 28). He went on to state "Though not abandoning completely the field's industrial arts roots, the standards were a clear statement that the old ways no longer were sufficient to maintain, let alone grow, the profession." Pearson referred to an earlier report that he co-edited with Young (2002). Pearson stated: "The report argued that citizens of a modern nation like ours, so dependent on technology, ought to be more conversant with it" (p. 28).

Dugger (2010b) indicated the vision of the *STL* (ITEA, 2007) was "that all students can and should become technologically literate" (p. 3). In response to educational inertia, the small amount of students exposed to technological literacy, and teaching to the test due to competency-based testing in the era of No Child Left Behind (NCTL), the *STL* (ITEA, 2007) contained the following statement:

> One is simple inertia. To keep doing what one has been doing is always easier than learning to do something new. A bigger reason, though, lies with the pressures on the educational system today. The back-to-basics push has emphasized competency in such traditional courses as English, mathematics, science, history, and social studies, but technology has never been a basic part of education for most students. Furthermore, the growing emphasis on standardized competency tests has encouraged schools to teach to those tests, which generally contain few questions gauging technological literacy. So, squeezed for time and resources, relatively few local school districts and states or provinces have opted for what they see as the luxury of including the study of technology as part of the core curriculum. (p. 3)

In giving background to the Back to Basics movement in an era of change in industrial arts and technology education during the decade of the 1980s, Foster (1997) indicated while the movement was intended for all students, the change of the American Industrial Arts Association (AIAA) to the International Technology Education Association (ITEA) was also intended to serve all students as a general education component. Technology education failed to gain the general education foothold and a period of decline ensued. Whether considered general or vocational, practical curriculum was in a position to serve all students. If the two fields were indecisive, once again Foster felt an opportunity would be lost.

Career education movement. In an article regarding elementary school technology education (ESTE), Foster (1999) noted the popularity of industrial arts activities in the elementary school during the period of the 1960s and early to mid 1970s. But, as philosophical issues emerged regarding industrial arts' position in the general curriculum as a subject area or a methodology, the use lost any traction it had until the technology education movement emerged. Hence, discussion among leaders ensued whether technology education was derived from industrial arts or had little common ground. At the end of the 20th century there were many calls for methods of education that would increase student achievement, motivation and engagement through practical application and real-world assessment.

The career education movement of the 1960s and 1970s according to Foster (1999) gave rise to the importance of industrial arts in elementary school curriculum. During the mid 1960s, 141 teacher education institutions had courses in elementary-based industrial arts. But, by the mid 1970s, only 80 colleges and universities remained that had courses in elementary-based industrial arts.

Skophammer's (2009) research corroborated the further erosion and compounding of the issue in K-12 education following the transition from industrial arts to technology education. Skophammer sampled 248 of the 697 accredited teacher education programs in the U.S. and noted, in his review of requirements in K-12 teacher preparation, only 32 institutions contained courses addressing technological literacy.

In reporting on the status of ESTE in the U.S. Foster (1999) determined three theories of delivery of technology education in the elementary setting (a) delivered as content, (b) delivered a process or skill to be taught to students, or (c) delivered as a methodology to assist in integrating disparate curricular areas.

Foster (1999) noted a call in the research and writings of Wright and Welty to consider delivery of ESTE as a combination of content and method, but calling for the inclusion of context and process.

New Math, Reform Math, and the Mathematics, Science and Technology Movement

Mathematics curriculum also experienced an ebb and flow of movements regarding how to deliver content. Once again, scores on national and international testing of aptitude typically drove the call for change in delivery methodology.

Although the launch of Sputnik in 1957 was commonly referred to as the event that began the new math movement, Herrera and Owens (2001) implied the movement was in progress 15 years before that date. During WWII leaders, educators and the public in general realized more technical skills and mathematics acumen were needed as a new age of technological advances loomed. Several national reports ensued, but had little effect until the National Defense Education Act (NDEA) was signed into law in 1958. Evans (1983) noted the Cold War and the resulting NDEA lead to changes in mathematics, science and language curriculum "…all strongly focused on process rather than product" (p. 176). Evans believed the NDEA had little positive impact on most children and felt a major problem was teacher's lacked the background and expertise to deliver these new curricula. Due to the difficulty of the course materials, a wider acceptance was found for use in gifted and talented programs.

According to Evans (1983), during the 1960s, there was a demand for educational equality from parents and students. At issue was the feeling of elitism evoked by special classes for advanced or challenged students. Evans stated "U.S. schools translated these objections into an academic equality based on the lowest common denominator — and the instructional innovations, though barely launched, fell into disuse" (p. 176).

Herrera and Owens (2001) indicated an initial positive reaction to the 'new math' movement following the NDEA as significant numbers of teachers were supported by National Science Foundation (NSF) grants to obtain training. But, there was a negative side to the movement as parents began questioning the curriculum as they were simply unable to assist children with mathematics problems as they arose. Because of this parental backlash, plus some mathematics leaders opposing the change, “The decade of the 1970s was characterized as a ‘back to the basics’ era” (p. 87). Support for the move to basics-based curriculum was supported by a documented decline in Scholastic Aptitude Test scores over a ten-year period. Once again, the emphasis was on students developing computational skills and abilities in algebra.

Evans (1983) indicated the call for excellence once again resurfaced during the period of the 1980s. Evans called for a return to challenge and rigor in coursework materials, coupled with increasing preschool and full-day kindergarten programs. The major component called for was competency testing after grades 2 and 4 to serve as a checkpoint for deficiencies and remediation to follow. As a solution for gifted and talented students, Evans suggested a concept utilized in some states using regional schools for delivery to the population, and alluded to the success of the concept in vocational education and special education. Once again, the Scholastic Aptitude Test (SAT) scores in the U.S. were falling and Evans did not pin lack of basic skills as the culprit, but instead placed blame on insufficient problem solving and abstract-reasoning skills. Evans supported this concept by noting modest gains in the SAT under 600, but the number of scores in the 600-800 range dropped. Evans indicated the level of knowledge necessary to score in the 600-800 range required problem-solving and abstract-reasoning skill sets.

Herrera and Owens (2001) intimated the publication of *A Nation at Risk* became the catalyst for another major change in mathematics curriculum and “Its rhetoric linked education to a national crisis, as in the days preceding the new math movement” (p. 88). The result became known as the ‘reform mathematics’ movement. As before, battle lines were once again drawn across two mathematics philosophies. Herrera and Owens identified two basic camps in what became known as the ‘math wars’. One side populated by traditionalists, believed in procedural math with linear solutions, i.e. ‘step-by-step’ versus the proponents of standards-based reform following the *Curriculum and Evaluation Standards for School Mathematics* published in 1989 under the auspices of the National Council of Teachers of Mathematics (NCTM). The traditionalists dubbed the reform movement as the ‘new new math’, but the authors indicated no publications where the two concepts were compared. The authors differed with the traditionalist claim of reform math being a reincarnation of the new math of the 1960s, but did note some similarities. “Both grew out of discontent with student performance and the incompatibility of traditional content offerings with advances in mathematics. Therefore, each added new content to the K-12 curriculum…” (p. 90). Where the two differed was the new math placed a priority on “deductive reasoning, set theory, rigorous proof, and abstraction, while the *Standards* emphasized applications in real world context, especially experimentation and data analysis.” (p. 91). Finally the authors noted a difference between the two movements in regard to pedagogy, indicating the reform math movement had ties to constructivism with the inherent focus on processes inherent in “communicating, reasoning, problem solving, making connections and representations” (p. 91).

Herrera and Owens (2001) further noted the reform movement, after initially having positive reaction, was being questioned by mathematicians, teachers and a concerned citizenry. These concerns eventually led to another document, *Principles and Standards for School Mathematics,* published in 2000 by the NCTM designed to clarify these concerns expressed “by the many stakeholders in mathematics education, to clarify NCTM’s positions, and to define its vision” (p. 90).

Kelley (2010) noted prior efforts linking technology education and its predecessors to interdisciplinary and multidisciplinary movements. Kelley focused on the Math, Science and Technology (MST) movement that occurred during the early 1990s and indicated an argument could be made for the MST movement in effect helping usher in the STEM movement. Kelley further noted the STEM movement had the greatest potential for effective change of any previous movement. Moore (1993) referred to the movement as science, mathematics and technology (SMT) and listed the need for change in SMT as it was "…now recognized as vital for maintaining the nation's infrastructure, industry, and worldwide competitiveness, for efficient utilization of resources, and for protection of the environment" (p. 239). For the purpose of this literature review, it will be assumed MST and SMT are the same educational concept,

Kelley (2010) noted the MST movement also began after National reports of US students scoring poorly in science and math testing. *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* was published by the National Research Council in 1991 and *Project 2061: Science for All Americans* was published by the American Association for Advancement of Science (AAAS) in 1989. Both reports called for schools to improve math and science understanding and knowledge. Moore (1993) did not call for an expansion of the status quo regarding science and mathematics delivery but called for a shift in how K-16 education delivered the SMT curriculum listing the following as elements of the shift: (a) increasing SMT to 20-25% of the curriculum, up from approximately 5% at the time of the article; (b) hands-on components were needed in SMT emphasizing understanding of concepts while limiting concentration on facts and memorization and using science as a method of knowing; (c) consideration of human problems as a key element of SMT; (d) SMT must make students aware of "efficient utilization of resources"; and (e) "for protection of the environment" (p. 239). Once again, numerous reports negatively reported U.S. ranks in science and technology compared to ranks of similar aged students in developing and industrialized countries and further indicated schools were doing little to educate in the field of technology.

Not all believed the international rankings of students were realistic. Rotberg (1984) questioned these international rankings of U.S. students by detailing the differences with the following:

> In Europe, academic schooling for those between ages 16 and 18, while perhaps not elitist, certainly does not attempt to serve virtually the entire age group. Only about 20% of the high-school-age children in Europe attend upper-secondary school — the highest-achieving 20%. About 80% of that age group in the U.S. attends high school. Consequently, international studies of achievement often compare the average score of more than three-fourths of the age group in the U.S. with the average score of the top 9% in West Germany, the top 13% in the Netherlands, or only the top 45% in Sweden. (p. 670)

Rotberg further indicated when equal age groups are compared proportionally, the US education system faired better. While abroad education systems typically focus or track students to areas of strength at an earlier age, U.S. schools provide a high quality education to all students, regardless of academic ability. So, while international rankings of achievement were a major argument for the impetus behind math reform and subsequent STEM movement, authors such as Bracey (2003) and Rotberg (1984) questioned the validity of said argument.

Moore (1993) intimated the issues with SMT could be fixed through additional funding of the U.S. education system. Moore noted the President and state governors stressed a main goal of U.S. students being ranked first in achievement rankings worldwide in mathematics and science. Disheartening to Moore was a similar desire as earlier in 1983 the National Science Board Commission called for a plan to improve SMT education to make achievement scores the "…best in the world by 1995". Moore further stated "If anything, the situation is worse today than it was in 1983". Moore called for SMT to provide more emphasis in K-6, as students "…seem to have an innate interest in science and an ability for profit from hands-on experiences" (p. 240). The author concluded SMT did not need to replace the other curricular areas but should be utilized as an integrating method in the curriculum and subsequently called for science and technology to be implemented as core general education components in curriculum.

Moore (1993) noted one study reporting 97% of elementary teachers lacked proper training in science and mathematics. Other reports listed inadequacies of science teachers at the elementary (67%), middle school (59%), and high school (71%). Inadequately trained mathematics teachers at the same grade levels were reported at 82%, 86%, and 88%. Emphasized was the need for a change in U.S. society's perception of teaching as a profession with a recommendation to increase the number of K-12 teachers coming from "the upper quartile of college and university students" (p. 241).

While some considered technology education as an excellent candidate as a core general education subject, Kelley (2010) reported research at the time indicated perceptions of technology education in relation to the core subjects of mathematics and science were poor and misconceptions were prevalent regarding technology education.

Kelley (2010) mentioned previous research warning against "…dangers of technology education becoming the stepchild in a bad marriage of math and science. Technology educators must learn from these past events in order to provide a vital case for technology education in the STEM movement" (p. 3).

Regarding the problem of "Border Crossing" in technology education and its predecessors Kelley (2010) referred to the manual training movement and the issues of the technology education curricular area being compromised. While some in technology education preferred to be a general education component of education, issues arose when the potential of missing out on career and technical education (CTE) funding from the federal government was realized.

Kelley (2010) noted technology education had great potential in STEM training for pre-professional teacher candidates and again challenged the technology education field to own the 'T' in STEM. Kelley called for more research noting the large amount of publication success stories, but little confirmation of technology education's value to general education through research. The importance of research regarding technology education's potential for contribution was also supported noting a failure of technology education during the MST movement attributed to the dearth of funding available for research.

Tech Prep: An "Inclusive" Interdisciplinary Initiative

Technical Preparation (Tech Prep) was a program instituted and funded by the federal government in the early 1990s. Local programs began in 1991 and 1992, a few years after the release of Parnell's *The Neglected Majority* published in 1985. Bragg (2000b) noted Parnell's publication was overshadowed by *A Nation at Risk* that had been published two years prior. The concept of tech prep gained financial support and a foothold due to the implementation of the Carl D. Perkins Vocational and Applied Technology Act Amendments of 1990 (Perkins II). The ensuing Tech Prep Education Act focused on 2+2 programs. In 1994 the School-to-Work

Opportunities Act (STWOA) placed emphasis on school to work initiatives in the local districts. The 1998 Perkins III legislation further expanded consortia involved in tech prep in creation of baccalaureate programs in the 2+2 arena (Barnett & Hughes, 2010; Bragg, 2000b; Farmer & Honeycutt, 1999).

Barnett and Hughes (2010) noted the “neglected majority” was the middle 50% of students on achievement testing scores nationally. Bragg (2000b) indicated although tech prep was targeted for the middle fifty-percent of high school students, leaders and educators began to see value in the concept as a tool for educational reform through the ability to improve the education system as a whole. After less than five years of implementation, tech prep was serving 88% of high school students nationally.

Bragg (2000b) indicated benefits included increased cooperation between high schools, community colleges and employers involved in the program. Tech prep evolved and expanded in unexpected ways from the original intent. Eventually the program expanded nationally to higher achieving students as they and parents realized the benefits of the program for those intent on university degrees. Also, Mitchell and Miller (1995) called for K-6 education to include activities in science and mathematics including scientific methodology, knowledge acquisition through discovery and integration of science and mathematics subject areas. Key components of the idea were interaction with business and industry communities, oral presentation experience, open-ended problem solving, collaborative and small group interaction and writing of reports. The authors stated: “By pursuing relevant, real life problems the classroom becomes an enjoyable extension of the children’s daily lives” (p. 422).

Bragg (2000b) indicated more students, who were considered non-college bound, were taking more academically strenuous coursework stating: “More educators now describe tech prep as appropriate for students who appear at every point on the academic ability continuum" (p. 28). Tech prep emphasized work-based learning on an exploratory scale, with the intention of students establishing future career and subsequent educational goals. This was a departure from the concept prevalent in vocational training where students studied and practiced in skills-based training for employment upon graduation from high school. Cantor (1999) stated "Tech Prep, as a school reform movement, is aimed at strengthening the academic preparation of students who typically pursue programs in the trades and technologies, ultimately leading to employment or further education" (p. 357).

In an overview of tech prep, Farmer and Honeycutt (1999) described the concept as such:

> …Tech Prep is essentially an innovative approach to vocational education. It is designed to integrate academic subjects (i.e., mathematics and science) with vocational-technical education subjects (i.e., engineering technology, applied science) and mechanical, industrial, or vocational subjects (i.e., agriculture, health, and business). (p. 717)

The authors furthered explained the 2+2 concept where 11th and 12th grade students were "enrolled in rigorous vocational and liberal arts courses with access to the faculty and facilities of two-year postsecondary institutions" (p. 718).

Pollard (1991) described the early proposed intent of the tech prep program was to prepare students to gear studies in high school towards an associate degree at a specific postsecondary institution through a "structured and closely articulated curriculum" (p. 34).

Barnett and Hughes (2010) of the Community College Research Center (CCRC) at the Teachers College at Columbia University outlined how tech prep changed noting stakeholders evolved the program to include "career pathways". Also indicated was a change "in the latest Perkins re-authorization defining Tech Prep as a 'program of study' " (p. 5).

Although there were benefits of tech prep as indicated in the literature review, the program was not without issues. A major issue alluded to by Cantor (1999) was while secondary school programs were fully fledged in developing and adopting the concept, some community colleges were viewing the program as another vocational program, rather than viewing the program as a solution with merit in associate degree programs. Community college administrators were challenged to adopt program offerings to fit the requirements and standards required by business and industry.

Bragg (2000a) was the site director for the National Centers for Career and Technical Education. Bragg looked back on the decade of funding leading to the tech prep movement. Through literature and the author's research activities, Bragg determined the following six core components of tech prep:

- Tech prep must be grounded in an integrated and authentic (real-world or simulation of real-world) core curriculum at both the secondary and postsecondary levels.
- Tech prep must have formal articulation agreements between the secondary and postsecondary levels.
- Tech prep must integrate theory and application, using experiential and work-based learning strategies that draw upon the community where students live and work.
- Tech prep must be a standards-driven, performance-based educational initiative, ensuring that academic and occupational content is rigorous and relevant.
- Tech prep must be an educational vehicle that is accessible to all.

- Tech prep must operate in a highly collaborative manner, utilizing joint planning, development and implementation processes involving a variety of stakeholders. (para. 9)

Pollard (1991) stated: “Tech-prep education programs potentially will exert a major influence upon future vocational education designs” (p. 34). Bragg (2000b) concluded although “Far from perfect, tech prep has been valuable as a test bed of ideas associated with secondary-to-postsecondary transition” (p. 29). Bragg listed successful traits of tech prep as (a) learning that is rigorous and engaging, (b) linking theory and practice in meaningful ways, (c) curriculum that is outcomes-focused, (d) an inclusive curriculum suitable for all students and (e) increased collaboration of educators through planning to help eliminate “turf battles” (p. 29).

When reviewing research and reports regarding the philosophy and accepted methodological practices, constructivism was identified as the main philosophical core of STEM methodology.

Constructivist Practices in STEM Methodology

A core tenet of STEM methodology was a shift from teacher-centered pedagogy to a student-centered approach. The constructivist approach railed against the “banking” system of education as coined by Freire (2007). Freire referred to an educational system based on a teacher-centered approach where the students were “containers” to be educated and filled with the knowledge of the teacher. At issue with Freire was “The more meekly the receptacles permit themselves to be filled, the better students they are” (p. 72).

Kolstad and Briggs (1995) used the term “ghettoization” when referring to the concept of silos in education. The authors noted, “…single-subject learning into discrete 50-minute segments is abnormal everywhere but in the classroom” (para. 18).

Wright State University (n.d.) listed a philosophy of STEM according to Michele Wheatly, Dean of Wright State University's College of Science and Mathematics. Wheatly described STEM as containing much more than a study of the sciences. "It's a philosophy of education—learning by doing—that can be applied in any discipline," As support for STEM methodology Wheatly further stated "The old-fashioned way of educating people clearly isn't working. We're trying to create a learning environment where we engage students in different ways. STEM boils down to really good instruction that could be applied to pretty much any area. STEM is for everybody." (para. 3).

Further, the Ohio STEM Learning Network (Ohio STEM Learning Network [OSLN], n.d.) outlined STEM school principles regarding the design of curriculum delivery as follows:

- STEM is based on the philosophy of comprehensive education with inquiry and experiential learning as key components.
- STEM schools are suited for P-16 integration striving for students developing a passion for science and mathematics in elementary grades, and eventually earning college credit and relevant work experiences.
- STEM schools are designed for educating the whole child, including curricular areas outside of the STEM acronym (arts, languages, humanities, social sciences) into the curriculum. Hence relying on an interdisciplinary approach allowing "students the opportunity to make sense of the world around them, rather than learn isolated bits and pieces of subjects in separate forums".
- STEM schools focus on the Technological Design Process serves as a forum to engage students in learning how to utilize technology to meet future life challenges.

- Collaboration and innovation are key, relying on partnerships in K-12, higher education, and business. Hence there is possibility of STEM schools being located on college campuses or a business location.

The Southwest Educational Development Laboratory (Southwest Educational Development Laboratory [SEDL], 1998) described constructivism as both a learning theory and philosophy, highlighting learning was an active process involving creation of knowledge versus acquisition of knowledge. The SEDL indicated research supported the use of technology as an effective strategy in student-centered learning. According to the SEDL, key educational concepts include inquiry, exploratory activities, autonomy of the student, coupled with a student's expression of knowledge and creativity. Constructivist approaches gained more traction in education as "…they shift instruction from passive to active learning and to authentic tasks" (p. 2).

The SEDL identified the following principles framing constructivist practices:

- Learners bring unique prior knowledge and beliefs to a learning situation.
- Knowledge is constructed uniquely and individually, in multiple ways, through a variety of tools, resources, and contexts.
- Learning is both an active and reflective process.
- Learning is developmental. We make sense of our world by assimilating, accommodating, or rejecting new information.
- Social interaction introduces multiple perspectives on learning.
- Learning is internally controlled and mediated by the learner. (p. 1)

The National Aeronautics and Space Administration (National Aeronautics and Space Administration [NASA], n.d.) indicated the following: "Constructivism is a philosophy about learning that proposes learners need to build their own understanding of new ideas." NASA further credited Piaget and Gardner as two prominent constructivist researchers (para. 9). The SEDL (1998) identified three conceptual components of constructivism:

- "Constructivist approaches match the way we learn". Highlighted were the concept of learning by doing, interaction with peers, and through authentic real-world experiences coupled with appropriate tools.
- "Constructivist approaches accommodate individual differences". The site noted students "tuning out" because they didn't see a connection to their perception of real-life experiences. Constructivism provided flexibility and gave more potential for varying needs of learners.
- "Constructivist approaches prepare learners for the workplace of their future." With future needs regarding job skills "…students must go beyond memorization of facts to knowing how and why. Constructivist approaches emphasize both the process and the product of learning" (p. 2).

The Miami Museum of Science (Miami Museum of Science [MMoS], 2001) also defined the philosophy of constructivism and leading theorists of the paradigm:

> The philosophy about learning, that proposes learners need to build their own understanding of new ideas, has been labeled constructivism. Much has been researched and written by many eminent leaders in the fields of learning theory and cognition. Scholars such as Jean Piaget, Eleanor Duckworth, George Hein, and Howard Gardener have explored these ideas in-depth. (para. 1)

Multiple websites (Biological Science Curriculum Study [BSCS], n.d.; MMoS, 2001; NASA, n.d.) indicated constructivist philosophy relied on the concept of giving students experiences on which to construct knowledge. These authors indicated a five-step process/model to assist students in the process was developed and attributed to Roger Bybee, Principal Investigator of the Biological Science Curriculum Study (BSCS). The process became known as the "Five Es": Engage, Explore, Explain, Elaborate, and Evaluate.

Anders Hedberg, (n.d.) an international consultant working with education institutions, governments, international business, academies of science and engineering to promote STEM workforce development indicated a need for transformation from passive to active methodologies, relying on inquiry-based and applied problem solving.

Regarding inquiry-based learning the BSCS (n.d.) indicated the curriculum was designed to limit rote memorization of facts, a traditional learning goal, with activities requiring inquiry and decision making. The goal was an approach that "encourages students to view science as an ongoing, relevant process of learning, as well as a body of currently available information and theories" (para. 11).

STEM: An Inclusive Education Concept for all Students

An overarching goal of the STEM movement was providing STEM-based experiences to all students (Bragg, 2000b; Dugger, 2010b; OSLN, n.d.; Sanders, 2009; Wright State University, n.d.) This concept was explained by the following excerpt from the San Diego County Office of Education (n.d.), when defining "What STEM education isn't":

- STEM education is not highly specialized education for an elite group of students. When fully realized, STEM will serve all students in public schools across San Diego.

> - STEM education is not only for those interested in science, engineering, technology or math. STEM education goes beyond training scientist, engineers and technology professionals. It helps all students develop and apply essential skills through a rigorous and diverse curriculum, a college-ready and work-ready culture, personalized learning opportunities, and a top-flight teaching force. These skills will serve students in all areas of their future education and careers.
> - STEM education is not beneficial only to those enrolled in STEM schools or STEM Programs of Excellence. All students benefit from a strong STEM infrastructure. STEM schools share curricular and teacher professional development tools and best practices, impacting surrounding traditional schools. Furthermore, regional STEM centers will develop STEM curriculum and instructional tools, train STEM teachers, share STEM best practices and provide STEM distance-learning experiences for students across the state. (n.d., para. 5-7)

STEM as a Meta-Discipline

Numerous authors (Dugger, 2010a; Katehi, 2009; Katehi et al, 2009; Kelley, 2010; Pearson & Young, 2002) alluded to a growing belief in the argument that K-12 engineering education should not be considered as an education topic itself, but rather a part of an integrated curriculum based on STEM.

Morrison (2006) referred to earlier work by Kaufman, et al. intimating STEM as a meta-discipline, borrowing and integrating practices and knowledge of other disciplines into a new "whole":

> This interdisciplinary bridging among discrete disciplines is now treated as an entity, STEM. It offers a chance for students to make sense of the world rather than learn

> isolated bits and pieces of phenomena. Yet, STEM is really greater than interdisciplinary. It is actually transdisciplinary in that it offers a 'multi-faceted whole' with greater complexities and new spheres of understanding that ensure the integration of disciplines. (p. 4)

STEM as a "meta-discipline", was also supported by Sandlin (2009) in testimony before the Subcommittee on Research and Science Education—Committee on Science, under the auspices of the U.S. House of Representatives.

Other general education areas were also intent on becoming involved with integrated studies. Kolstad and Briggs (1995) called for a "genial admixture" of the arts and mathematics and recognized the possibilities of easier integration of subject areas in the self-contained classroom of elementary schools. Crayton (2010) advocated inclusion of the arts in a STEM curriculum for future success of students, as creative skills were critical to the process of innovation and design:

> Educators are finding that a unique approach to teaching STEM through immersion of arts is fostering desired skills for an innovative workforce. However, STEM education without the arts simply encourages an education gap in the students' ability to innovate, because they lack creative skills for innovation which are obtained through practice and inquiry through the arts process. (p. 9)

The Influence of Dewey

John Dewey was a supporter of manual and experiential activities as a means of bringing reality to other classic curricular subjects in the early classroom. Bennett (1937) indicated Dewey was a proponent of active learning, including constructive, occupational, scientific observation and experimental activities and felt these would be intrinsically tied to and supportive of the other classic curriculum. During this time leaders were calling for education activities to be tied to real life situations to help students comprehension. Table 1 excerpts paragraphs 31-35 from Dewey's (1897) *My Pedagogic Creed.*

Table 1

Excerpts from Dewey's My Pedagogic Creed (1897)

Paragraphs 31-35 of John Dewey's *My Pedagogic Creed* (1897)	• I believe accordingly that the primary basis of education is in the child's powers at work along the same general constructive lines as those which have brought civilization into being. • I believe that the only way to make the child conscious of his social heritage is to enable him to perform those fundamental types of activity which make civilization what it is. • I believe, therefore, in the so-called expressive or constructive activities as the center of correlation. • I believe that this gives the standard for the place of cooking, sewing, manual training, etc., in the school. • I believe that they are not special studies which are to be introduced over and above a lot of others in the way of relaxation or relief, or as additional accomplishments. • I believe rather that they represent, as types, fundamental forms of social activity; and that it is possible and desirable that the child's introduction into the more formal subjects of the curriculum be through the medium of these activities.

Bennett (1937) noted in 1901 that Charles R. Richards, Director of the Department of Manual Training at Columbia University was concerned about elementary school practices of the time. Richards called for a more realistic school life, based on the realities of the real world.

Dugger (2010a) called for education to integrate typically disparate curricular areas when he stated the following: "The study of STEM offers students a chance to make sense of the integrated world we live in rather than learning fragmented bits and pieces of knowledge and practices about it" (p. 2).

Impetus Behind the STEM Movement

The National Science Foundation (NSF) coined the STEM acronym in the early 2000s (Helton, n d). Prior to this time the acronym Science, Mathematics, Engineering and Technology (SMET) was used. Judith Ramalay, who at that time was the Director of the NSF's Education and Human Resources Division, stated "I always thought it was terrible," regarding the SMET initials. "It made me think of many things, but none of them had to do with science and technology" (Crayton, 2010; Mugan, 2009; Sanders, 2009)

Dugger (2010a) stated the evolution of STEM and implementation and momentum in the United States was due to:

- The emphasis of the National Science Foundation (NSF);
- Federal funding;
- Some states including "T and E" in offerings;
- Evolution and implementation of content standards in all areas for K-12;
- ITEEA name change.

Dugger (2010a) indicated a "promising future" in the STEM movement. That future would be dependent "…on the acceptance and buy-in that schools and teachers give to the integration of these four disciplines in an already crowded curriculum" (p. 7).

A collaborative effort between industry and education resulted in the development of the Partnership for 21st Century Skills (P21). The desired skills were defined as critical thinking, problem solving, communication and collaborative skills (Atkinson & Mayo, 2010).

Central to the U.S. becoming competitive in global economics was the provision of a 21st century educational system according to a report from P21. Paige Kuni, Chair of the P21 and worldwide manager of K-12 education stated, "Equally important to the domestic achievement gap is the global achievement gap between U.S. students – even top performers – and their international counterparts" (as cited by eSchool News staff, 2008b).

Regarding success and wealth of a country, Dugger (2010a) noted education as a key component of future economic wealth:

> An educational system that is based solely on the basics (reading, writing, and arithmetic) does not prepare future citizens to compete and be successful in the technological world of today and tomorrow. The required study of STEM for all students in an educational system will provide a more relevant and meaningful preparation for students in the future. (p. 7)

While Dugger and other leaders supported a "STEM for All" approach, Atkinson and Mayo (2010) took a contradictory tack. The "All STEM for Some" approach stressed recruitment of students most interested and showing aptitude in STEM-related fields: "While 'Some STEM for All' is a worthy goal, 'All STEM for Some' is a far more achievable goal, and the one immediately necessary for the creation of our next generation of technology innovators" (p. 60).

What Business and Industry Desire

Authors such as Atkinson and Mayo (2010) and Pines (2009) indicated what industry desired from products of the K-12 education system was not knowledge, but skills. Atkinson and Mayo further explained the roots of the modern education system:

> The public school system arose in the Middle Ages, when books were rare and the knowledge in them prized. The Old English term, boeccraft, literally, "book creation," embodies this thinking and was used to connote literature, scholarship, and learning. The concept that factual knowledge and book learning are the desired end-points of education has permeated U.S. schooling to this day. The more "books" (subjects, courses) we

> absorb, the more learned we are supposed to be. Adolescents study disciplines abstracted from life: English, history, civics, physics, and mathematics. These are divided into courses, most of which are required for all students, and taught in formal classes. It amounts to production work with students processed by the batch; teachers instruct 25 to 30 or more students who move week-by-week through the subject and chapter-by-chapter through the text. The idea is to cover and to master the particular subject matter of the course rather than develop generic skills (e.g., the ability to analyze and to solve problems, to comprehend complex situations, to think critically, to be creative, to be adaptable, to be able to work with others and learn and re-learn over a lifetime). The assumption is that all students will know all subjects. Secondary students are tested mainly on their ability to recall factual knowledge. Success is defined as scoring well on tests for that knowledge, most involving testing for discrete, right or-wrong answers. (p. 63)

Moore (1993) alluded to this issue regarding relevancy of the curriculum by stating "The complaint is that for far too long the emphasis has been on Western civilization, which critics are wont to say is the creation of dead, white, European males" (p. 239).

The Missing "T & E" in STEM

Dugger (2010a) noted "The power and position of science (S) and mathematics (M) in STEM education and the tendency to say STEM when one really means science or mathematics is a significant barrier to the fully-integrated STEM for the future. The S, T, E, and M are separate and not equal" (p. 7).

Several authors indicated the federal, and in some cases, state governments committed significant resources to support STEM education in the K-12 setting. Yet, schools lagged in implementation of comprehensive STEM curriculum. Also, there was disparity how STEM was implemented in various school districts across the United States. STEM articles recently bemoaned the fact of the missing “T and E” in many STEM adoptions noting a distressing number curricular solutions in schools being limited to science and math and to a lesser amount engineering (Cavanagh, 2008; Dugger, 2010a; Dugger, 2010b; Katehi, 2009; Katehi et al, 2009; Murray, 2007).

Boe (2010) conducted Delphi research to determine technology education’s leadership role in STEM education. Conclusions regarding strategies for technology education leaders to gain broader acceptance as a viable component of STEM education included:

- Continue to build math and science partnerships and promote the value of technology and engineering education in STEM.
- The profession needs to aggressively pursue opportunities in STEM education regardless of whether they are part of the core curriculum.
- Actively promote technology and engineering education through published research in math and science education journals.
- Establish methods for identifying and preparing new leaders in the profession that have a passion for technology and engineering education, STEM and the vision of ITEA. (p. 95)

The Narrow View of Technological Literacy

The *Standards for Technological Literacy* (ITEA, 2007) indicated technological literacy was typically relegated to the study of computers. While computers were a component of technological literacy, computers were only one part of the total technological literacy concept. In an educational setting, it is more accurate to refer to computers in education as educational technology, not technology education. Dugger (2010b) also noted the issue of the public holding a narrow view of considering computers as the core of technology.

STEM: What Does the Future Hold?

The literature review indicated the major drive behind the STEM movement was the eventual education of more domestic university trained engineers. STEM leaders and politicians assumed benefit to the national economy of increased innovation of new technologies and processes to revitalize the U.S. as an innovation nation. But, there is an underlying issue regarded standards for engineering education in the K-12 setting.

The Committee on Standards for K-12 Engineering Education (2010) decided to not develop K-12 standards for engineering education. Hence, science, technology and mathematics groups were again in the same position as before, attempting to define and deliver engineering standards and content in the K-12 setting. The ITEA and its latest iteration, the International Technology and Engineering Educators Association (ITEEA) developed a curriculum *Engineering by Design* that is a comprehensive curriculum with regards with addressing standards relying on groundwork completed by the *STL*:

> The International Technology Education Association's Center to Advance the Teaching of Technology and Science (ITEA-CATTS) has developed the only standards-based national model for Grades K-12 that delivers technological literacy. The model, Engineering by Design™ (EbD), is built on Standards for Technological Literacy (ITEA); Principles and Standards for School Mathematics (NCTM); and Project 2061, Benchmarks for Science Literacy (AAAS). (Dugger, 2010b, p. 6)

ITEEA Responds to "A Framework for Science Education"

Starkweather (2010), Executive Director/CEO of the ITEEA, represented various constituencies of the ITEEA in an open letter to Board on Science Education (BOSE) members, questioned components of the preliminary public draft of *A Framework for Science Education* published in 2010. At the center of the concern was ITEEA's challenge questioning whether the field of science education could effectively deliver technology and engineering studies in U.S. classrooms. Starkweather stated, "We also found that technology and engineering (in the same order as they appear in the STEM acronym) were used interchangeably, leading to the impression that they are one and the same. They are not" (para. 3).

Following are points gleaned from the Starkweather (2010) letter to BOSE members:

- While technology and engineering consist of activities consisting of problem solving and making, in essence "doing", the framework is limited to designing with no focus on how to make products. (para. 4).
- The initial draft of the framework did not address the "laboratory nature of science". Hence there was a concern about the value of laboratory work. (para. 6).
- "Engineers 'design and do' within constraints. Your proposed framework talks about technology and engineering, but does not provide avenues for students to work with any depth of content or process." (para. 8).
- Engineers were not included on the writing team of the preliminary document.
- Medicine and health, two fields that heavily rely on science, were not included in the framework.

- Concern for qualifying teachers in technology and engineering. While the science field did not desire unlicensed teachers in science, the same was said for the technology and engineering fields. The framework in essence would allow science teachers, with no licensure in technology or engineering, to teach these subject areas. Starkweather referred to Skophammer's (2009) research findings regarding lower student scores in professions utilizing unlicensed teachers.
- There was a dearth of research regarding core standards required to effectively deliver engineering content. Starkweather noted the *Standards for Technological Literacy* (ITEA, 2007) were the most closely aligned standards in regards to engineering education in the K-12 setting and were in the process of another rewrite of the standards.
- "The framework goes into great detail in its description of science. However, engineering has not been studied sufficiently for it to become a dimension of science in the public schools. The view of technology and engineering is shallow…" (para. 14).

What may have been Starkweather's strongest statement in the letter was the reference to issues in the "new math" movement as an example of a failed educational experiment and the danger of not looking to the past when dealing with matters of educational reform:

> Professionally, we feel strongly that the field of engineering has not been properly analyzed to determine how it should be taught in K-12 education. It is important for these areas of knowledge to be in the curriculum to improve citizenry and the nation as a whole, but the research has not been undertaken to validate what and how we should approach this content for K-12 learning. Yes, it is needed knowledge just as science,

> mathematics, and language are needed in our schools. However, without the research or the expertise to properly structure it within the science curriculum, we believe that this move may result in an example of where the profession went wrong, such as is associated with the ill-fated implementation of “new math.” (para. 15)

In conclusion, Starkweather (2010) offered to assist in further development of the framework. The open letter may have had a positive effect. In an email to ITEEA membership Starkweather (2011) indicated further input in the framework was in progress. Indicated was a potential for technology and engineering educators teaching courses in science programs. Apparently the lines of communication were open and Starkweather indicated a chance for influence the direction of the framework.

Harvard: Ties to the Committee of 10 and the Pathways to Prosperity Project

The literature review identified a document regarding educational reform, The *Pathways to Prosperity Project* (PtPP), a project and resulting report promoting educational reform from the Harvard Graduate School of Education (2011).

In a discussion of *The Forgotten Half* the PtPP report outlined the challenge facing the U.S. During the 19th century. The U.S. had the most educated cross-section of youth on the planet. After an initial period of catching up by European countries once again the U.S. surged ahead regarding the education of youth as the proliferation of high schools gained momentum in the early 20th century. Following World War II, the GI Bill allowed another push in higher education and again, the U.S. reigned supreme in the number of college/university graduates. At the beginning of the 21st century, the report indicated the U.S. was not delivering a quality education to millions of youth. The PtPP noted a skills gap and work ethic issues for youth, confounded by the lowest employment rates of high school and young adults since the period following WW II.

“The Forgotten Half” was a term coined by the William T. Grant Foundation in 1988 regarding non-college bound youth. Ten years later, additional reports further extoled the issues facing education and youth in the U.S. (PtPP, p. 2).

The PtPP noted skills stressed by the Partnership for 21st Century Skills (P21) as lacking in the following areas: oral communication, written communication, critical thinking, professionalism, problem solving and creativity. Paramount to the work of the P21 and PtPP was “college readiness”. Education programs would not afford graduates the necessary “skills and abilities they will need in the workplace, or to successfully complete the transition from adolescence to adulthood” (p. 4).

According to the PtPP, in an era where jobs requiring only a high school diploma were decreasing, employers were increasingly reluctant to hire young adults with only high school completed. The issue was exacerbated by a system not working for the forgotten half—those who failed to see the relevance and need for a high school diploma:

> The problem is most visible in our high schools, which are plagued by extraordinarily high dropout rates. Every year, some one million students leave before earning a high school degree. Many drop out because they struggle academically. But large numbers say they dropped out because they felt their classes were not interesting, and that high school was unrelentingly boring. In other words, they didn’t believe high school was relevant, or providing a pathway to achieving their dreams. (p. 10)

At issue according to the PtPP was an education system that had not adapted to meet the needs of industry and society, and hence did not prepare a large number of students to compete in a vastly different economic landscape.

Barriers Research, Scale and Instrument Development

Previous Barriers Research

Identified barriers research and journal articles featuring designs and instrumentation concepts of interest to this research typically were found in health fields, social services, and education. Although none were found that conformed closely to the intended direction and design of this proposed research, elements of previously completed research gave a reference frame for direction in developing a study of barriers pertaining to STEM implementation.

Instrumentation Development

Regarding development of a measure, various authors indicated a first step of conceptualizing the variable of importance to the intended research as key to a successful research project (Clark & Watson, 1995; Haynes, Richard, & Kubany, 1995; Lent & Brown, 2006).

Clark and Watson (1995) further identified the literature review and development of the item pool as the next steps in scale development. The authors noted the "…pool (a) should be broader and more comprehensive than one's own theoretical view of the target construct and (b) should include content that ultimately will be shown to be tangential or even unrelated to the core construct" (p. 311).

Research regarding career development was an evolving area since the mid-twentieth century. According to Penn State Extension (n. d.), Lent, Brown and Hackett developed the Social Cognitive Career Theory (SCCT) in 1987 as an extension or derivative of Bandura's

Social Cognitive Theory. The SCCT relied on the constructs of self-efficacy, outcome expectations and personal goals that affected career choice. Lent and Brown (2006) authored an article to serve as a guide in developing social cognitive scales and was used as a conceptual guide in developing this research instrumentation. Indicated was a dearth of barriers measures and inherent support for the concept of "design or adaptation of support and barrier measures that are specific to the criteria at hand" (p. 30). Further, as SCCT was more specific in regards to an individual's ability to control their own locus and create change—because of the level of specificity, all-purpose measures were not suitable and researchers often designed new measures. The authors also indicated two contextual variables of a sample being surveyed: support and barriers: "SCCT is also concerned with proximal contextual variables—in particular, environmental supports (facilitative influences) and barriers (obstacles)—that people anticipate will accompany their goal pursuit" (Lent & Brown, 2006, p. 18). Lent and Brown also indicated contextual supports may be categorized as documented or perceived from the perspective and experience of the participant.

Likert Scale Development

Lent and Brown (2006), provided background for constructing and/or adapting existing scales to measure a construct of interest. They promoted the importance of properly developing measures that were specific to the domain and variables of interest to the research. Further, when researchers attempted to predict, explain, or change a dependent variable, Lent and Brown proposed a process of developing the dependent variable and then using a backwards approach to identify theoretical variables that may have an effect.

Lent and Brown also cautioned against too few response options on attitude scales and indicated social constructs typically consisted of 5-, 7- or 10-point scales. Regarding Likert scale development, Clark and Watson (1995) detailed the concepts of even versus odd number of response options. In even numbered responses options, great care must be taken in writing the mid-range response. To eliminate the issue, an even number of response items could be developed, but forced respondents out of a “neutral” response and as the authors indicated might be considered objectionable or improper by some. Also, the authors cautioned against utilizing too many response options, as the practice would not necessarily improve reliability or validity. Noted was increased responses in some cases may decrease validity if subtle distinctions are not discernable by respondents. Because of these aforementioned concerns, the authors advocated the importance of pilot testing for preliminary information on a proposed instrument.

Of interest to the STEM Barriers concept were indications from Clark and Watson (1995) regarding their process of developing indicators of contextual supports and barriers in a population. The process involved a qualitative study to two education institutions to determine factors in college students’ locus. Through content analysis of responses, quantitative measures were developed for future research.

Pilot Testing

Clark and Watson (1995) further noted the real possibility of some decisions and adaptations of an instrument after the initial pilot testing and hence a “large and appropriately heterogeneous sample for the first major state of scale development” was appropriate (p. 314). Lent and Brown (2006) called for pilot testing of instruments to increase validity, and called for reliability estimated in the >.70 range as a minimum and preferably at >.80. Clark and Watson also recommended .80 as a minimum for estimates.

The avoidance of unbalanced item results in Likert scales was noted by Clark and Watson (1995) as: (a) a high number of similar responses yields little information; (b) due to lack of variability, the questions would yield weak correlations; and (c) unbalanced distributions can lead to highly mutable correlations.

In summary, Lent and Brown advocated: (a) contextualized measures with specific domain context; (b) measures that were comprehensive in sampling the domain, and required multiple measures according to the complexity of the criterion; (c) ensured compatibility in "content, context, temporal orientation, and level of specificity". In addition when dealing with self-efficacy, measures should also (d) include challenging task; and (e) should be subject to personal control (p. 32).

Validity

Haynes, Richard and Kubany (1995) described content validity as "…the degree to which elements of an assessment instrument are relevant to and representative of the targeted construct for a particular assessment purpose" (p. 238). The authors also defined construct as "…the concept, attribute, or variable that is the target of measurement" (p. 239). Finally, the concept of content was explained with the following: "Content validation of an assessment instrument unavoidably involves validation, and sometimes refinement, of the targeted construct" (p. 239).

During the early development of concepts of validity in research, In reference to the types of validation, Cronbach and Meehl (1955) indicated predictive and concurrent validity were criterion-oriented validation processes. With these two processes geared to experimental research, in particular geared to predictive ability, content and construct validity were of greater interest to this research as a new instrument and constructs were developed. Two points regarding validity were in the background piece: (a) the authors cautioned against high internal consistency as it may in effect lower validity unless the construct being measured calls for high intercorrelations, and (b) "negative item-test correlations may support construct validity, provided that the items with negative correlations are believed irrelevant to the postulated construct and serve as suppressor variables" (p. 288).

Cronbach and Meehl (1955) noted factor analysis was beneficial when attempting to further break down a construct "into more meaningful parts". The authors also intimated the value of factor analysis to "predict complex behaviors" (p. 287).

Haynes et al (1995) outlined content validation guidelines of importance to the development of a new instrument:

- Carefully define the domain and facets of the construct and subject them to content validation before developing other elements of the assessment instrument.
- Subject all elements of an assessment instrument to content validation.
- Use population and expert sampling for the initial generation of items and other elements.
- Use multiple judges of content validity and quantify judgments using formalized scaling procedures.
- Examine the proportional representation of items.
- Report the results of content validation when publishing a new assessment instrument.
- Use subsequent psychometric analyses for assessment instrument refinement. (pp. 244-245).

Lent and Brown (2006) were also proponents of utilizing confirmatory factor analysis to identify underlying interrelationships between variables.

Summary

Chapter 2 consisted of a review of literature of interest to the research. Included in the review were (a) historical applied science, interdisciplinary, and comprehensive education movements and the ties to industry and economy; (b) philosophical roots and practices of STEM methodology; (c) impetus behind the STEM movement; (d) identified barriers to STEM adoption; and (e) barriers research, scale and instrument development.

The literature review was utilized in answering Research Question 1 (*In what ways is the iSTEM movement similar to previous educational reform movements in the United States?*). Similarities of the current STEM movement with educational reform movements were identified and findings are reported in Chapter 5.

To aid in the development of the Integrative STEM Implementation Barriers Instrument (iSTEMIBI), barriers identified through the literature review were driven by Research Question 2 (*What do stakeholders perceive to be barriers to implementation?*) and utilized in the process of developing Likert statements. The attributed barriers by authors or survey respondents utilized in the process of development of the instrument Likert items are detailed in Chapter 3 and the complete list of identified barriers are found in Appendix E.

CHAPTER 3. METHODOLOGY AND PROCEDURES

Introduction

The study utilized a correlational model approach including quantitative and qualitative elements. Qualitative methods were utilized to identify previous educational movements and the inherent similarities and issues regarding methodology of the current STEM movement. Also, qualitative analysis of the literature review identified barriers by STEM authors. The identified barriers were utilized to develop Likert statements for the quantitative portion of the research.

A new tool, the Integrative STEM Implementation Barriers Instrument (iSTEMIBI), was developed by the researcher to measure 12 constructs of interest. The quantitative portion of the iSTEMIBI consisted of 50 Likert statements pertaining to STEM implementation barriers. Likert Statements were grouped by construct on each page of the instrument. Each respondent had the option to complete an open-ended response in each construct to further qualify perceptions on barriers. The Embedded Design research correlational model, detailed by Creswell and Plano-Clark (2007), influenced the overall design of the research. Throughout the analysis of the results, Alpha level $p = .05$ was set to establish statistical significance for quantitative data.

Purpose of the Study

The purpose of the study was to determine factors that served as barriers to STEM implementation the K-12 setting. The sample studied was drawn from classroom teachers and administrators with training in STEM methodology or experience in STEM methods and subsequent experience regarding integrative STEM (iSTEM) implementation barriers. The participants, through the completion of the researcher-designed iSTEMIBI, gave specific insight regarding implementation barriers.

Research Questions

To complete the research, the following research questions were identified:

1. In what ways is the STEM movement similar to previous educational reform movements in the United States?
2. What do stakeholders perceive to be barriers to implementation?
3. Do barriers and factors that affect STEM adoption vary between groups?
4. What factors contribute to STEM implementation?
5. What barriers and contributing factors have the greatest impact on implementation?

Review of Related Literature

The review of literature was driven by the need for historical background regarding previous educational movements in the United States, with an emphasis on earlier applied, interdisciplinary and comprehensive educational efforts. Focus in this portion of the research also concentrated on philosophy and practices germane to the STEM movement, including previous and current practices and inherent similarities with current STEM pedagogy. Additional background regarding impetus behind the growth of the movement with particular attention paid to government, business and industry needs were explored. The literature included seminal texts pertaining to industrial education and training history, published government and industry reports calling for educational change in the STEM-related areas — especially in the fields of science and mathematics. Various sources providing background on philosophy, methods, content and context were also perused regarding STEM pedagogy and methodology. Findings from the literature review regarding answers to Research Question 1 (*In what ways is the STEM movement similar to previous educational reform movements in the United States?)* are found in Chapter 5.

A second area of concentration in the literature review focused on previously identified implementation barriers and issues from recognized STEM authors as required for answering Research Question 2 (*What do stakeholders perceive to be barriers to implementation?*). Sandlin (2009), Miaoulis (2009), Lantz (2009), Ashida and Hunter (2009 a-f) and, Atkinson and Mayo (2010) identified barriers and constraints that served as a basis for development of measures to identify factors having impact on STEM implementation. In addition, previously unpublished data by the researcher in conjunction with STEM-based workshops completed under the auspices of the Great Plains STEM Education Center (Gjøvik, 2010) identified barriers from the perspective of practicing teachers. Identified barriers were compiled and served as background for the researcher's development of the Likert item statements utilized in the iSTEMIBI. The review resulted in an initial set of 94 barriers statements developed by the researcher (Appendix E). The statements were further refined by an Informal STEM Experts Group (ISEG) with the intent of compressing the size of the instrument while retaining conceptual underpinnings of the original STEM authors and workshop participants. The work of the ISEG resulted in 50 Likert items in the instrument to determine the extent barriers affect STEM implementation in the K-12 school setting. The resulting iSTEMIBI is found in Appendix D and was deployed by paper-based consent (Appendix B) and browser-based consent (Appendix C) methods.

Sources of Identified Barriers to STEM Implementation

Rick Sandlin (2009), a mathematics and engineering elementary school principal, in testimony before U.S. House of Representative Committee on Science and Technology noted issues found in Table 2 that became items for consideration in the iSTEMIBI instrument. Sandlin focused on issues of professional development (including quality and funding support), teacher preparation, and females entering careers including mathematics and engineering.

Table 2

Sandlin's (2009) Identified Barriers to iSTEM Implementation

Issues for Consideration in the iSTEMIBI	Related Construct or Factor
Quality Integrated STEM education professional development.	*Professional Development Barriers; Pre-Service Training Barriers;* Factor 1: *Teacher Education Gap in iSTEM Methodology.*
Elementary education teacher preparation programs lack of math and science content.	*Barriers Regarding Efficacy; Professional Development Barriers; Pre-Service Training Barriers;* Factor 7: *Resistance to Changing Methodology*
Funding to help support professional development at the elementary level (beginning of the STEM pipeline)	*Professional Development Barriers; Pre-Service Training Barriers; Barriers Regarding Efficacy;* Factor 1: *Teacher Education Gap in iSTEM Methodology.*
Buy-in of public and educators in preparing students for careers in engineering	*Barriers of Integrative STEM Buy-In; Barriers of Regulation;* Factor 3: *Resistance to iSTEM-Based Reform*
Females entering mathematical and engineering careers.	*Barriers of Male-Oriented Content;* Factor 6: *Barriers of Male-Oriented Content*

Also in testimony before the Research and Science Education Subcommittee on Science and Technology, Ioannis Miaoulis (2009), Director of the National Center for Technological Literacy (NCTL) identified challenges to implementation in schools found in Table 3. Identified were issues of fear of implementation of engineering based curriculum, resource issues, limited time available for implementation, lack of separate engineering standards to guide development, and the lack of an integrated, broad spectrum approach when implementing iSTEM methodology.

The NCTL was developed by the Museum of Science, Boston with a goal of imparting knowledge of engineering and technology. The ultimate goal was to make students aware of opportunities and gaining requisite pre-engineering skill sets to develop future generations of engineers, scientists, and inventors/innovators.

Table 3

Miaoulis' (2009) Identified Barriers to iSTEM Implementation

Issues for Consideration in the iSTEMIBI	Related Construct or Factor
Fear of implementing engineering based curriculum by classroom teachers and administrators.	*Barriers Regarding Efficacy; Barriers of Integrative STEM Buy-in; Barriers of a Narrow View; Barriers of Adoption;* Factor 7: *Resistance to Changing Methodology;* Factor 10: *The Missing T and E in iSTEM*
Lack of needed resources.	*Resource Barriers;* Factor 8: *Resources*
Perception of no time available to implement STEM.	*No Child Left Behind Barriers; Barriers of a Narrow View; Barriers of Regulation;* Factor 3: *Resistance to iSTEM-Based Reform;* Factor 5: *No Child Left Behind*
Lack of separate engineering standards to guide curriculum development, teacher professional development and student assessment.	*Technology and Engineering Education Standards Barriers;* Factor 2: *Technology and Engineering Standards*
Issue with policy makers and leaders in education failing to recognize the full spectrum of STEM methodology potential noting many projects deal strictly with math and/or science but exclude technology and engineering.	*Barriers of a Narrow View;* Factor 9: *Limited View of iSTEM*

Lantz (2009) listed barriers connected to perception and narrow view of STEM. Table 4 lists Lantz's barriers to STEM that limit implementation in said regard in U.S. schools. Lantz focused on implementation barriers due to perception of iSTEM as another cyclical fad, technology literacy standards being met by only providing computers and software to students, confusion regarding hands-on and inquiry based learning, iSTEM lacked laboratory based activities including the scientific method, mathematics exclusion in science education, iSTEM education merely as an education methodology designed to meet work force issues.

Also problematic to implementation of an iSTEM approach was the ongoing issue of a belief that technology education teachers and engineers were not able or equipped with methodology and content knowledge to teach mathematics and science.

Table 4

Lantz's (2009) Identified Barriers to iSTEM Implementation

Issues for Consideration in the iSTEMIBI	Related Construct or Factor
STEM education is just another "fad" in education and will soon go away.	*Barriers of Perception;* Factor 4: *Perception*
Technology means additional computers and hardware for schools and students.	*Barriers of a Narrow View*
All inquiry is open-ended/ Hands-on learning and inquiry are the same thing..	*Barriers of Perception;* Factor 4: *Perception*
STEM education does not include laboratory work or the scientific method.	*Barriers of Perception;* Factor 4: *Perception*
Mathematics education is not part of science education.	*Barriers of Perception;* Factor 4: *Perception*
STEM education addresses only workforce issues.	*Barriers of Perception;* Factor 4: *Perception*
Technology Education teachers or engineers cannot teach science or mathematics.	*Barriers of a Narrow View;* Factor 9: *Limited View of iSTEM*
STEM education consists only of the two bookends – science and mathematics.	*Barriers of a Narrow View;* Factor 11: *Status Quo Regarding Science and Mathematics*

Hunter (2010) outlined the work of the PAST Foundation in conjunction with the Empire State Educational Initiative to transform education through the use of STEM methodology to enhance students' 21st century skills. Key to the process was an attempt to outline new ways of educating with partnerships involving the private sector and public education entities. An ethnographic study was undertaken across eight regions of the state and data was analyzed to identify constraints and challenges to needed transition to effect change with in the state network. Ashida and Hunter (2009 a-f) compiled results and identified the following transition issues (pp. 2-3) found in Table 5. Key issues regarding implementation included regulatory boundaries impacting local educational reform, a general lack of knowledge of the iSTEM concept by stakeholders, and incentive programs were tied to enrollment numbers and not on student performance or teaching quality. An issue also emerged regarding schools finding teachers trained in iSTEM content and methods. Assessment issues emerged as current measures do not assess mastery in project-based or problem-based learning, and the Adequate Yearly Progress indicator also contributed to the issue. The authors also noted the problem caused by Carnegie seat time requirements not being conducive to implementing iSTEM methods. Aging classroom technology, reliance on textbooks coupled with outdated classroom resources, and lack of financial resources limited iSTEM implementation. Finally, the authors noted issues of breaking from the typical delivery method of disciplines being taught as distinct and separate subject areas.

Table 5

Ashida and Hunter's (2009) Identified Barriers to iSTEM Implementation

Issues for Consideration in the iSTEMIBI	Related Construct or Factor
State and federal regulatory boundaries are rigid and constrain local scale educational reform.	*Barriers of Regulation;* Factor 9: *Limited View of STEM*
The STEM education concept is not commonly understood, and the values and benefits associated with STEM education are not well known in education, business and industry, nor by the general public.	*Barriers of a Narrow View; Barriers of Adoption;* Factor 10: *Missing T and E of STEM*
The current system of incentives does not motivate key outcomes (ex., education funding tied to enrollment, not to student performance or teaching quality).	*Barriers of Regulation;* Factor 3: *Resistance to iSTEM-Based Reform*
There are shortages of STEM-qualified teachers and a lack of professional development in STEM (both pre-service and in-service), needed at the elementary, middle and high school levels. There is no STEM-specific certification at the state level.	*Professional Development Barriers; Pre-Service Training Barriers;* Factor 1: *Teacher Education Gap in iSTEM Methodology*
Current assessments do not measure mastery in project- and problem-based learning, and assessment innovation is limited by the Adequate Yearly Progress indicator	*No Child Left Behind Barriers;* Factor 5: *No Child Left Behind*
Time segments used in education – school year, school day, and class period – constrain classroom innovations that would be conducive to STEM learning. For example, the class period constrains project-based learning opportunities; seat-time requirements do the same.	*Barriers of Regulation;* Factor 3: *Resistance to iSTEM-Based Reform*
Use of technology in the classroom is 15-25 years out of sync with the real world, bound by traditional reliance on textbooks and other outdated classroom resources, and by lack of capital investment.	*Resource Barriers;* Factor 8: *Resources*
Effective education must break with current practices that deliver siloed instruction in order to link with real world interests and needs that are meaningful to students who must achieve multiple literacies	*Barriers of a Narrow View;* Factor 9: *Limited View of iSTEM*

Atkinson and Mayo (2010, p. 71) in supporting the curricular concept of the "All STEM for Some" approach identified the following project-based barriers due to existing school structure and increased expectations and pressure on teachers (See Table 6). Time was a key component with regard to set class period length and the required need for units encompassing several days or weeks. Pressure on teachers to cover multiple content areas was problematic as were the requirements of NCLB. Cost of implementation and difficulties finding teachers versed in problem-based learning methods were also considered issues for implementation.

Table 6

Atkinson and Mayo's (2010) Identified Barriers to iSTEM Implementation

Issues for Consideration in the iSTEMIBI	Related Construct or Factor
Length of class periods.	*Barriers of Regulation;* Factor 3: *Resistance to iSTEM-Based Reform*
Pressure on teachers to cover multitude of topics	*Barriers Regarding Efficacy; Barriers of Integrative STEM Buy-In;* Factor 7: *Resistance to Changing Methodology;* Factor 10: *The Missing T and E of iSTEM*
Project Based Learning (PBL) took more time to complete/Unit lengths of several days or weeks.	*Barriers of Regulation;* Factor 3: *Resistance to iSTEM-Based Reform*
Requirements of NCLB.	*No Child Left Behind Barriers;* Factor 5: *No Child Left Behind*
Inquiry was more difficult to implement.	*Barriers of Perception;* Factor 4: *Perception*
There were difficulties finding and/or maintaining leaders and teachers in PBL.	*Professional Development Barriers; Pre-Service Barriers;* Factor 1: *Teacher Education Gap in iSTEM Methods*
Additional costs.	*Resource Barriers;* Factor 8: *Resources*

Gjøvik (2010) issued surveys to identify barriers from the perspective of classroom teachers regarding iSTEM implementation. Findings were not published, but served as a background to development items for the iSTEMIBI, thus ensuring statements also contained the perspective of practicing professional teachers. These practicing teachers participated in iSTEM-based professional development at the GPSEC and identified barriers concepts found in Table 7.

Table 7

Gjøvik's (2010) Great Plains STEM Education Center Participants' Identified Barriers to iSTEM Implementation

Issues for Consideration in the iSTEMIBI	Related Construct or Factor
Isolation and/or access to professional development regarding STEM methodology was a problem.	*Professional Development Barriers;* Factor 1: *Teacher Education Gap in iSTEM Methods*
The skills and knowledge to implement all areas of iSTEM were challenging.	*Barriers Regarding Efficacy;* Factor 7: *Resistance to Changing Methodology*
There were difficulties developing interdisciplinary content.	*Barriers Regarding Efficacy;* Factor 7: *Resistance to Changing Methodology*
Without participation in iSTEM workshops, it was difficult to understand the goals of iSTEM methodology.	*Barriers Regarding Efficacy*
Without training, iSTEM methodologies and concepts were difficult to implement.	*Barriers Regarding Efficacy*
iSTEM initiatives were negatively affected if industry, scientists, engineers and parents were not involved.	*Barriers of Integrative STEM Buy-In;* Factor 10: *The Missing T and E in iSTEM*
Non-supportive teachers and administrators hindered implementation.	*Barriers of Integrative STEM Buy-In; Barriers of Adoption;* Factor 3: Resistance to iSTEM-Based Reform; Factor 10: *The Missing T and E of iSTEM;*
Teachers were not empowered to change teaching methodology to include iSTEM	*Barriers of Adoption;* Factor 7: *Resistance to Changing Methodology*
Without collaboration in the form of team-teaching and professional learning communities, implementation was limited.	*Barriers of Integrative STEM Buy-In;* Factor 3: Resistance to iSTEM-Based Reform
There was a pervasive issue where some teachers saw no need to change methodology in order to incorporate STEM.	*Barriers of a Narrow View;* Factor 11: *Status Quo Regarding Science and Mathematics*
Administrators saw no need to change methodology in order to incorporate STEM.	*Barriers of Adoption;* Factor 10: *The Missing T and E of iSTEM*
Teachers and administrators perceiving little benefit from STEM in the classroom was a barrier. Perception of lack of benefit from STEM professional development limited implementation.	*Barriers of Integrative STEM Buy-in;* Factor 8: *The Missing T and E of iSTEM* *Professional Development Barriers*
Lack of financial support by Administration hindered implementation	*Resource Barriers; Barriers of Adoption;* Factor 8: *Resources*
A perception by some that administrators inhibited STEM implementation.	*Barriers of Adoption;* Factor 10: *The Missing T and E of iSTEM*
The requirements of NCLB limited implementation of new methodologies and/or content.	*No Child Left Behind Barriers;* Factor 5: *No Child Left Behind*
Teachers were limited in time to network and collaborate regarding STEM implementation.	*No Child Left Behind Barriers; Barriers of Regulation;* Factor 3: *Resistance to iSTEM-Based Reform*; Factor 5: *No Child Left Behind*

A myriad of issues were identified tied to professional development, lack of involvement of stakeholders, non-supportive teachers and administrators (collaboration issues, perceived lack of benefit, lack of resource support,), requirements of NCLB limited time available for changing teaching methods and collaboration required to successfully implement iSTEM.

Previous Barriers Research and Development

The literature review included previous barriers research from other research fields that reported on inherent methodology, instrument and construct development to serve as background for development of the iSTEMIBI Likert statements and constructs.

Extensive use of the Allen Memorial Library facilities at Valley City State University were utilized for textbook lending and online database services such as Educational Resources Information Center (ERIC); *Academic Search Premier Database* (EBSCOHost)*;* and *Digital Library and Archives of Virginia Tech* (DLA)*.* Also publications available from the National Academies Press, International Technology and Engineering Educators Association (ITEEA) and its predecessor International Technology Educators Association (ITEA) were utilized. Several texts from the researcher's personal library were utilized. Additionally, several documents were obtained through interlibrary loan through the Allen Memorial Library.

Population and Sample

In answer to the growing demand for STEM trained teachers, several professional development initiatives were implemented by organizations for licensed teachers and pre-professional teacher candidates. Also, there were a number of schools districts in the U.S. that were early implementers in STEM methodology. The sample studied was drawn from completers of STEM-related professional development workshops and trainings and/or teachers and administrators with previous experience in STEM methodology implementation. The study utilized a heterogeneity purposive nonprobability sampling method with the goal of sampling for diversity or variety of ideas and perceptions as per Trochim (2000).

Through the researcher's contacts in STEM-related organizations, leadership in said organizations were contacted to determine if there was interest in providing access to members that fit the above criteria. Eventually, the following organizations provided invitations through list serves to solicit potential participants. Table 8 identifies organizations, reported number of individuals receiving invitations to participate and response rates. The researcher determined 150-175 respondents would give sufficient sample sizes within groups to allow analysis according to accepted statistical practices.

The cooperating organizations provided opportunity to determine perceptions on STEM implementation barriers from practicing professionals working directly with STEM methodology or intending STEM implementation. The sample provided diverse perceptions regarding ideas on implementation barriers in the K-12 setting.

Table 8

Participating Organization Response Rates

Cooperating Organization	Valid Responses	Invited	Response %
Center for Innovation in Engineering and Science Education (CIESE)	23	67	34.3
Great Plains STEM Education Center	44	235	18.7
International Technology and Engineering Educators Association (ITEEA)	65	350[a]	18.6
Maryland State Department of Education	12	150	8.0
Missouri River Education Cooperative	9	115	7.8
Total	153	917	16.7

[a] Reported value is an average based on range of potential respondents indicated by organization.

Instrumentation

Initial Development of Pilot Instrument

The study included the following elements to initially develop Likert statement items for potential use in the iSTEMIBI instrument:

- *Literature Review*: The literature review was used to identify previously published barriers research to locate reported methods of instrument and construct development, and to compile barriers as reported by expert stakeholders regarding STEM implementation and practices in the United States.
- *Quantitative Component Development:* This phase included the development of a bank of Likert-based statements identifying potential barriers to STEM methodology implementation in the K-12 setting based on findings of the literature. The Likert scale was a 6-point scale with an opt-out option (*No Opinion/Don't Know*) to limit effect on central tendency. The *Air University Sampling and Surveying Handbook* (2002) was used as a reference regarding development of proven Likert-based phrases regarding degrees of agreement. The following scale descriptors (with the exception of *No Opinion/Don't Know*) were chosen as the scale descriptors contained parallel wording: 1 = *Strongly Disagree*; 2 = *Disagree*; 3 = *Slightly Disagree*; 4 = *Slightly Agree*; 5 = *Agree*; 6 = *Strongly Agree* (p. 84); 7 = *No Opinion/Don't know* (null).
- *Qualitative component:* Throughout the pilot instrument, respondents were given opportunity for open-ended response on each Likert statement to further qualify their answers or indicate any concerns or issues with the statement. This component served as a method of identifying potential additional barriers perceived by instrument pilot

test participants and also as a triangulation device for corroboration of barriers identified in the instrument.

The afore-mentioned qualitative component was utilized in the pilot and ensuing final version of the research instrument using an Embedded Design method utilizing a correlational model as outlined in Creswell and Plano-Clark (2007). The Embedded Design correlation model was described as follows:

> The correlational model is another embedded variant, in which qualitative data are embedded within a quantitative design. In this design, researchers collect qualitative data as part of their correlational study to help explain how the mechanisms work in the correlational model. (p. 70)

Following initial identification and compilation of STEM implementation barriers identified in the literature review, a preliminary list of 94 potential Likert item statements were identified prior to evaluation and further refinement through semi-structured analysis and review by an informal STEM experts panel. Panel members were convened to initially discuss the merits and commonalities of each identified barrier statement with the intent of compressing the number of statements in the final data-gathering instrument. Likert statement wording was critically examined and edited by the panel following initial combination of similar concepts. Eventually Likert item statements were pared down to 50 items for the pilot test. In addition, to meet the intent of utilizing the Embedded Design correlation variant model as outlined in Creswell and Plano Clark (2007), an open-ended response was allowed for each statement prior to the deployment of the pilot survey.

The pilot instrument was developed in Zoomerang for online browser-based deployment. The pilot instrument included seven items in the initial demographics section to identify the starting time of the instrument, years of experience as a K-12 teacher/administrator, gender of respondent, grade level currently taught, content area taught, personal degrees and content area completed, and information regarding professional development completed. Each page of the Zoomerang survey was limited to five Likert statements per page and included a progress bar with the intent of giving participants a feeling of progression in the pilot. Following the 50 Likert statements, an additional item was added to allow up to four open-ended responses if a respondent felt there were additional barriers to implementation not indicated in the pilot. The last item asked testers to indicate what time the survey was finished. This allowed the researcher to determine average time of completion for the final version of the instrument.

Pilot Instrument Deployment

The pilot instrument was administered to 26 volunteers contacted by cooperating organizations including: (a) workshop completers of the Engineering is Elementary (EiE) curriculum developed by the National Center for Technological Literacy (NCTL); (b) the Ohio Technology and Engineering Educators Association (OTEEA) and (c) participants in workshops provided by the Great Plains STEM Education Center (GPSEC).

Changes to the iSTEMIBI Based on the Pilot Study

The open-ended qualitative portions of the pilot instrument were designed to provide support and qualify the quantitative research. Analysis of the open-ended responses supported quantitative data gathered on an item-by-item basis and no additional barriers were identified for inclusion in the iSTEMIBI instrument. Following Cronbach’s Alpha testing and analysis of responses wording changes were deemed necessary to clarify intent of the statements as follows:

- Item 11 in final was changed by adding “/coursework” to reflect that some respondents might have completed workshops and/or courses in STEM.

- Item 17 in final version of instrument was changed by inserting “of educators and stakeholders” to original pilot item. This further refined the statement to include both educators (defined as teachers or administrators) and stakeholders (defined as parents, business/industry, and government leaders).
- Item 39 in the final version of instrument was changed by replacing “do not measure” with “are limited in measurement of”.
- Items 51 and 52 in the final version of instrument were adapted by changing from “science and/or mathematics” to “science and mathematics”.
- Item 54 in the final version of instrument was edited to remove “limit students’ understanding of multiple literacies and their interconnectedness” to “limits implementation of integrative STEM”.

The researcher determined the addition of implementation levels and definitions for the demographic section of the instrument was necessary to allow further group analysis. The ISEG was convened a second time to develop implementation levels and definitions to allow respondents to classify where each felt the their local school/district was with regard to implementation in the final version of the iSTEMIBI.

An implementation model noted by Fixsen, Blase, Horner, and Sugai (2009) was analyzed by panel members to determine appropriateness of stages of implementation for eventual modification for use as levels of implementation in the iSTEM Barriers instrument. The Fixsen et al (2009) model consisted of six stages: Exploration; Installation; Initial Implementation; Full Implementation; Innovation; and Sustainability. The STEM experts determined a combination of stage concepts and redefinition according to levels of iSTEM implementation was appropriate. The panel also decided a level for schools that had yet to implement any iSTEM methods was necessary. The levels identified for use in the study are found in Table 9.

While the original online pilot test instrument was developed in Zoomerang, a change was necessary before the final deployment of the browser-based survey. Zoomerang assets were acquired and assimilated into Survey Monkey and thus the final iSTEMIBI needed to be ported over, converted and deployed in Survey Monkey. There were no issues in the process of converting other than timing of deployment as the researcher had to wait for the conversion to happen before the final version could be offered online. There was approximately a 30-day delay in deployment due to this merger.

Table 9

Defined Levels of iSTEM Implementation as Developed by Informal STEM Experts Group

iSTEM Implementation Level	Description
No Implementation	No development of iSTEM methodology is taking place in my school at this time.
Preparation	My school is in the process of: identifying the need for iSTEM; training teachers in iSTEM methodology; developing stakeholder relationships; and/or identifying and procuring needed resources for implementation.
Partial Implementation	I/We have implemented iSTEM methodology with training; not all teachers are implementing, but others in my school are learning how to support iSTEM methods.
Full Implementation	iSTEM is infused in the curriculum throughout our school and is supported by administration. Knowledge gained in iSTEM delivery is being evaluated and used to sustain persistent and skillful support of teachers and staff who are using iSTEM innovation effectively.

IRB approval. The IRB approval form is found in Appendix A. Two versions of the instrument were developed— one browser-based for electronic deployment and one paper-based for face-to-face workshops where the researcher identified volunteers willing to complete the instrument. There were subtle differences in acquiring adult consent between the two methods of deployment. The paper-based adult consent form (Appendix B) was given to potential respondents and explained by a research team member. To accomplish informed consent in the online version of the instrument, adult consent required information was supplied in the first "page" of the online instrument (Appendix C), and by clicking the "Submit" button, the participant agreed to the terms and was routed to the demographics section of the iSTEMIBI.

Throughout the data analysis component of the research, all statistical procedures utilized the education field accepted alpha level ($p = .05$) as a test for significance. The data analyses were designed to answer RQ3, RQ4 and RQ5. The following quantitative statistical analysis techniques and qualitative techniques were utilized to answer the remaining research questions:

1. (RQ3) *Do barriers and factors that affect STEM adoption vary between groups?* Group comparisons were completed utilizing ANOVA as an initial test for significance within a construct. Follow up analysis utilizing Tukey post hoc procedures further identified significant differences between groups by individual Likert item. Results of these analyses are found in Chapter 4.
2. (RQ4) *What factors contribute to STEM implementation?* Principal component analysis was utilized to generate a correlation matrix. Due to strength of initial communality values, .4 was established as a cut off value for loadings. The process involved extraction of an initial factor solution; rotation and interpretation; construction of scales or factor scores to use in further analysis; and naming 11 factors pertaining to the appropriate underlying construct. Results are found in Chapter 4.
3. (RQ5) *What barriers and contributing factors have the greatest impact on implementation?* Following identification of factors that had impact on

implementation from the Principal Component Analysis performed for RQ4, the researcher developed a ranking scale to describe the level of impact individual factors had by implementation level group. As a final step in the analysis, a Structural Equation Model (SEM) was run to do a path analysis to determine a latent-variable structural model for factor items in the iSTEMIBI. The data was analyzed using Amos (version 21) to compute a maximum-likelihood solution. Throughout the initial factor analysis and subsequent descriptive analysis, two factors were consistently among the highest ranked factors regarding barriers to implementation levels; Factor 1 — *Teacher Education Gap in iSTEM Methodology* and Factor 5 — *No Child Left Behind.* These two factors served as a starting point to build the conceptual model. Details and results of the Principal Component Analysis and SEM process are found in Chapter 4.

CHAPTER 4. ANALYSIS OF DATA

Statement of the Problem

The purpose of the study was to determine factors that served as barriers to STEM implementation the K-12 setting. The sample studied was drawn from classroom teachers and administrators with training in STEM methodology or experience in STEM methods and subsequent experience regarding integrative STEM (iSTEM) implementation barriers. The participants, through the completion of the researcher-designed Integrative STEM Implementation Barriers Instrument (iSTEMIBI), gave specific insight regarding implementation barriers from the perspective of teachers and administrators with understanding and/or experience in implementing STEM methodology.

Research Questions

A review of related literature and survey of STEM-based workshop participants was completed to answer the following research questions:

1. In what ways is the iSTEM movement similar to previous educational reform movements in the United States?
2. What do stakeholders perceive to be barriers to implementation?
3. Do factors that affect iSTEM adoption vary between groups?
4. What factors contribute to iSTEM implementation?
5. What barriers and contributing factors have the greatest impact on implementation?

Response Rate

The sample was drawn from completers of STEM-related professional development workshops and trainings and/or teachers and administrators with experience in STEM methodology implementation. Leaders from several STEM-related organizations volunteered to provide access to the researcher by providing an invitation to participate by list serve contact or by direct solicitation to participate at STEM professional development trainings.

A total of 917 invitations to participate were offered under the auspices of the cooperating organizations and 153 surveys were completed for a completed response rate of 16.7%. Table 10 contains response rates for the cooperating organizations.

Aggregated six-point Likert scale response frequency tables by items that served as the source of data for the research are located in Appendix Tables F1 through F12.

Table 10

Participating Organization Response Rates

Cooperating Organization	Valid Responses	Invited	Response %
Center for Innovation in Engineering and Science Education (CIESE)	23	67	34.3
Great Plains STEM Education Center	44	235	18.7
International Technology and Engineering Educators Association (ITEEA)	65	350[a]	18.6
Maryland State Department of Education	12	150	8.0
Missouri River Education Cooperative	9	115	7.8
Total	153	917	16.7

[a] Reported value is an average based on range of potential respondents indicated by organization.

Demographic Data

The following demographic data was gathered to provide background on respondents to be utilized for classification and eventual group comparison: (a) Years of teaching/administrative experience; (b) Current position as a teacher, administrator, or administrator with teaching responsibilities; (c) Grade level responsibility; (d) Content area taught; (e) Degree(s); (f) STEM-related workshops attended; and (g) Integrative STEM implementation level in current school district.

Each of the demographic items included an open-ended response option to provide any additional information a respondent felt appropriate to clarify an answer or provide additional details deemed important. The open-ended responses were important for the researcher as open-ended format allowed further classification of responses for future group comparisons. Coding systems were developed for classifying open-ended responses for data analysis utilizing quantitative statistics.

Findings

Research Question 1

The literature review was utilized to answer Research Question 1 (RQ 1): *In what ways is the STEM movement similar to previous educational reform movements in the United States?* Details of the results of findings with regard to RQ1 are found in Chapter 5.

Research Question 2

The literature review provided needed information regarding previously identified STEM barriers in public schools as required in Research Question 2 (*What do stakeholders perceive to be barriers to implementation?*). In addition, unpublished research by the researcher from previous iSTEM-based workshops was compiled to gain perspectives from classroom teachers regarding barriers to implementation. Identified barriers utilized as a basis for Likert item development in the iSTEMIBI are found in Chapter 3.

Research Question 3

To answer Research Question 3 (*Do factors that affect iSTEM adoption vary between groups?*) group comparisons were run in SPSS to determine between group differences by comparing responses to each Likert statement by researcher determined construct between the following demographic parameters: (a) by implementation level indicated; (b) by grade levels taught; and (c) by content area taught.

The six-point Likert scale developed for the iSTEMIBI contained the following statements with corresponding value: *Strongly Disagree* = 1.00; *Disagree* = 2.00; *Slightly Disagree* = 3.00; *Slightly Agree* = 4.00; *Agree* = 5.00; *Strongly Agree* = 6.00. Respondents were also given a response option to limit effect on central tendency with the *No Opinion/Don't know* statement. For statistical computation, this statement was considered a null value. For the purpose of describing the mean responses of groups in the study, the following scale mean score ranges were assigned: *Strongly Disagree* ($\bar{x}$ = 1.00 to 1.49); *Disagree* ($\bar{x}$ = 1.50 to 2.49); *Slightly Disagree* ($\bar{x}$ = 2.50 to 3.49); *Slightly Agree* ($\bar{x}$ = 3.50 to 4.49); *Agree* ($\bar{x}$ = 4.50 to 5.49); *Strongly Agree* ($\bar{x}$ = 5.50 to 6.00). The statistically neutral mean ($\bar{x}$ = 3.50) for descriptive reporting was established.

Initially a one-way ANOVA was run to determine if the construct contained any significant mean differences between groups. A second analysis of individual items in the construct was conducted utilizing a post hoc Tukey HSD analysis. The Tukey analysis allowed the researcher to evaluate pairwise differences among means within each item of the construct. Results were determined to be significant at $p \leq .05$.

Between group analysis of Implementation Level and Barriers Regarding Efficacy construct. Results of *Implementation Level* group comparisons within the *Barriers Regarding Efficacy* construct are found in Table 11. A one-way ANOVA test of variance within the construct indicated significance difference for three items: Item 8, F = (3, 145) = 2.90, p = .037; Item 9, F = (3, 144) = 3.99, p = .009; and Item 10, F = (3, 149) = 4.08, p = .008.

Post hoc Tukey analysis indicated a significant difference (*p* = .021) between the *No Implementation* ($\bar{x}$ = 4.11) and *Full Implementation* ($\bar{x}$ = 3.05) groups on Item #8 —*Teachers are uncomfortable with implementing technology content and concepts.* Also, there were significant differences between the *Full Implementation* ($\bar{x}$ = 3.32) group and all other implementation groups (*No Implementation:* $\bar{x}$ = 4.51; *Preparation:* $\bar{x}$ = 4.39; and *Partial Implementation:* $\bar{x}$ = 4.33) on Item 9 —*Teachers are uncomfortable with their ability to deliver engineering content and concepts.* Results of mean difference comparisons indicated significant difference between the *No Implementation* and *Full Implementation* groups (*p* = .044), the *Preparation* and *Full Implementation* groups (*p* = .006), and the *Partial Implementation* and *Full Implementation* groups (*p* = .019).

Table 11

ANOVA for Barriers Regarding Efficacy by Implementation Level (p = .05)

Item #		NI	P	PI	FI	Paired Difference	*p* value
8. Teachers are uncomfortable with implementing technology content concepts.	*N:*	44	23	63	19	NI/P: .418	NI/P: .609
	M:	4.11	3.70	3.71	3.05	NI/PI: .399	NI/PI: .417
	SD:	1.35	1.36	1.22	1.51	NI/FI: 1.061	NI/FI: *.021
						P/PI: .019	P/PI: 1.000
						P/FI: .643	P/FI: .399
						PI/FI: .662	PI/FI: .227
9. Teachers are uncomfortable with their ability to deliver engineering content and concepts.	*N:*	45	23	61	19	NI/P: .120	NI/P: .984
	M:	4.51	4.39	4.33	3.32	NI/PI: .183	NI/PI: .892
	SD:	1.36	1.37	1.25	1.29	NI/FI: 1.195	NI/FI: *.006
						P/PI: .063	P/PI: .997
						P/FI: 1.076	P/FI: *.044
						PI/FI: 1.012	PI/FI: *.019
10. Access to professional development regarding integrative STEM education is limited.	*N:*	47	23	64	19	NI/P: .056	NI/P: .999
	M:	4.55	4.61	3.89	3.53	NI/PI: .663	NI/PI: .071
	SD:	1.25	1.27	1.49	1.61	NI/FI: 1.027	NI/FI: *.040
						P/PI: .718	P/PI: .157
						P/FI: 1.082	P/FI: .066
						PI/FI: .364	PI/FI: .754
11.Without training in integrative STEM methodology it is difficult to understand the goals and concepts.	*N:*	47	23	64	19	NI/P: .425	NI/P: .579
	M:	4.53	4.96	4.86	4.68	NI/PI: .327	NI/PI: .562
	SD:	1.44	.878	1.30	1.42	NI/FI: .152	NI/FI: .973
						P/PI: .097	P/PI: .990
						P/FI: .272	P/FI: .907
						PI/FI: .175	PI/FI: .956

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

A significant difference (p = .040) was indicated on Item 10 — Access to professional development regarding integrative STEM education is limited between the No Implementation ($\bar{x}$ = 4.55) and Full Implementation ($\bar{x}$ = 3.53) groups.

No significant differences were found between groups in Item 11 — *Without training in integrative STEM methodology it is difficult to understand the goals and concepts.*

When comparing means of the implementation levels in Item 8, the *Full Implementation* group indicated slight disagreement with the statement, while the remaining groups indicated slight agreement. On Item 9, the *Full Implementation* group indicated slight disagreement; the *Preparation* and *Partial Implementation* groups indicated slight agreement; and the *No Implementation* group indicated agreement with the statement. Item 10 group means indicated the *No Implementation* and *Preparation* groups agreed with the statement and the *Partial* and *Full Implementation* groups indicated slight agreement. These results indicated a possible shift in perception or reality as participants moved through various implementation levels to full implementation of iSTEM methods.

All groups agreed with Item 11.

Between group analysis of Implementation Level and Barriers Regarding Integrative STEM Buy-In construct. Results of Implementation Level group analysis of *Barriers Regarding Integrative STEM Buy-In* construct are found in Table 12.

Post hoc Tukey analysis between groups by item indicated a significant difference (*p* = .014) between the *No Implementation* ($\bar{x}$ = 4.35) and *Full Implementation* ($\bar{x}$ = 3.12) group on Item 13 —*Buy-in of stakeholders regarding preparing students for careers in engineering is an issue*.

There were significant differences between the *Full Implementation* ($\bar{x}$ = 2.88) group and all other implementation groups (*No Implementation:* $\bar{x} = 4.50$; *Preparation:* $\bar{x} = 4.37$; and *Partial Implementation:* $\bar{x} = 3.98$) on Item 15 — *Implementation of integrative STEM education is negatively affected by lack of stakeholder involvement*.

Results of mean difference comparisons indicated significant difference between the *No Implementation* and *Full Implementation* groups ($p = .000$), the *Preparation* and *Full Implementation* groups ($p = .007$), and the *Partial Implementation* and *Full Implementation* groups ($p = .020$). Results may indicate a perceptual shift as participants move to higher levels of iSTEM implementation.

Remaining items in the construct had no significant difference between groups including: Item 14 — *Buy-in of teachers regarding preparing students for careers in engineering is an issue*; Item 16 —*Non-supportive teachers hinder implementation of integrative STEM education*; Item 17 — *Without collaboration of educators and stakeholders, implementation is limited*; and Item 18 — *The perception that integrative STEM education does little to improve student outcomes is a barrier.*

The *Full Implementation* group slightly disagreed with Items 13, 14 and 18 while other groups indicated slight agreement. Although the test was not significant, the results indicate a shift in perception towards disagreement as teachers reached full implementation experience. The *No Implementation* group agreed with Item 15, the *Preparation* and *Partial Implementation* groups slightly agreed, and the *Full Implementation* group slightly disagreed. On Item 16, the *Preparation* group indicated slight agreement, while all other groups implied agreement with the statement. All groups were in agreement with Item 17.

Table 12

ANOVA for Barriers of Integrative STEM Buy-In by Implementation Level (p = .05)

Item #		NI	P	PI	FI	Paired Difference	*p* value
13. Buy-in of stakeholders regarding preparing students for careers in engineering is an issue.	*N:*	43	20	58	17	NI/P: .249	NI/P: .913
	M:	4.35	4.10	3.95	3.12	NI/PI: .401	NI/PI: .487
	SD:	1.40	1.59	1.43	.993	NI/FI: 1.231	NI/FI: *.014
						P/PI: .152	P/PI: .975
						P/FI: .982	P/FI: .149
						PI/FI: .831	PI/FI: .142
14. Buy-in of teachers regarding preparing students for careers in engineering is an issue.	*N:*	46	21	58	17	NI/P: .086	NI/P: .996
	M:	3.85	3.76	4.09	3.35	NI/PI: .238	NI/PI: .836
	SD:	1.61	1.41	1.41	1.06	NI/FI: .495	NI/FI: .621
						P/PI: .324	P/PI: .813
						P/FI: .409	P/FI: .820
						PI/FI: .733	PI/FI: .256
15. Implementation of integrative STEM education is negatively affected by lack of stakeholder involvement.	*N:*	44	19	59	17	NI/P: .132	NI/P: .985
	M:	4.50	4.37	3.98	2.88	NI/PI: .517	NI/PI: .230
	SD:	1.39	1.38	1.36	1.27	NI/FI: 1.618	NI/FI: *.000
						P/PI: .385	P/PI: .706
						P/FI: 1.486	P/FI: *.007
						PI/FI: 1.101	PI/FI: *.020
16. Non-supportive teachers hinder implementation of integrative STEM education.	*N:*	45	20	61	18	NI/P: .228	NI/P: .927
	M:	4.58	4.35	4.70	4.56	NI/PI: .127	NI/PI: .965
	SD:	1.45	1.53	1.22	1.50	NI/FI: .022	NI/FI: 1.000
						P/PI: .355	P/PI: .749
						P/FI: .206	P/FI: .968
						PI/FI: .149	PI/FI: .977
17. Without collaboration of educators and stakeholders, implementation is limited.	*N:*	46	22	60	18	NI/P: .379	NI/P: .513
	M:	4.85	5.23	5.05	4.94	NI/PI: .202	NI/PI: .765
	SD:	1.25	.685	.910	1.35	NI/FI: .097	NI/FI: .988
						P/PI: .177	P/PI: .908
						P/FI: .283	P/FI: .836
						PI/FI: .106	PI/FI: .983
18. The perception that integrative STEM education does little to improve student outcomes is a barrier.	*N:*	41	21	58	19	NI/P: .145	NI/P: .985
	M:	3.90	4.05	3.71	3.21	NI/PI: .196	NI/PI: .923
	SD:	1.61	1.47	1.43	1.72	NI/FI: .692	NI/FI: .365
						P/PI: .341	P/PI: .818
						P/FI: .837	P/FI: .313
						PI/FI: .496	PI/FI: .610

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

Between group analysis of Implementation Level and Barriers of Adoption construct. Results of *Implementation Level* group comparisons within the *Barriers of Adoption* construct are found in Table 13. One-way ANOVA test of variance within the construct indicated significant difference for Item 20, $F = (3, 138) = 3.41$, $p = .019$ and Item 21, $F = (3, 142) = 8.65$, $p < .001$.

After additional post hoc Tukey analysis Item 20 —*Integrative STEM education is not commonly understood by stakeholders* had one group comparison, *No Implementation* $\bar{x} = 4.73$) and *Full implementation* ($\bar{x} = 3.88$) just outside the pre-determined significance level ($p = .056$). The *No Implementation* and *Preparation* groups inferred agreement, while the *Partial* and *Full Implementation* groups indicated slight agreement with the statement.

There were significant differences between the *Full Implementation* ($\bar{x} = 2.83$) group and all other implementation groups (*No Implementation:* $\bar{x} = 4.65$; *Preparation:* $\bar{x} = 4.48$; and *Partial Implementation:* $\bar{x} = 4.11$) on Item 21 —*Teachers don't feel empowered to change teaching methods to include integrative STEM*. Results of paired mean difference comparisons indicated significant difference between the *No Implementation* and *Full Implementation* groups ($p < .001$), the *Preparation* and *Full Implementation* groups ($p = .001$), and the *Partial Implementation* and *Full Implementation* groups ($p = .002$). The *No Implementation* group agreed with the statement, the *Preparation* and *Partial Implementation* groups indicated slight agreement, and the *Full Implementation* group implied slight disagreement. No significant differences were found between groups in Item 22 — *Lack of support by administrators hinders implementation*. The *No Implementation* groups agreed, and the remaining groups indicated slight agreement with the statement.

Table 13

ANOVA for Barriers of Adoption by Implementation Level (p = .05)

Item #		NI	P	PI	FI	Paired Difference	*p* value
20. Integrative STEM education is not commonly understood by stakeholders.	*N:*	45	20	60	17	NI/P: .017	NI/P: 1.000
	M:	4.73	4.75	4.22	3.88	NI/PI: .517	NI/PI: .117
	SD:	1.27	.851	1.20	1.11	NI/FI: .851	NI/FI: .056
						P/PI: .533	P/PI: .293
						P/FI: .868	P/FI: .115
						PI/FI: .334	PI/FI: .726
21. Teachers don't feel empowered to change teaching methods to include integrative STEM.	*N:*	46	21	61	18	NI/P: .176	NI/P: .957
	M:	4.65	4.48	4.11	2.83	NI/PI: .537	NI/PI: .162
	SD:	1.34	1.29	1.31	1.34	NI/FI: 1.819	NI/FI: *.000
						P/PI: .361	P/PI: .700
						P/FI: 1.643	P/FI: *.001
						PI/FI: 1.281	PI/FI: *.002
22. Lack of support by administrators hinders implementation.	*N:*	43	21	61	18	NI/P: .320	NI/P: .880
	M:	4.56	4.24	4.13	3.56	NI/PI: .427	NI/PI: .551
	SD:	1.53	1.48	1.71	1.69	NI/FI: 1.003	NI/FI: .128
						P/PI: .107	P/PI: .994
						P/FI: .683	P/FI: .558
						PI/FI: .576	PI/FI: .550

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

Between group analysis of Implementation Level and Resource Barriers construct. Results of *Implementation Level* group comparisons within the *Resource Barriers* construct are found in Table 14. Overall one-way ANOVA test of variance within the construct indicated significant difference for Item 24, $F = (3, 144) = 2.79$, $p = .043$. There was significant difference ($p = .028$) between the No Implementation ($\bar{x} = 5.37$) and Full Implementation ($\bar{x} = 4.37$) groups on Item 24 — Lack of needed resources (funding, equipment, supplies, etc.) causes issues for implementing integrative STEM *education*. While the *Full Implementation* group intimated slight agreement with the statement, the remaining groups indicated agreement.

No significant differences were found between groups in Item 25 — *Reliance on textbooks and other outdated classroom resources hinder integrative STEM implementation.* The *Preparation* group indicated agreement, the remaining groups slightly agreed. On Item 26 —

Inadequate facilities limit STEM implementation, the *Full Implementation* group slightly agreed and remaining groups agreed with the statement.

Table 14

ANOVA for Resource Barriers by Implementation Level (p = .05)

Item #		NI	P	PI	FI	Paired Difference	*p* value
24. Lack of needed resources (funding, equipment, supplies, etc.) causes issues for implementing integrative STEM education.	*N:*	46	22	61	19	NI/P: .279	NI/P: .843
	M:	5.37	5.09	4.93	4.37	NI/PI: .435	NI/PI: .323
	SD:	1.02	1.07	1.48	1.54	NI/FI: 1.001	NI/FI: *.028
						P/PI: .156	P/PI: .963
						P/FI: .722	P/FI: .292
						PI/FI: .566	PI/FI: .353
25. Reliance on textbooks and other outdated classroom resources hinder integrative STEM implementation.	*N:*	45	22	61	19	NI/P: .757	NI/P: .213
	M:	4.29	5.05	4.43	4.26	NI/PI: .137	NI/PI: .966
	SD:	1.69	.844	1.52	1.49	NI/FI: .026	NI/FI: 1.000
						P/PI: .619	P/PI: .345
						P/FI: .782	P/FI: .342
						PI/FI: .163	PI/FI: .976
26. Inadequate facilities limit STEM implementation.	*N:*	46	22	61	19	NI/P: .099	NI/P: .994
	M:	4.83	4.73	4.54	3.95	NI/PI: .285	NI/PI: .752
	SD:	1.45	1.08	1.49	1.78	NI/FI: .879	NI/FI: .128
						P/PI: .186	P/PI: .956
						P/FI: .780	P/FI: .328
						PI/FI: .594	PI/FI: .415

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

Between group analysis of Implementation Level and Professional Development Barriers construct. Results of *Implementation Level* group comparisons within the *Professional Development Barriers* construct are found in Table 15. A one-way ANOVA test of variance within the construct indicated a potential significant difference on Item 28 — *Lack of perceived benefit of professional development for integrative STEM methodology limits implementation F* = (3, 135) = 3.07, *p* = .030.

Post hoc Tukey analysis between groups indicated no significant difference for all construct items: Item 28; Item 29 — *Funding for professional development is an issue*; Item 30

— *A shortage of teachers trained in integrative STEM education limits implementation*; Item 31 — *Limited availability of professional development for in-service teachers is an issue*; and Item 32 — *Lacking STEM certification at the State level is an issue*. This disparity may be due to difference in sample sizes within the groups.

Table 15

ANOVA for Professional Development Barriers by Implementation Level (p = .05)

Item #		NI	P	PI	FI	Paired Difference	*p* value
28. Lack of perceived benefit of professional development for integrative STEM methodology limits implementation.	*N:*	43	19	60	17	NI/P: .231	NI/P: .909
	M:	4.56	4.79	4.03	3.88	NI/PI: .525	NI/PI: .162
	SD:	1.20	.787	1.37	1.41	NI/FI: .676	NI/FI: .243
						P/PI: .756	P/PI: .107
						P/FI: .907	P/FI: .140
						PI/FI: .151	PI/FI: .972
29. Funding for professional development is an issue.	*N:*	43	21	60	18	NI/P: .373	NI/P: .734
	M:	4.67	5.05	4.62	4.39	NI/PI: .058	NI/PI: .997
	SD:	1.41	.865	1.37	1.69	NI/FI: .286	NI/FI: .878
						P/PI: .431	P/PI: .599
						P/FI: .659	P/FI: .438
						PI/FI: .228	PI/FI: .925
30. A shortage of teachers trained in integrative STEM education limits implementation.	*N:*	47	21	61	18	NI/P: .153	NI/P: .952
	M:	5.09	5.24	4.98	4.67	NI/PI: .101	NI/PI: .965
	SD:	1.12	.625	1.10	1.46	NI/FI: .418	NI/FI: .522
						P/PI: .254	P/PI: .799
						P/FI: .571	P/FI: .376
						PI/FI: .317	PI/FI: .708
31. Limited availability of professional development for in-service teachers is an issue.	*N:*	46	21	61	18	NI/P: .118	NI/P: .989
	M:	4.74	4.86	4.30	4.44	NI/PI: .444	NI/PI: .366
	SD:	1.32	1.01	1.44	1.76	NI/FI: .295	NI/FI: .872
						P/PI: .562	P/PI: .387
						P/FI: .413	P/FI: .794
						PI/FI: .149	PI/FI: .978
32. Lacking STEM certification at the State level is an issue.	*N:*	36	20	51	17	NI/P: .244	NI/P: .941
	M:	4.44	4.20	3.94	3.65	NI/PI: .503	NI/PI: .440
	SD:	1.52	1.58	1.48	1.73	NI/FI: .797	NI/FI: .298
						P/PI: .259	P/PI: .920
						P/FI: .553	P/FI: .698
						PI/FI: .294	PI/FI: .904

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

On Items 28 and 31, the *No Implementation* and *Preparation* groups implied agreement and the *Partial Implementation* and *Full Implementation* groups indicated slight agreement. The

Full Implementation group slightly agreed and all remaining groups agreed with Item 29. All groups agreed with Item 30 and slightly agreed with Item 32.

Between group analysis of Implementation Level and Pre-Service Training Barriers construct. Results of *Implementation Level* group comparisons within the *Pre-Service Training* construct are found in Table 16. One-way ANOVA test of variance within the construct indicated significant difference for Item 36, $F = (3, 115) = 2.70$, $p = .049$. After additional post hoc Tukey analysis Item 36 — *Lack of integrative STEM methodology in secondary teacher education programs limits implementation* had one group comparison, *No Implementation* ($\bar{x} = 5.11$) and *Full implementation* ($\bar{x} = 4.18$), with a significant difference between means ($p = .032$). The results indicated the respondents at the *Full Implementation* level did not feel as strongly about lack of STEM methods in secondary teacher preparation programs.

No significant differences were found between groups in Item 34 —*Limited availability of professional development for pre-service teachers is an issue*; Item 35 — *Lack of integrative STEM methodology in elementary teacher education programs limits implementation*; and Item 37 — *Integrative STEM education is limited by low numbers of teacher education programs that include technological literacy as part of content and methods courses*.

The *No Implementation* and *Preparation* groups implied agreement with the statement in Item 34, while the *Partial Implementation* and *Full Implementation* groups had means indicating slight agreement. On Item 35, the *Partial Implementation* group registered slight agreement and all remaining groups indicated agreement with the statement. On Items 36 and 37, the *Full Implementation* group indicated slight agreement and all remaining groups indicated agreement.

Table 16

ANOVA for Pre-Service Training Barriers by Implementation Level (p = .05)

Item #		NI	P	PI	FI	Paired Difference	*p* value
34. Limited availability of professional development for pre-service teachers is an issue.	*N:*	35	16	54	17	NI/P: .252	NI/P: .932
	M:	4.69	4.94	4.33	4.00	NI/PI: .352	NI/PI: .649
	SD:	1.37	1.06	1.41	1.62	NI/FI: .686	NI/FI: .346
						P/PI: .604	P/PI: .426
						P/FI: .938	P/FI: .219
						PI/FI: .333	PI/FI: .825
35. Lack of integrative STEM methodology in elementary teacher education programs limits implementation.	*N:*	33	12	53	13	NI/P: .091	NI/P: .997
	M:	5.09	5.00	4.49	4.62	NI/PI: .600	NI/PI: .147
	SD:	1.04	.853	1.45	1.26	NI/FI: .476	NI/FI: .660
						P/PI: .509	P/PI: .590
						P/FI: .385	P/FI: .872
						PI/FI: .125	PI/FI: .989
36. Lack of integrative STEM methodology in secondary teacher education programs limits implementation.	*N:*	38	14	50	17	NI/P: .320	NI/P: .809
	M:	5.11	4.79	4.68	4.18	NI/PI: .425	NI/PI: .317
	SD:	.924	.893	1.13	1.70	NI/FI: .929	NI/FI: *.032
						P/PI: .106	P/PI: .990
						P/FI: .609	P/FI: .458
						PI/FI: .504	PI/FI: .403
37. Integrative STEM education is limited by low numbers of teacher education programs that include technological literacy as part of content and methods courses.	*N:*	37	14	52	16	NI/P: .106	NI/P: .993
	M:	5.11	5.21	4.87	4.19	NI/PI: .243	NI/PI: .793
	SD:	1.17	.699	1.19	1.72	NI/FI: .921	NI/FI: .063
						P/PI: .349	P/PI: .780
						P/FI: 1.027	P/FI: .106
						PI/FI: .678	PI/FI: .219

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

Between group analysis of Implementation Level and No Child Left Behind Barriers construct. Results of implementation level group comparisons within the *No Child Left Behind* (NCLB) construct are found in Table 17.

A one-way ANOVA test of variance within the construct yielded no significance difference. Follow up post hoc Tukey analysis indicated no significant difference between groups within Item 39 — *Current standardized assessments are limited in measurement of mastery in project and problem-based learning*; Item 40 — *Assessment innovation is limited by Adequate Yearly Progress (AYP) indicator required by NCLB*; and Item 41 — *The requirements of NCLB limit time available for integrative STEM education.*

All groups indicated agreement with Items 39, 40 and 41and results indicate potential of *NCLB* as a strong candidate regarding impact on implementation.

Table 17

ANOVA for No Child Left Behind Barriers by Implementation Level (p = .05)

Item #		NI	P	PI	FI	Paired Difference	*p* value
39. Current standardized assessments are limited in measurement of mastery in project and problem-based learning.	*N:*	42	20	58	17	NI/P: .443	NI/P: .492
	M:	5.14	4.70	4.98	5.00	NI/PI: .160	NI/PI: .902
	SD:	.926	1.66	1.08	1.17	NI/FI: .143	NI/FI: .973
						P/PI: .283	P/PI: .780
						P/FI: .300	P/FI: .859
						PI/FI: .017	PI/FI: 1.000
40. Assessment innovation is limited by Adequate Yearly Progress (AYP) indicator required by NCLB.	*N:*	40	17	50	15	NI/P: .150	NI/P: .965
	M:	5.15	5.00	4.98	4.73	NI/PI: .170	NI/PI: .886
	SD:	.921	1.28	1.10	1.34	NI/FI: .417	NI/FI: .596
						P/PI: .020	P/PI: 1.000
						P/FI: .267	P/FI: .903
						PI/FI: .247	PI/FI: .872
41. The requirements of NCLB limit time available for integrative STEM education.	*N:*	41	19	51	13	NI/P: .329	NI/P: .771
	M:	5.17	4.84	4.94	4.69	NI/PI: .230	NI/PI: .811
	SD:	1.09	1.61	1.21	1.11	NI/FI: .478	NI/FI: .615
						P/PI: .099	P/PI: .991
						P/FI: .150	P/FI: .987
						PI/FI: .249	PI/FI: .915

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

Between group analysis of Implementation Level and Technology and Engineering Standards Barriers Construct. Results of *Implementation Level* group comparisons within the *Technology and Engineering Standards Barriers* construct are found in Table 18. A one-way ANOVA test of variance within the construct indicated significant difference for Item 45, F = (3, 134) = 2.87, p = .039.

Item 43 — *Lack of required K-12 technology and engineering standards limits integrative STEM implementation* did not indicate a significant difference on the overall ANOVA, but did result in a significant difference between *No Implementation* ($\bar{x}$ = 4.69) and

Full Implementation ($\overline{x}$ = 3.59) groups (*p* = .049) on the post hoc Tukey analysis.

Item 45 — *Lack of required K-12 technology and engineering standards limits student assessment in integrative STEM curriculum* had significant difference between the *No Implementation* ($\overline{x}$ = 4.82) and *Full Implementation* ($\overline{x}$ = 3.75) groups (*p* = .041). No significant differences were found between groups in Item 44 — *Lack of required K-12 technology and engineering standards limits professional development in integrative STEM curriculum*.

Consistent levels of agreement on Items 43, 44, and 45 were found in the construct. The *No Implementation* group implied agreement with all items, and all remaining groups indicated slight agreement.

Table 18

ANOVA for Technology and Engineering Standards Barriers by Implementation Level (p = .05)

Item #		NI	P	PI	FI	Paired Difference	*p* value
43. Lack of required K-12 technology and engineering standards limits integrative STEM implementation.	*N:*	45	20	57	17	NI/P: .639	NI/P: .381
	M:	4.69	4.05	4.32	3.59	NI/PI: .373	NI/PI: .589
	SD:	1.40	1.67	1.42	1.70	NI/FI: 1.101	NI/FI: *.049
						P/PI: .266	P/PI: .901
						P/FI: .462	P/FI: .781
						PI/FI: .728	PI/FI: .290
44. Lack of required K-12 technology and engineering standards limits professional development in integrative STEM curriculum.	*N:*	45	20	57	17	NI/P: .422	NI/P: .710
	M:	4.62	4.20	4.26	3.59	NI/PI: .359	NI/PI: .614
	SD:	1.40	1.58	1.43	1.66	NI/FI: 1.034	NI/FI: .070
						P/PI: .063	P/PI: .998
						P/FI: .612	P/FI: .591
						PI/FI: .675	PI/FI: .350
45. Lack of required K-12 technology and engineering standards limits student assessment in integrative STEM curriculum.	*N:*	45	19	58	16	NI/P: .717	NI/P: .231
	M:	4.82	4.11	4.45	3.75	NI/PI: .374	NI/PI: .522
	SD:	1.25	1.63	1.30	1.65	NI/FI: 1.072	NI/FI: *.041
						P/PI: .343	P/PI: .782
						P/FI: .355	P/FI: .872
						PI/FI: .698	PI/FI: .279

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

Between group analysis of Implementation Level and Barriers of a Male-Oriented Content construct. Results of *Implementation Level* group comparisons within the *Barriers of a Male-Oriented Content* construct are found in Table 19. No significant differences by item were identified from the overall one-way ANOVA test of variance within the construct or the post hoc Tukey group comparisons on the following: Item 47 —*The perception of STEM as a male-oriented curriculum limits its significance* and Item 48 — *The perception of STEM as a male-oriented curriculum limits implementation*.

Table 19

ANOVA for Barriers of a Male-Oriented Content by Implementation Level (p = .05)

Item #		NI	P	PI	FI	Paired Difference	*p* value
47. The perception of STEM as a male-oriented curriculum limits its significance.	*N:*	42	20	58	17	NI/P: .048	NI/P: .999
	M:	3.45	3.50	3.17	2.88	NI/PI: .280	NI/PI: .785
	SD:	1.53	1.47	1.43	1.50	NI/FI: .570	NI/FI: .537
						P/PI: .328	P/PI: .827
						P/FI: .618	P/FI: .584
						PI/FI: .290	PI/FI: .892
48. The perception of STEM as a male-oriented curriculum limits implementation.	*N:*	44	18	58	17	NI/P: .068	NI/P: .998
	M:	3.43	3.50	3.02	2.82	NI/PI: .415	NI/PI: .503
	SD:	1.59	1.43	1.43	1.43	NI/FI: .608	NI/FI: .479
						P/PI: .483	P/PI: .624
						P/FI: .676	P/FI: .534
						PI/FI: .194	PI/FI: .965

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

When comparing means of the implementation levels the means in Item 47 for *No Implementation* ($\bar{x}$ = 3.45)*, Partial Implementation* ($\bar{x}$ = 3.17) and *Full Implementation* ($\bar{x}$ = 2.88) groups indicated a level of slight disagreement with the statement while the *Preparation* group indicated a statistically neutral mean ($\bar{x}$ = 3.50). Similar results were obtained for Item 48. The *No Implementation* ($\bar{x}$ = 3.43), *Partial Implementation* ($\bar{x}$ = 3.02) and *Full Implementation* ($\bar{x}$ = 2.82) groups indicating a level of slight disagreement with the statement. The *Preparation* group once again indicated a statistically neutral position on the statement ($\bar{x}$ = 3.50). Across all

Implementation Level groups, gender barriers due to male-oriented curriculum did not appear to be perceived as causing significant impact.

Between group analysis of Implementation Level and Barriers of a Narrow View construct. Results of *Implementation Level* group comparisons within the *Barriers of a Narrow View* construct are found in Table 20. The one-way ANOVA test of variance within the construct did not indicate a significant difference, but one Item 50, $F = (3, 125) = 2.32$, $p = .078$, was deemed close to the p level and the researcher determined warranted further Tukey ANOVA analysis.

A significant difference ($p = .046$) was indicated on Item 50 —*Policy makers and leaders fail to recognize the equal importance of the full spectrum of integrative STEM education* between the *No Implementation* ($\overline{x} = 5.02$) and *Full Implementation* ($\overline{x} = 4.06$) groups.
No significant differences were found between groups in the following: Item 51 —*For many educators, STEM education consists only of science and mathematics*; Item 52 — *For many stakeholders, STEM education consists only of science and mathematics*; Item 53 — *For many educators computer literacy requirements serve as a barrier to integrative STEM implementation*; Item 54 — *Current education practices delivering separate and 'siloed' instruction, limits implementation of integrative STEM*; Item 55 —*The perception that technology and engineering education teachers cannot teach science or mathematics content is a barrier to implementation of integrative STEM education*; Item 56 — *Science educators see no need to change methodology to include technology and engineering*; Item 57 — *Mathematics educators see no need to change methodology to include technology and engineering*; and Item 58 — *The perception that inclusion of technology and engineering limits time for learning mathematics and science, limits implementation of integrative STEM curriculum.*

Table 20

ANOVA for Barriers of a Narrow View by Implementation Level (p = .05)

Item #		NI	P	PI	FI	Paired Difference	*p* value
50. Policy makers and leaders fail to recognize the equal importance of the full spectrum of integrative STEM education.	*N:*	42	19	52	16	NI/P: .234	NI/P: .903
	M:	5.02	4.79	4.77	4.06	NI/PI: .255	NI/PI: .756
	SD:	1.07	1.44	1.29	1.24	NI/FI: .961	NI/FI: *.046
						P/PI: .020	P/PI: 1.000
						P/FI: .727	P/FI: .314
						PI/FI: .707	PI/FI: .196
51. For many educators, STEM education consists only of science and mathematics.	*N:*	43	21	56	16	NI/P: .048	NI/P: .999
	M:	5.00	4.95	4.75	4.06	NI/PI: .250	NI/PI: .789
	SD:	1.13	1.36	1.42	1.44	NI/FI: .938	NI/FI: .080
						P/PI: .202	P/PI: .933
						P/FI: .890	P/FI: .185
						PI/FI: .688	PI/FI: .265
52. For many stakeholders, STEM education consists only of science and mathematics.	*N:*	38	21	51	16	NI/P: .195	NI/P: .945
	M:	5.05	4.86	4.82	4.31	NI/PI: .229	NI/PI: .843
	SD:	1.16	1.49	1.32	1.25	NI/FI: .740	NI/FI: .227
						P/PI: .034	P/PI: 1.000
						P/FI: .545	P/FI: .587
						PI/FI: .511	PI/FI: .518
53. For many educators computer literacy requirements serve as a barrier to integrative STEM implementation.	*N:*	44	21	56	17	NI/P: .089	NI/P: .996
	M:	4.14	4.05	4.09	3.29	NI/PI: .047	NI/PI: .999
	SD:	1.53	1.43	1.46	1.31	NI/FI: .842	NI/FI: .187
						P/PI: .042	P/PI: 1.000
						P/FI: .754	P/FI: .393
						PI/FI: .795	PI/FI: .207
54. Current education practices delivering separate and “siloed” instruction, limits implementation of integrative STEM.	*N:*	41	18	53	16	NI/P: .070	NI/P: .998
	M:	4.71	4.78	5.02	4.13	NI/PI: .312	NI/PI: .666
	SD:	1.52	1.26	1.08	1.50	NI/FI: .582	NI/FI: .439
						P/PI: .241	P/PI: .907
						P/FI: .653	P/FI: .474
						PI/FI: .894	PI/FI: .086
55. The perception that technology and engineering education teachers cannot teach science or mathematics content is a barrier to implementation of integrative STEM education.	*N:*	41	17	54	17	NI/P: .624	NI/P: .393
	M:	4.32	4.94	4.44	3.76	NI/PI: .127	NI/PI: .970
	SD:	1.25	1.30	1.42	1.52	NI/FI: .552	NI/FI: .502
						P/PI: .497	P/PI: .562
						P/FI: 1.176	P/FI: .064
						PI/FI: .680	PI/FI: .285
56. Science educators see no need to change methodology to include technology and engineering.	*N:*	41	18	55	16	NI/P: .191	NI/P: .972
	M:	3.98	4.17	3.78	3.25	NI/PI: .194	NI/PI: .929
	SD:	1.41	1.69	1.55	1.69	NI/FI: .726	NI/FI: .385
						P/PI: .385	P/PI: .795
						P/FI: .917	P/FI: .313
						PI/FI: .532	PI/FI: .619

(continued)

Table 20

ANOVA for Barriers of a Narrow View by Implementation Level (p = .05) (continued)

Item #		NI	P	PI	FI	Paired Difference	*p* value
57. Mathematics educators see no need to change methodology to include technology and engineering.	*N:*	40	18	53	14	NI/P: .289	NI/P: .913
	M:	4.10	4.39	4.02	3.36	NI/PI: .081	NI/PI: .994
	SD:	1.41	1.50	1.59	1.82	NI/FI: .743	NI/FI: .414
						P/PI: .370	P/PI: .817
						P/FI: 1.032	P/FI: .246
						PI/FI: .662	PI/FI: .488
58. The perception that inclusion of technology and engineering limits time for learning mathematics and science, limits implementation of integrative STEM curriculum.	*N:*	43	18	55	13	NI/P: .105	NI/P: .994
	M:	4.60	4.50	4.36	3.69	NI/PI: .241	NI/PI: .838
	SD:	1.22	1.62	1.43	1.70	NI/FI: .912	NI/FI: .183
						P/PI: .136	P/PI: .985
						P/FI: .808	P/FI: .404
						PI/FI: .671	PI/FI: .421

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

When comparing means of the implementation levels in Items 53, 56 and 57, the means for the *Full Implementation* group, Item 53 ($\bar{x} = 3.29$); Item 56 ($\bar{x} = 3.25$); and Item 57 ($\bar{x} = 3.36$) indicated a level of slight disagreement with the statements, while the other implementation groups indicated a level of slight agreement with the statements ($\bar{x} > 3.50$ and < 4.50).

Items 53, 56, and 57 had similar results with the *Full Implementation* group indicating slight disagreement, and the remaining groups inferring slight agreement on all three items. On Item 55 the *Preparation* group agreed with the statement, while the three remaining groups indicated slight agreement.

The No Implementation and Preparation groups indicated agreement on Item 58 and the Partial Implementation and Full Implementation groups implied slight agreement.

Between group analysis of Implementation Level and Barriers of Perception construct. Results of *Implementation Level* group comparisons within the *Barriers of Perception* construct are found in Table 21. No significant differences by item were identified by the overall one-way ANOVA test of variance within the construct or the post hoc Tukey group comparisons.

Table 21

ANOVA for Barriers of Perception by Implementation Level (p = .05)

Item #		NI	P	PI	FI	Paired Difference	*p* value
60. STEM is perceived by educators as another “fad” that will soon go away.	*N:*	37	19	55	16	NI/P: .265	NI/P: .924
	M:	3.95	4.21	3.62	3.50	NI/PI: .328	NI/PI: .733
	SD:	1.47	1.48	1.42	1.83	NI/FI: .446	NI/FI: .753
						P/PI: .592	P/PI: .449
						P/FI: .711	P/FI: .503
						PI/FI: .118	PI/FI: .992
61. Negative perception of open-ended inquiry learning limits implementation of integrative STEM education.	*N:*	41	19	56	16	NI/P: .186	NI/P: .964
	M:	4.02	4.21	3.89	3.56	NI/PI: .132	NI/PI: .969
	SD:	1.42	1.44	1.33	1.59	NI/FI: .462	NI/FI: .682
						P/PI: .318	P/PI: .830
						P/FI: .648	P/FI: .528
						PI/FI: .330	PI/FI: .841
62. There is a negative perception that integrative STEM education diminishes the individual importance of each content area.	*N:*	37	18	50	16	NI/P: .177	NI/P: .973
	M:	3.62	3.44	3.54	3.56	NI/PI: .082	NI/PI: .994
	SD:	1.46	1.38	1.33	1.67	NI/FI: .059	NI/FI: .999
						P/PI: .096	P/PI: .995
						P/FI: .118	P/FI: .995
						PI/FI: .022	PI/FI: 1.000
63. A perception that mathematics is not a significant part of science education is an issue.	*N:*	43	20	57	16	NI/P: .473	NI/P: .653
	M:	2.98	3.45	3.40	3.19	NI/PI: .427	NI/PI: .501
	SD:	1.54	1.57	1.44	1.60	NI/FI: .211	NI/FI: .964
						P/PI: .046	P/PI: .999
						P/FI: .263	P/FI: .954
						PI/FI: .216	PI/FI: .957
64. A perception that integrative STEM education addresses only workforce issues limits implementation.	*N:*	41	18	52	14	NI/P: .033	NI/P: 1.000
	M:	3.63	3.67	3.87	3.00	NI/PI: .231	NI/PI: .860
	SD:	1.51	1.41	1.30	1.47	NI/FI: .634	NI/FI: .467
						P/PI: .199	P/PI: .955
						P/FI: .667	P/FI: .546
						PI/FI: .865	PI/FI: .178

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

Statements were: Item 60 — *STEM is perceived by educators as another “fad” that will soon go away*; Item 61 — *Negative perception of open-ended inquiry learning limits implementation of integrative STEM education*; Item 62 — *There is a negative perception that integrative STEM education diminishes the individual importance of each content area*; Item 63 — *A perception that mathematics is not a significant part of science education is an issue*; and

Item 64 — *A perception that integrative STEM education addresses only workforce issues limits implementation*.

The *Full Implementation* ($\bar{x}$ = 3.50) group had a statistically neutral view on Item 60 while the remaining groups indicated slight agreement with the statement. All groups on the statement in Item 61 inferred slight agreement; all groups slightly disagreed with the statement on Item 63. The *Preparation* group indicated slight disagreement with Item 62 and all remaining implementation groups indicated slight agreement. Item 64 results included slight disagreement by the *Full Implementation* group and remaining groups indicated slight agreement with the statement.

Between group analysis of Implementation Level and Barriers of Regulation construct. Results of *Implementation Level* group comparisons within the *Barriers of Regulation* construct are found in Table 22.

A one-way ANOVA test of variance within the construct indicated significant difference for Item 67, F = (3, 123) = 3.74, p = .012 and Item 68, F = (3, 133) = 9.34, p = .000.

Post hoc Tukey analysis indicated a significant difference between the *Preparation* ($\bar{x}$ = 5.47) and *Partial Implementation* ($\bar{x}$ = 4.50) groups (p = .038) and between the *Partial Implementation* ($\bar{x}$ = 5.47) and *Full Implementation* ($\bar{x}$ = 4.00) groups (p = .010) on Item 67 — *There is currently a lack of incentives to motivate key outcomes for improving educational quality.* The results indicated that as schools progressed into higher implementation levels, perception of lack of incentives as a barrier decreased.

Table 22

ANOVA for Barriers of Regulation by Implementation Level (p = .05)

Item #		NI	P	PI	FI	Paired Difference	*p* value
66. State and federal regulatory boundaries are rigid and constrain local educational reform.	*N:*	40	14	49	15	NI/P: .250	NI/P: .943
	M:	4.75	5.00	4.29	3.87	NI/PI: .464	NI/PI: .427
	SD:	1.48	1.47	1.41	1.30	NI/FI: .883	NI/FI: .180
						P/PI: .714	P/PI: .356
						P/FI: 1.133	P/FI: .149
						PI/FI: .419	PI/FI: .754
67. There is currently a lack of incentives to motivate key outcomes for improving educational quality.	*N:*	41	19	52	15	NI/P: .888	NI/P: .085
	M:	4.59	5.47	4.50	4.00	NI/PI: .085	NI/PI: .990
	SD:	1.61	.612	1.37	1.07	NI/FI: .585	NI/FI: .474
						P/PI: .974	P/PI: *.038
						P/FI: 1.474	P/FI: *.010
						PI/FI: .500	PI/FI: .583
68. Class-periods and seat-time requirements constrain the use of integrative STEM methodologies.	*N:*	45	20	55	17	NI/P: .283	NI/P: .873
	M:	4.87	5.15	4.31	3.00	NI/PI: .558	NI/PI: .196
	SD:	1.47	1.14	1.33	1.62	NI/FI: 1.867	NI/FI: *.000
						P/PI: .841	P/PI : .100
						P/FI: 2.150	P/FI: *.000
						PI/FI: 1.309	PI/FI: *.005

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

There were significant differences between the *Full Implementation* ($\bar{x}$ = 3.00) group and all other implementation groups (*No Implementation:* $\bar{x}$ = 4.87; *Preparation:* $\bar{x}$ = 5.15; and *Partial Implementation:* $\bar{x}$ = 4.31) on Item 68 — *Class-periods and seat-time requirements constrain the use of integrative STEM methodologies*. Results of mean difference comparisons indicated significant difference between the *No Implementation* and *Full Implementation* groups (*p* = .000), the *Preparation* and *Full Implementation* groups (*p* = .000), and the *Partial Implementation* and *Full Implementation* groups (*p* = .005). Results indicated as schools reached the *Full Implementation* level, respondents disagreed with the statement with regard to impact on implementation.

The *No Implementation* and *Preparation* groups indicated agreement with Item 66, while the *Partial Implementation* and *Full Implementation* groups suggested slight agreement. The Full

Implementation group implied slight agreement on Item 67 and the remaining groups indicated agreement with the statement. The *No Implementation* and *Preparation* groups agreed, the *Partial Implementation* group slightly agreed, and the *Full Implementation* group slightly disagreed on Item 68.

Between group analysis of Grade Level and Barriers Regarding Efficacy construct. Results of *Grade Level* reported by group comparisons within the *Barriers Regarding Efficacy* construct are found in Table 23. A one-way ANOVA test of variance within the construct and post hoc Tukey analysis of paired groups indicated no significant difference in the following: Item 8 — *Teachers are uncomfortable with implementing technology content and concepts;* Item 9 — *Teachers are uncomfortable with their ability to deliver engineering content and concepts;* Item 10 — *Access to professional development regarding integrative STEM education is limited;* and Item 11 — *Without training in integrative STEM methodology it is difficult to understand the goals and concepts.*

All groups indicated slight agreement with Items 8 and 10. Also, all groups indicated agreement with Item 11 and mean scores indicated Item 11 was a possible impact factor candidate. On Item 9 the *Elementary School* group inferred agreement with the statement while the *Middle School, High School, and Middle School/High School* groups indicated slight agreement with the statement.

Table 23

ANOVA for Barriers Regarding Efficacy by Grade Level (p = .05)

Item #		ES	MS	HS	MSHS	Paired Difference	*p* value
8. Teachers are uncomfortable with implementing technology content and concepts.	*N:*	30	31	64	24	ES/MS: .522	ES/MS: .425
	M:	4.17	3.65	3.52	3.96	ES/HS: .651	ES/HS: .127
	SD:	1.26	1.45	1.31	1.33	ES/MSHS: .208	ES/MSHS: .941
						MS/HS: .130	MS/HS: .971
						MS/MSHS: .313	MS/MSHS: .824
						HS/MSHS: .443	HS/MSHS: .510
9. Teachers are uncomfortable with their ability to deliver engineering content and concepts.	*N:*	30	31	63	24	ES/MS: .635	ES/MS: .252
	M:	4.70	4.06	4.10	4.42	ES/HS: .605	ES/HS: .179
	SD:	.952	1.29	1.49	1.38	ES/MSHS: .283	ES/MSHS: .866
						MS/HS: .031	MS/HS: 1.000
						MS/MSHS: .352	MS/MSHS: .767
						HS/MSHS: .321	HS/MSHS: .748
10. Access to professional development regarding integrative STEM education is limited.	*N:*	30	31	68	24	ES/MS: .784	ES/MS: .143
	M:	4.30	3.52	4.31	4.38	ES/HS: .009	ES/HS: 1.000
	SD:	1.47	1.44	1.39	1.47	ES/MSHS: .075	ES/MSHS: .997
						MS/HS: .793	MS/HS: .054
						MS/MSHS: .859	MS/MSHS: .123
						HS/MSHS: .066	HS/MSHS: .997
11. Without training in integrative STEM methodology it is difficult to understand the goals and concepts.	*N:*	30	31	68	24	ES/MS: .190	ES/MS: .942
	M:	4.90	4.71	4.74	4.67	ES/HS: .165	ES/HS: .940
	SD:	1.21	1.16	1.35	1.52	ES/MSHS: .233	ES/MSHS: .916
						MS/HS: .026	MS/HS: 1.000
						MS/MSHS: .043	MS/MSHS: .999
						HS/MSHS: .069	HS/MSHS: .996

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

Between group analysis of Grade Level and Barriers of Integrative STEM Buy-In construct. Results of *Grade Level* group comparisons within the *Barriers of Integrative STEM Buy-In* construct are found in Table 24. A one-way ANOVA test of variance within the construct indicated significant difference for Item 14, *F* = (3, 138) = 3.61, *p* = .015.

Post hoc Tukey analysis indicated a significant difference (*p* = .011) between the *Elementary School* ($\bar{x}$ = 4.52) and *High School* ($\bar{x}$ = 3.52) groups on Item 14 — *Buy-in of teachers regarding preparing students for careers in engineering is an issue.* The result indicated perception in this regard as a barrier was significantly higher for the *Elementary School* group.

Table 24

ANOVA for Barriers of Integrative STEM Buy-In by Grade Level (p = .05)

Item #		ES	MS	HS	MSHS	Paired Difference	*p* value
13. Buy-in of stakeholders regarding preparing students for careers in engineering is an issue.	*N:*	28	27	60	23	ES/MS: .616	ES/MS: .380
	M:	4.36	3.74	3.83	4.26	ES/HS: .524	ES/HS: .379
	SD:	1.31	1.38	1.52	1.36	ES/MSHS: .096	ES/MSHS: .995
						MS/HS: .093	MS/HS: .992
						MS/MSHS: .520	MS/ MSHS: .574
						HS/MSHS: .428	HS/MSHS: .614
14. Buy-in of teachers regarding preparing students for careers in engineering is an issue.	*N:*	29	28	61	24	ES/MS: .767	ES/MS: .171
	M:	4.52	3.75	3.52	4.13	ES/HS: .993	ES/HS: *.011
	SD:	1.33	1.40	1.45	1.39	ES/MSHS: .392	ES/MSHS: .743
						MS/HS: .225	MS/HS: .896
						MS/MSHS: .375	MS/MSHS: .773
						HS/MSHS: .600	HS/MSHS: .290
15. Implementation of integrative STEM education is negatively affected by lack of stakeholder involvement.	*N:*	27	29	61	22	ES/MS: .826	ES/MS: .137
	M:	4.48	3.66	4.13	3.91	ES/HS: .350	ES/HS: .712
	SD:	1.19	1.32	1.48	1.66	ES/MSHS: .572	ES/MSHS: .502
						MS/HS: .476	MS/HS: .452
						MS/MSHS: .254	MS/MSHS: .922
						HS/MSHS: .222	HS/MSHS: .923
16. Non-supportive teachers hinder implementation of integrative STEM education.	*N:*	30	30	63	21	ES/MS: .300	ES/MS: .830
	M:	4.57	4.87	4.41	4.81	ES/HS: .154	ES/HS: .957
	SD:	1.22	1.11	1.53	1.37	ES/MSHS: .243	ES/MSHS: .924
						MS/HS: .454	MS/HS: .442
						MS/MSHS: .057	MS/MSHS: .999
						HS/MSHS: .397	HS/MSHS: .658
17. Without collaboration of educators and stakeholders, implementation is limited.	*N:*	30	29	63	24	ES/MS: .201	ES/MS: .887
	M:	5.17	4.97	4.92	5.04	ES/HS: .246	ES/HS: .725
	SD:	.70	1.05	1.15	1.20	ES/MSHS: .125	ES/MSHS: .973
						MS/HS: .045	MS/HS: .998
						MS/MSHS: .076	MS/MSHS: .994
						HS/MSHS: .121	HS/MSHS: .965
18. The perception that integrative STEM education does little to improve student outcomes is a barrier.	*N:*	28	27	61	23	ES/MS: .103	ES/MS: .995
	M:	3.79	3.89	3.62	3.87	ES/HS: .163	ES/HS: .967
	SD:	1.62	1.40	1.52	1.69	ES/MSHS: .084	ES/MSHS: .997
						MS/HS: .266	MS/HS: .879
						MS/MSHS: .019	MS/MSHS: 1.000
						HS/MSHS: .247	HS/MSHS: .915

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

No significant differences were found between groups in Item 13 — *Buy-in of stakeholders regarding preparing students for careers in engineering is an issue;* Item 15 — *Implementation of integrative STEM education is negatively affected by lack of* stakeholder involvement; Item 16 — Non-supportive teachers hinder implementation of integrative STEM education; Item 17 — Without collaboration of educators and *stakeholders, implementation is limited;* and Item 18 — *The perception that integrative STEM education does little to improve student outcomes is a barrier.*

All grade level groups suggested slight agreement with Items 13, 15 and 18. All groups also inferred agreement on Item 17. The *High School* group indicated slight agreement with Item 16, while all remaining groups registered agreement with the statement. The congruency of mean scores on Items 16 and 17 indicated potential as impact items regarding iSTEM implementation.

Between group analysis of Grade Level and Barriers of Adoption construct. Results of *Grade Level* group comparisons within the *Barriers of Adoption c*onstruct are found in Table 25. A one-way ANOVA test of variance within the construct indicated no significant difference. Item 21 — *Teachers don't feel empowered to change teaching methods to include integrative STEM* did not meet significance criteria ($p \leq .05$) at this stage, $F = (3, 142) = 2.41$, $p = .069$. After post hoc Tukey analysis, a significant difference ($p = .047$) between the *Elementary School* ($\bar{x} = 4.66$) and *Middle School* ($\bar{x} = 3.70$) groups was indicated resulting in a potential view of empowerment to changing methods being perceived as a larger issue regarding impact at the elementary level.

No significant differences were found between groups in Item 20 — *Integrative STEM education is not commonly understood by stakeholders* and Item 22 — *Lack of support by administrators hinders implementation.* On Items 20 and 22 the *Middle School/High School* respondents indicated agreement with the statements and remaining groups implied slight agreement. Agreement was indicated by the *Elementary School* group on Item 21 and all remaining groups registered slight agreement.

Table 25

ANOVA for Barriers of Adoption by Grade Level (p = .05)

Item #		ES	MS	HS	MSHS	Paired Difference	*p* value
20. Integrative STEM education is not commonly understood by stakeholders.	*N:*	28	29	61	24	ES/MS: .222	ES/MS: .899
	M:	4.43	4.21	4.43	4.63	ES/HS: .002	ES/HS: 1.000
	SD:	1.03	1.15	1.35	1.06	ES/MSHS: .196	ES/MSHS: .936
						MS/HS: .219	MS/HS: .851
						MS/MSHS: .418	MS/ MSHS: .591
						HS/MSHS: .199	HS/MSHS: .903
21. Teachers don't feel empowered to change teaching methods to include integrative STEM.	*N:*	29	30	63	24	ES/MS: .955	ES/MS: *.047
	M:	4.66	3.70	4.24	4.04	ES/HS: .417	ES/HS: .545
	SD:	1.26	1.44	1.38	1.55	ES/MSHS: .614	ES/MSHS: .387
						MS/HS: .538	MS/HS: .309
						MS/MSHS: .342	MS/MSHS: .809
						HS/MSHS: .196	HS/MSHS: .936
22. Lack of support by administrators hinders implementation.	*N:*	30	30	62	21	ES/MS: .667	ES/MS: .385
	M:	4.30	3.63	4.27	4.67	ES/HS: .026	ES/HS: 1.000
	SD:	1.69	1.77	1.53	1.56	ES/MSHS: .367	ES/MSHS: .856
						MS/HS: .641	MS/HS: .287
						MS/MSHS: 1.033	MS/MSHS: .117
						HS/MSHS: .392	HS/MSHS: .772

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

Between group analysis of Grade Level and Resource Barriers construct. Results of *Grade Level* group comparisons within the *Resource Barriers* construct are found in Table 26. A one-way ANOVA test of variance within the construct indicated no significant difference between grade level groups for the following: Item 24 — *Lack of needed resources (funding, equipment, supplies, etc.) causes issues for implementing integrative STEM education*; Item 25 — *Reliance on textbooks and other outdated classroom resources hinder integrative STEM implementation*; and Item 26 — *Inadequate facilities limit STEM implementation*.

All groups registered agreement with Item 24. On Item 25 the *Elementary School* and *Middle School/High School* groups indicated agreement and the *Middle School* and *High School* groups inferred slight agreement with the statement. The *Middle School* group intimated slight agreement and remaining groups indicated agreement with the statement in Item 26.

Table 26

ANOVA for Resource Barriers by Grade Level (p = .05)

Item #		ES	MS	HS	MSHS	Paired Difference	*p* value
24. Lack of needed resources (funding, equipment, supplies, etc.) causes issues for implementing integrative STEM…	*N:* *M:* *SD:*	30 5.33 1.06	30 4.77 1.57	65 5.03 1.32	23 4.91 1.31	ES/MS: .567 ES/HS: .303 ES/MSHS: .420 MS/HS: .264 MS/MSHS: .146 HS/MSHS: .118	ES/MS: .352 ES/HS: .731 ES/MSHS: .664 MS/HS: .804 MS/ MSHS: .979 HS/MSHS: .983
25. Reliance on textbooks and other outdated classroom resources hinder integrative STEM implementation.	*N:* *M:* *SD:*	30 5.00 .98	30 4.20 1.75	64 4.22 1.58	23 4.74 1.32	ES/MS: .800 ES/HS: .781 ES/MSHS: .261 MS/HS: .019 MS/MSHS: .539 HS/MSHS: .520	ES/MS: .159 ES/HS: .084 ES/MSHS: .920 MS/HS: 1.000 MS/MSHS: .554 HS/MSHS: .471
26. Inadequate facilities limit STEM implementation.	*N:* *M:* *SD:*	30 4.67 1.52	30 4.40 1.65	65 4.63 1.49	23 4.57 1.20	ES/MS: .267 ES/HS: .036 ES/MSHS: .101 MS/HS: .231 MS/MSHS: .165 HS/MSHS: .066	ES/MS: .899 ES/HS: 1.000 ES/MSHS: .995 MS/HS: .896 MS/MSHS: .978 HS/MSHS: .998

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

Between group analysis of Grade Level and Professional Development Barriers construct. Results of *Grade Level* group comparisons within the *Professional Development Barriers* construct are found in Table 27. A one-way ANOVA test of variance within the construct indicated significant difference for Item 28, F = (3, 138) = 3.31, p = .022 and Item 31, F = (3, 142) = 3.65, p = .014.

Post hoc Tukey analysis indicated a significant difference (p = .013) between the *Elementary School* ($\bar{x}$ = 4.83) and *Middle School* ($\bar{x}$ = 3.83) groups on Item 28 — *Lack of perceived benefit of professional development for integrative STEM methodology limits implementation.* The result indicated elementary respondents recorded a higher level of agreement than other groups regarding the issue of lack of perceived benefit of professional development.

Table 27

ANOVA for Professional Development Barriers by Grade Level (p = .05)

Item #		ES	MS	HS	MSHS	Paired Difference	*p* value
28. Lack of perceived benefit of professional development for integrative STEM methodology limits implementation.	*N:*	30	29	57	23	ES/MS: 1.006	ES/MS: *.013
	M:	4.83	3.83	4.28	4.13	ES/HS: .553	ES/HS: .211
	SD:	1.02	1.49	1.31	1.06	ES/MSHS: .703	ES/MSHS: .185
						MS/HS: .453	MS/HS: .391
						MS/MSHS: .303	MS/ MSHS: .823
						HS/MSHS: .150	HS/MSHS: .962
29. Funding for professional development is an issue.	*N:*	29	29	61	23	ES/MS: .172	ES/MS: .963
	M:	4.62	4.45	4.61	5.17	ES/HS: .014	ES/HS: 1.000
	SD:	1.27	1.50	1.41	1.11	ES/MSHS: .553	ES/MSHS: .464
						MS/HS: .158	MS/HS: .955
						MS/MSHS: .726	MS/MSHS: .226
						HS/MSHS: .567	HS/MSHS: .323
30. A shortage of teachers trained in integrative STEM education limits implementation.	*N:*	30	30	64	23	ES/MS: .267	ES/MS: .786
	M:	5.10	4.83	4.95	5.30	ES/HS: .147	ES/HS: .932
	SD:	.96	1.12	1.20	.97	ES/MSHS: .204	ES/MSHS: .909
						MS/HS: .120	MS/HS: .961
						MS/MSHS: .471	MS/MSHS: .418
						HS/MSHS: .351	HS/MSHS: .560
31. Limited availability of professional development for in-service teachers is an issue.	*N:*	30	30	62	24	ES/MS: .500	ES/MS: .489
	M:	4.67	4.17	4.35	5.29	ES/HS: .312	ES/HS: .733
	SD:	1.24	1.37	1.53	1.00	ES/MSHS: .625	ES/MSHS: .341
						MS/HS: .188	MS/HS: .925
						MS/MSHS: 1.125	MS/MSHS: *.016
						HS/MSHS: .937	HS/MSHS: *.025
32. Lacking STEM certification at the State level is an issue.	*N:*	27	22	55	20	ES/MS: .675	ES/MS: .423
	M:	4.63	3.95	3.87	4.10	ES/HS: .757	ES/HS: .160
	SD:	1.25	1.46	1.65	1.65	ES/MSHS: .530	ES/MSHS: .648
						MS/HS: .082	MS/HS: .997
						MS/MSHS: .145	MS/MSHS: .990
						HS/MSHS: .227	HS/MSHS: .942

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

Between group analysis of Grade Level and Pre-Service Training Barriers construct. Results of *Grade Level* group comparisons within the *Pre-Service Training Barriers* construct are found in Table 28.

A one-way ANOVA test of variance within the construct indicated no significant difference between grade level groups for the following: Item 34 — *Limited availability of professional development for pre-service teachers is an issue*; Item 35 — *Lack of integrative*

STEM methodology in elementary teacher education programs limits implementation; Item 36 — *Lack of integrative STEM methodology in secondary teacher education programs limits implementation*; and Item 37 — *Integrative STEM education is limited by low numbers of teacher education programs that include technological literacy as part of content and methods courses*.

Table 28

ANOVA for Pre-Service Training Barriers by Grade Level (p = .05)

Item #		ES	MS	HS	MSHS	Paired Difference	*p* value
34. Limited availability of professional development for pre-service teachers is an issue.	*N:*	26	25	52	19	ES/MS: .182	ES/MS: .966
	M:	4.46	4.28	4.29	5.21	ES/HS: .173	ES/HS: .954
	SD:	1.27	1.31	1.55	1.08	ES/MSHS: .749	ES/MSHS: .280
						MS/HS: .008	MS/HS: 1.000
						MS/MSHS: .931	MS/ MSHS: .126
						HS/MSHS: .922	HS/MSHS: .067
35. Lack of integrative STEM methodology in elementary teacher education programs limits implementation.	*N:*	29	25	41	16	ES/MS: .617	ES/MS: .278
	M:	4.90	4.28	4.68	5.31	ES/HS: .214	ES/HS: .896
	SD:	1.01	1.40	1.42	.873	ES/MSHS: .416	ES/MSHS: .711
						MS/HS: .403	MS/HS: .586
						MS/MSHS: 1.032	MS/MSHS: .055
						HS/MSHS: .630	HS/MSHS: .327
36. Lack of integrative STEM methodology in secondary teacher education programs limits implementation.	*N:*	19	24	57	19	ES/MS: .279	ES/MS: .860
	M:	4.74	4.46	4.68	5.37	ES/HS: .053	ES/HS: .998
	SD:	.933	1.25	1.27	.761	ES/MSHS: .632	ES/MSHS: .333
						MS/HS: .226	MS/HS: .851
						MS/MSHS: .910	MS/MSHS: .054
						HS/MSHS: .684	HS/MSHS: .118
37. Integrative STEM education is limited by low numbers of teacher education programs that include technological literacy as part of content and methods courses.	*N:*	23	26	51	19	ES/MS: .007	ES/MS: 1.000
	M:	4.61	4.62	4.98	5.37	ES/HS: .372	ES/HS: .628
	SD:	1.20	1.27	1.39	.597	ES/MSHS: .760	ES/MSHS: .199
						MS/HS: .365	MS/HS: .611
						MS/MSHS: .753	MS/MSHS: .186
						HS/MSHS: .388	HS/MSHS: .647

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

Although no items in the construct passed the test for significance, several group comparisons were near the pre-determined level ($p \leq .05$): Item 34 between *High School* ($\bar{x}$ = 4.29) and *Middle School/High School* ($\bar{x}$ = 5.21) groups (p = .067); Item 35 between *Middle School* ($\bar{x}$ = 4.21) and *Middle School/High School* ($\bar{x}$ = 5.31) groups (p = .055); and Item 36 between *Middle School* ($\bar{x}$ = 4.46) and *Middle School/High School* ($\bar{x}$ = 5.37) groups (p = .054).

Between group analysis of Grade Level and No Child Left Behind Barriers construct. Results of *Grade Level* group comparisons within the *No Child Left Behind Barriers* construct are found in Table 29.

Table 29

ANOVA for No Child Left Behind Barriers by Grade Level (p = .05)

Item #		ES	MS	HS	MSHS	Paired Difference	*p* value
39. Current standardized assessments are limited in measurement of mastery in project and problem-based learning.	*N:*	29	29	58	21	ES/MS: .241	ES/MS: .853
	M:	4.90	5.14	4.84	5.33	ES/HS: .052	ES/HS: .997
	SD:	1.21	1.06	1.27	.73	ES/MSHS: .437	ES/MSHS: .545
						MS//HS: .293	MS/HS: .675
						MS/MSHS: .195	MS/ MSHS: .933
						HS/MSHS: .489	HS/MSHS: .341
40. Assessment innovation is limited by Adequate Yearly Progress (AYP) indicator required by NCLB.	*N:*	27	26	47	22	ES/MS: .684	ES/MS: .102
	M:	5.22	4.54	5.13	5.05	ES/HS: .095	ES/HS: .984
	SD:	.85	1.36	1.08	.95	ES/MSHS: .177	ES/MSHS: .941
						MS/HS: .589	MS/HS: .120
						MS/MSHS: .507	MS/MSHS: .370
						HS/MSHS: .082	HS/MSHS: .991
41. The requirements of NCLB limit time available for integrative STEM education.	*N:*	28	23	51	22	ES/MS: .123	ES/MS: .985
	M:	4.96	5.09	4.92	5.00	ES/HS: .043	ES/HS: .999
	SD:	1.35	.85	1.32	1.23	ES/MSHS: .036	ES/MSHS: 1.000
						MS/HS: .165	MS/HS: .951
						MS/MSHS: .087	MS/MSHS: .995
						HS/MSHS: .078	HS/MSHS: .995

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

A one-way ANOVA test of variance within the construct indicated no significant difference between grade level groups for the following: Item 39 — *Current standardized assessments are limited in measurement of mastery in project and problem-based learning*; Item 40 — *Assessment innovation is limited by Adequate Yearly Progress (AYP) indicator required by NCLB*; and Item 41 — *The requirements of NCLB limit time available for integrative STEM education.* There were similar levels of agreement between all groups on Items 39, 40, and 41 in the construct with means ranging from 4.54 to 5.33. The results indicated a similar level of agreement regarding perception of *NCLB* impacting implementation as a contributing factor across all *Grade Level* groups.

Between group analysis of Grade Level and Technology and Engineering Standards Barriers construct. Results of *Grade Level* group comparisons within the *Technology and Engineering Barriers* construct are found in Table 30.

A one-way ANOVA test of variance within the construct indicated no significant difference between grade level groups for the following: Item 43 — *Lack of required K-12 technology and engineering standards limits integrative STEM implementation*; Item 44 — *Lack of required K-12 technology and engineering standards limits professional development in integrative STEM curriculum*; and Item 45 — *Lack of required K-12 technology and engineering standards limits student assessment in integrative STEM curriculum.*

Table 30

ANOVA for Technology and Engineering Standards Barriers by Grade Level (p = .05)

Item #		ES	MS	HS	MSHS	Paired Difference	*p* value
43. Lack of required K-12 technology and engineering standards limits integrative STEM implementation	*N:* *M:* *SD:*	29 4.62 1.27	27 3.93 1.52	61 4.25 1.59	22 4.55 1.54	ES/MS: .695 ES/HS: .375 ES/MSHS: .075 MS/HS: .320 MS/MSHS: .620 HS/MSHS: .300	ES/MS: .314 ES/HS: .687 ES/MSHS: .998 MS/HS: .794 MS/ MSHS: .480 HS/MSHS: .854
44. Lack of required K-12 technology and engineering standards limits professional development in integrative STEM curriculum.	*N:* *M:* *SD:*	29 4.76 1.19	27 4.07 1.30	61 4.07 1.60	22 4.55 1.65	ES/MS: .685 ES/HS: .693 ES/MSHS: .213 MS/HS: .009 MS/MSHS: .471 HS/MSHS: .480	ES/MS: .310 ES/HS: .165 ES/MSHS: .956 MS/HS: 1.000 MS/MSHS: .683 HS/MSHS: .560
45. Lack of required K-12 technology and engineering standards limits student assessment in integrative STEM curriculum.	*N:* *M:* *SD:*	28 4.68 1.25	27 4.26 1.26	60 4.23 1.52	23 4.91 1.35	ES/MS: .419 ES/HS: .445 ES/MSHS: .234 MS/HS: .026 MS/MSHS: .654 HS/MSHS: .680	ES/MS: .680 ES/HS: .503 ES/MSHS: .932 MS/HS: 1.000 MS/MSHS: .352 HS/MSHS: .197

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

Between group analysis of Grade Level and Barriers of Male-Oriented Content construct. Results of *Grade Level* group comparisons within the *Barriers of Male-Oriented Content* construct are found in Table 31. A one-way ANOVA test of variance within the construct indicated no significant difference between grade level groups for the following: Item 47 — *The perception of STEM as a male-oriented curriculum limits its significance* and Item 48 — *The perception of STEM as a male-oriented curriculum limits implementation*.

The comparison of mean scores between all groups within the *Barriers of Male-Oriented Content* construct indicated slight disagreement with statements. Item 47 means ranged from 3.12 to 3.40, and Item 48 means ranged from 2.82 to 3.36 with ranges indicating slight disagreement with statements. Low mean scores indicated participants did not perceive gender barriers due to a male-oriented curriculum to be an issue.

Table 31

ANOVA for Barriers of Male-Oriented Content by Grade Level Groups (p = .05)

Item #		ES	MS	HS	MSHS	Paired Difference	*p* value
47. The perception of STEM as a male-oriented curriculum limits its significance.	*N:*	26	28	60	23	ES/MS: .027	ES/MS: 1.000
	M:	3.12	3.14	3.40	3.26	ES/HS: .285	ES/HS: .846
	SD:	1.48	1.53	1.45	1.51	ES/MSHS: .145	ES/MSHS: .986
						MS/HS: .257	MS/HS: .873
						MS/MSHS: .118	MS/ MSHS: .992
						HS/MSHS: .139	HS/MSHS: .981
48. The perception of STEM as a male-oriented curriculum limits implementation.	*N:*	26	28	61	22	ES/MS: .294	ES/MS: .887
	M:	3.12	2.82	3.36	3.27	ES/HS: .245	ES/HS: .896
	SD:	1.45	1.47	1.52	1.49	ES/MSHS: .157	ES/MSHS: .983
						MS/HS: .539	MS/HS: .390
						MS/MSHS: .451	MS/MSHS: .712
						HS/MSHS: .088	HS/MSHS: .995

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

Between group analysis of Grade Level and Barriers of a Narrow View construct. Results of *Grade Level* group comparisons within the *Barriers of a Narrow View* construct are found in Table 32. A one-way ANOVA test of variance within the construct indicated no significant difference between grade level groups for all items within the construct: Item 50 — *Policy makers and leaders fail to recognize the equal importance of the full spectrum of integrative STEM education*; Item 51 — *For many educators, STEM education consists only of science and mathematics*; Item 52 — *For many stakeholders, STEM education consists only of science and mathematics*; Item 53 — *For many educators computer literacy requirements serve as a barrier to integrative STEM implementation*; Item 54 — *Current education practices delivering separate and "siloed" instruction, limits implementation of integrative STEM*; Item 55 — *The perception that technology and engineering education teachers cannot teach science or mathematics content is a barrier to implementation of integrative STEM education*; Item 56 —

Science educators see no need to change methodology to include technology and engineering; Item 57 — *Mathematics educators see no need to change methodology to include technology and engineering*; and Item 58 — *The perception that inclusion of technology and engineering limits time for learning mathematics and science, limits implementation of integrative STEM curriculum*.

Table 32

ANOVA for Barriers of a Narrow View by Grade Level (p = .05)

Item #		ES	MS	HS	MSHS	Paired Difference	*p* value
50. Policy makers and leaders fail to recognize the equal importance of the full spectrum of integrative STEM education.	*N:*	28	24	55	22	ES/MS: .619	ES/MS: .292
	M:	5.04	4.42	4.71	4.95	ES/HS: .327	ES/HS: .678
	SD:	.999	1.53	1.33	.999	ES/MSHS: .081	ES/MSHS: .996
						MS/HS: .292	MS/HS: .777
						MS/MSHS: .538	MS/ MSHS: .470
						HS/MSHS: .245	HS/MSHS: .866
51. For many educators, STEM education consists only of science and mathematics.	*N:*	28	28	58	22	ES/MS: .321	ES/MS: .803
	M:	4.68	4.36	4.88	5.18	ES/HS: .201	ES/HS: .914
	SD:	1.12	1.47	1.44	1.05	ES/MSHS: .503	ES/MSHS: .548
						MS/HS: .522	MS/HS: .326
						MS/MSHS: .825	MS/MSHS: .136
						HS/MSHS: .303	HS/MSHS: .801
52. For many stakeholders, STEM education consists only of science and mathematics.	*N:*	26	25	54	21	ES/MS: .368	ES/MS: .742
	M:	4.81	4.44	4.89	5.19	ES/HS: .081	ES/HS: .994
	SD:	1.20	1.29	1.41	1.08	ES/MSHS: .383	ES/MSHS: .746
						MS/HS: .449	MS/HS: .482
						MS/MSHS: .750	MS/MSHS: .210
						HS/MSHS: .302	HS/MSHS: .802
53. For many educators computer literacy requirements serve as a barrier to integrative STEM implementation.	*N:*	29	27	59	23	ES/MS: .300	ES/MS: .868
	M:	4.45	4.15	3.86	3.61	ES/HS: .584	ES/HS: .295
	SD:	1.40	1.20	1.59	1.44	ES/MSHS: .840	ES/MSHS: .171
						MS/HS: .284	MS/HS: .837
						MS/MSHS: .539	MS/ MSHS: .562
						HS/MSHS: .256	HS/MSHS: .892
54. Current education practices delivering separate and “siloed” instruction, limits implementation of integrative STEM.	*N:*	25	27	54	22	ES/MS: .136	ES/MS: .983
	M:	4.84	4.70	4.76	4.82	ES/HS: .081	ES/HS: .995
	SD:	1.41	1.30	1.27	1.50	ES/MSHS: .022	ES/MSHS: 1.000
						MS/HS: .056	MS/HS: .998
						MS/MSHS: .114	MS/MSHS: .991
						HS/MSHS: .059	HS/MSHS: .998

(continued)

Table 32

ANOVA for Barriers of a Narrow View by Grade Level (p = .05) (continued)

Item #		ES	MS	HS	MSHS	Paired Difference	*p* value
55. The perception that technology and engineering education teachers cannot teach science or mathematics content is a barrier to implementation.	*N:*	26	27	54	22	ES/MS: .084	ES/MS: .996
	M:	4.27	4.19	4.48	4.50	ES/HS: .212	ES/HS: .920
	SD:	1.40	1.33	1.44	1.37	ES/MSHS: .231	ES/MSHS: .941
						MS/HS: .296	MS/HS: .805
						MS/MSHS: .315	MS/MSHS: .861
						HS/MSHS: .019	HS/MSHS: 1.000
56. Science educators see no need to change methodology to include technology and engineering.	*N:*	24	27	58	21	ES/MS: .421	ES/MS: .765
	M:	3.79	3.37	3.95	4.14	ES/HS: .157	ES/HS: .975
	SD:	1.59	1.57	1.63	1.15	ES/MSHS: .351	ES/MSHS: .871
						MS/HS: .578	MS/HS: .378
						MS/MSHS: .772	MS/MSHS: .317
						HS/MSHS: .195	HS/MSHS: .960
57. Mathematics educators see no need to change methodology to include technology and engineering.	*N:*	24	25	55	21	ES/MS: .477	ES/MS: .698
	M:	3.92	3.44	4.16	4.48	ES/HS: .247	ES/HS: .913
	SD:	1.47	1.83	1.49	1.33	ES/MSHS: .560	ES/MSHS: .615
						MS/HS: .724	MS/HS: .211
						MS/MSHS: 1.036	MS/MSHS: .108
						HS/MSHS: .313	HS/MSHS: .857
58. The perception that inclusion of technology and engineering limits time for learning mathematics and science, limits implementation of integrative STEM curriculum.	*N:*	27	25	57	20	ES/MS: .157	ES/MS: .978
	M:	3.96	4.12	4.63	4.65	ES/HS: .669	ES/HS: .184
	SD:	1.68	1.30	1.42	1.09	ES/MSHS: .687	ES/MSHS: .355
						MS/HS: .512	MS/HS: .435
						MS/MSHS: .530	MS/MSHS: .596
						HS/MSHS: .018	HS/MSHS: 1.000

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

Items 50, 51 and 52 yielded similar agreement. The *Middle School* group indicated slight agreement and all other grade level groups registered agreement. All groups had similar agreement levels on Items 53 and 54. Slight agreement was registered in Item 53 and agreement was indicated on Item 54. The *Middle School/High School* group agreed with Item 55 and remaining groups indicated slight agreement. The *Middle School* group indicated slight disagreement on Items 56 and 57 and remaining groups indicated slight agreement. The

Elementary School and *Middle School* groups registered slight agreement with Item 58 and the *High School* and *Middle School/High School* groups agreed.

Between group analysis of Grade Level and Barriers of Perception construct. Results of *Grade Level* group comparisons within the *Barriers of Perception* construct are found in Table 33.

Table 33

ANOVA for Barriers of Perception by Grade Level (p = .05)

Item #		ES	MS	HS	MSHS	Paired Difference	*p* value
60. STEM is perceived by educators as a "fad" that will soon go away.	*N:*	26	27	53	21	ES/MS: .256	ES/MS: .927
	M:	3.92	3.67	3.83	3.67	ES/HS: .093	ES/HS: .994
	SD:	1.50	1.44	1.54	1.56	ES/MSHS: .256	ES/MSHS: .939
						MS/HS: .164	MS/HS: .968
						MS/MSHS: .000	MS/ MSHS: 1.000
						HS/MSHS: .164	HS/MSHS: .975
61.Negative perception of open-ended inquiry learning limits implementation of integrative STEM education.	*N:*	27	28	55	22	ES/MS: .147	ES/MS: .980
	M:	4.11	3.96	3.78	4.09	ES/HS: .329	ES/HS: .754
	SD:	1.42	1.40	1.41	1.41	ES/MSHS: .020	ES/MSHS: 1.000
						MS/HS: .182	MS/HS: .944
						MS/MSHS: .127	MS/MSHS: .989
						HS/MSHS: .309	HS/MSHS: .821
62. There is a negative perception that integrative STEM education diminishes the individual importance of each content area.	*N:*	24	26	50	21	ES/MS: .048	ES/MS: .999
	M:	3.63	3.58	3.46	3.67	ES/HS: .165	ES/HS: .966
	SD:	1.53	1.42	1.37	1.43	ES/MSHS: .042	ES/MSHS: 1.000
						MS/HS: .117	MS/HS: .986
						MS/MSHS: .090	MS/MSHS: .996
						HS/MSHS: .207	HS/MSHS: .944
63. A perception that mathematics is not a significant part of science education is an issue.	*N:*	29	28	57	22	ES/MS: .410	ES/MS: .731
	M:	3.52	3.11	3.04	3.64	ES/HS: .482	ES/HS: .496
	SD:	1.43	1.45	1.51	1.62	ES/MSHS: .119	ES/MSHS: .992
						MS/HS: .072	MS/HS: .997
						MS/MSHS: .529	MS/MSHS: .604
						HS/MSHS: .601	HS/MSHS: .384
64. A perception that integrative STEM education addresses only workforce issues limits implementation.	*N:*	25	24	55	21	ES/MS: .033	ES/MS: 1.000
	M:	3.80	3.83	3.51	3.71	ES/HS: .291	ES/HS: .832
	SD:	1.29	1.37	1.48	1.49	ES/MSHS: .086	ES/MSHS: .997
						MS/HS: .324	MS/HS: .788
						MS/MSHS: .119	MS/MSHS: .992
						HS/MSHS: .205	HS/MSHS: .943

Note. Grade Level Reported: ES=Elementary School, MS=Middle School, HS=High School, MSHS=Middle/High School.

A one-way ANOVA test of variance within the construct indicated no significant difference between grade level groups for all items within the construct: Item 60 — *STEM is perceived by educators as another "fad" that will soon go away*; Item 61 — *Negative perception of open-ended inquiry learning limits implementation of integrative STEM education*; Item 62 — *There is a negative perception that integrative STEM education diminishes the individual importance of each content area*; Item 63 — *A perception that mathematics is not a significant part of science education is an issue*; and Item 64 — *A perception that integrative STEM education addresses only workforce issues limits implementation*.

All groups on Items 60, 61, and 64 indicated slight agreement. Slight disagreement on Item 62 was inferred by the *High School* group, with remaining groups indicating slight agreement with the statement. Two groups, *Middle School* and *High School,* mean scores resulted in a level of slight disagreement while the *Elementary School* and *Middle School/High School* groups indicated slight agreement on Item 63.

Between group analysis of Grade Level and Barriers of Regulation Construct. Results of *Grade Level* group comparisons within the *Barriers of Regulation* construct are found in Table 34.

A one-way ANOVA test of variance between all items in the construct indicated no significant difference between grade level groups for all items within the construct: Item 66 — *State and federal regulatory boundaries are rigid and constrain local educational reform*; Item 67— *There is currently a lack of incentives to motivate key outcomes for improving educational quality*; and Item 68 — *Class-periods and seat-time requirements constrain the use of integrative STEM methodologies.* The *Elementary School* and *High School* groups mean scores indicated agreement and the *Middle School* and *Middle School/High School* groups slightly agreed with Items 66 and 68. All group means suggested agreement with the statement in Item 67.

Table 34

ANOVA for Barriers of Regulation by Grade Level (p = .05)

Item #		ES	MS	HS	MSHS	Paired Difference	*p* value
66. State and federal regulatory boundaries are rigid and constrain local educational reform.	*N:*	26	23	48	21	ES/MS: .142	ES/MS: .987
	M:	4.58	4.43	4.50	4.33	ES/HS: .077	ES/HS: .996
	SD:	1.33	1.34	1.47	1.74	ES/MSHS: .244	ES/MSHS: .942
						MS/HS: .065	MS/HS: .998
						MS/MSHS: .101	MS/ MSHS: .996
						HS/MSHS: .167	HS/MSHS: .973
67. There is currently a lack of incentives to motivate key outcomes for improving educational quality.	*N:*	27	22	57	21	ES/MS: .278	ES/MS: .900
	M:	4.78	4.50	4.58	4.62	ES/HS: .199	ES/HS: .929
	SD:	1.16	1.34	1.46	1.56	ES/MSHS: .159	ES/MSHS: .980
						MS/HS: .079	MS/HS: .996
						MS/MSHS: .119	MS/MSHS: .992
						HS/MSHS: .040	HS/MSHS: .999
68. Class-periods and seat-time requirements constrain the use of integrative STEM methodologies.	*N:*	29	27	59	22	ES/MS: .822	ES/MS: .175
	M:	4.90	4.07	4.54	4.09	ES/HS: .354	ES/HS: .725
	SD:	1.35	1.47	1.56	1.57	ES/MSHS: .806	ES/MSHS: .233
						MS/HS: .468	MS/HS: .537
						MS/MSHS: .017	MS/MSHS: 1.000
						HS/MSHS: .451	HS/MSHS: .625

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

Between group analysis of Content Area and Barriers Regarding Efficacy construct. Results of *Content Area* group comparisons within the *Barriers Regarding Efficacy* construct are found in Table 35. A one-way ANOVA test of variance within the construct and post hoc Tukey analysis indicated no significant difference between groups.

Item 8 — *Teachers are uncomfortable with implementing technology content and concepts* had the within construct lowest mean ($\bar{x}$ = 3.74) across all groups.

Table 35

ANOVA for Barriers Regarding Efficacy by Content Area (p = .05)

Item #		S	TE	M	E	NS	Paired Difference	*p* value
8. Teachers are uncomfortable with implementing technology content and concepts.	*N:*	29	45	12	16	47	S/TE: .501	S/TE: .523
	M:	4.03	3.53	3.83	4.13	3.62	S/M: .201	S/M: .992
	SD:	1.21	1.44	1.19	1.31	1.38	S/E: .091	S/E: 1.000
							S/NS: .417	S/NS: .683
							TE/M: .300	TE/M: .959
							TE/E: .592	TE/E: .557
							TE/NS: .084	TE/NS: .998
							M/E: .292	M/E: .980
							M/NS: .216	M/NS: .988
							E/NS: .508	E/NS: .689
9. Teachers are uncomfortable with their ability to deliver engineering content and concepts.	*N:*	28	46	12	16	46	S/TE: .019	S/TE: 1.000
	M:	4.21	4.20	4.17	4.56	4.28	S/M: .048	S/M: 1.000
	SD:	1.50	1.41	.84	.96	1.44	S/E: .348	S/E: .925
							S/NS: .068	S/NS: 1.000
							TE/M: .029	TE/M: 1.000
							TE/E: .367	TE/E: .885
							TE/NS: .087	TE/NS: .998
							M/E: .396	M/E: .941
							M/NS: .116	M/NS: .999
							E/NS: .280	E/NS: .954
10. Access to professional development regarding integrative STEM education is limited.	*N:*	30	47	12	16	48	S/TE: .450	S/TE: .673
	M:	3.93	4.38	4.58	4.25	3.94	S/M: .650	S/M: .682
	SD:	1.31	1.51	1.17	1.53	1.49	S/E: .317	S/E: .955
							S/NS: .004	S/NS: 1.000
							TE/M: .200	TE/M: .993
							TE/E: .133	TE/E: .998
							TE/NS: .445	TE/NS: .564
							M/E: .333	M/E: .974
							M/NS: .646	M/NS: .639
							E/NS: .313	E/NS: .945
11. Without training in integrative STEM methodology it is difficult to understand the goals and concepts.	*N:*	30	47	12	16	48	S/TE: .062	S/TE: 1.000
	M:	4.70	4.64	4.58	4.94	4.88	S/M: .117	S/M: .999
	SD:	1.21	1.42	1.24	1.24	1.32	S/E: .237	S/E: .977
							S/NS: .175	S/NS: .979
							TE/M: .055	TE/M: 1.000
							TE/E: .299	TE/E: .934
							TE/NS: .237	TE/NS: .905
							M/E: .354	M/E: .955
							M/NS: .292	M/NS: .959
							E/NS: .063	E/NS: 1.000

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported*,* NS=*Non-STEM* content background.

The *Elementary* group had agreement with Item 9 — *Teachers are uncomfortable with their ability to deliver engineering content and concepts* and the *Science, Technology and Engineering, Mathematics,* and *Non-STEM* groups indicated slight agreement.

Item 10 — *Access to professional development regarding integrative STEM education is limited* had the *Mathematics* group indicating agreement. All other content area groups registered slight agreement with the statement.

Item 11 — *Without training in integrative STEM methodology it is difficult to understand the goals and concepts* had all groups indicating agreement with the statement.

Between group analysis of Content Area and Barriers of Integrative STEM Buy-In construct. Results of *Content Area* group comparisons within the *Barriers of Integrative STEM Buy-In* construct are found in Table 36. A one-way ANOVA test of variance within the construct and post hoc Tukey analysis indicated no significant difference between groups. Mean scores within the construct ranged from 3.20 (*Slightly Disagree*) to 5.36 (*Agree*).

Item 13 — *Buy-in of stakeholders regarding preparing students for careers in engineering is an issue* had the *Elementary* group indicating a level of slight disagreement ($\bar{x} = 3.38$), while all other groups indicated a level of slight agreement with the statement with means ranging from 3.90 to 4.11.

Item 14 — *Buy-in of teachers regarding preparing students for careers in engineering is an issue* resulted in all groups indicating a level of slight agreement with the statement ranging from *Non-STEM* ($\bar{x} = 3.65$) to *Middle School* ($\bar{x} = 4.36$).

Item 15 — *Implementation of integrative STEM education is negatively affected by lack of stakeholder involvement* indicated agreement with the statement by the *Mathematics* group with all other groups indicating slight agreement.

Table 36

ANOVA for Barriers of Integrative STEM Buy-In by Content Area (p = .05)

Item #		S	TE	M	E	NS	Paired Difference	*p* value
13. Buy-in of stakeholders regarding preparing students for careers in engineering in an issue.	*N:*	28	42	10	13	45	S/TE: .107	S/TE: .998
	M:	4.11	4.00	3.90	3.38	4.11	S/M: .207	S/M: .995
	SD:	1.26	1.45	1.45	1.56	1.50	S/E: .723	S/E: .566
							S/NS: .004	S/NS: 1.000
							TE/M: .100	TE/M: 1.000
							TE/E: .615	TE/E: .662
							TE/NS: .111	TE/NS: .996
							M/E: .515	M/E: .914
							M/NS: .211	M/NS: .993
							E/NS: .726	E/NS: .497
14. Buy-in of teachers regarding preparing students for careers in engineering is an issue.	*N:*	28	44	11	13	46	S/TE: .091	S/TE: .999
	M:	4.00	3.91	4.36	3.85	3.65	S/M: .364	S/M: .955
	SD:	1.54	1.36	1.43	1.52	1.46	S/E: .154	S/E: .998
							S/NS: .348	S/NS: .855
							TE/M: .455	TE/M: .885
							TE/E: .063	TE/E: 1.000
							TE/NS: .257	TE/NS: .918
							M/E: .517	M/E: .907
							M/NS: .711	M/NS: .589
							E/NS: .194	E/NS: .993
15. Implementation of integrative STEM education is negatively affected by lack of stakeholder involvement.	*N:*	26	43	9	15	46	S/TE: .068	S/TE: 1.000
	M:	4.23	4.16	4.56	3.67	3.91	S/M: .325	S/M: .977
	SD:	1.24	1.45	.88	1.40	1.62	S/E: .564	S/E: .746
							S/NS: .318	S/NS: .897
							TE/M: .393	TE/M: .946
							TE/E: .496	TE/E: .780
							TE/NS: .250	TE/NS: .925
							M/E: .889	M/E: .587
							M/NS: .643	M/NS: .737
							E/NS: .246	E/NS: .978
16. Non-supportive teachers hinder implementation of integrative STEM education.	*N:*	27	44	11	16	46	S/TE: .061	S/TE: 1.000
	M:	4.67	4.73	5.18	4.75	4.24	S/M: .515	S/M: .826
	SD:	1.14	1.35	.75	1.24	1.59	S/E: .083	S/E: 1.000
							S/NS: .428	S/NS: .692
							TE/M: .455	TE/M: .858
							TE/E: .023	TE/E: 1.000
							TE/NS: .488	TE/NS: .433
							M/E: .432	M/E: .926
							M/NS: .943	M/NS: .239
							E/NS: .511	E/NS: .693

(continued)

Table 36

ANOVA for Barriers of Integrative STEM Buy-In Construct by Content Area. (continued)

Item #		S	TE	M	E	NS	Paired Difference	*p* value
17. Without collaboration of educators and stakeholders, implementation is limited.	*N:*	29	44	11	16	46	S/TE: .230	S/TE: .895
	M:	4.79	5.02	5.36	4.88	5.07	S/M: .571	S/M: .553
	SD:	1.15	1.02	.67	1.025	1.12	S/E: .082	S/E: .999
							S/NS: .272	S/NS: .816
							TE/M: .341	TE/M: .875
							TE/E: .148	TE/E: .989
							TE/NS: .042	TE/NS: 1.000
							M/E: .489	M/E: .765
							M/NS: .298	M/NS: .918
							E/NS: .190	E/NS: .972
18. The perception that integrative STEM education does little to improve student outcomes is a barrier.	*N:*	29	41	10	15	44	S/TE: .342	S/TE: .886
	M:	3.41	3.76	4.00	3.20	4.09	S/M: .586	S/M: .832
	SD:	1.35	1.55	1.25	1.66	1.61	S/E: .214	S/E: .992
							S/NS: .677	S/NS: .344
							TE/M: .244	TE/M: .991
							TE/E: .556	TE/E: .745
							TE/NS: .335	TE/NS: .849
							M/E: .800	M/E: .700
							M/NS: .091	M/NS: 1.000
							E/NS: .891	E/NS: .293

Note. Content Area Reported: S=Science, TE=Technology and Engineering, M=Mathematics, E= Elementary specialization/generalist reported, NS=Non-STEM content background.

Item 16 — *Non-supportive teachers hinder implementation of integrative STEM education* had the lowest group mean ($\bar{x} = 4.24$) indicating slight agreement with the statement. All other *Content Area* groups implied agreement with the statement.

All groups agreed with Item 17 — *Without collaboration of educators and stakeholders, implementation is limited.*

Respondents indicating *Science* and *Elementary* as content areas indicated slight disagreement with Item 18 — *The perception that integrative STEM education does little to improve student outcomes is a barrier.* The *Technology and Engineering, Mathematics* and *Non-STEM* content areas implied slight agreement.

Between group analysis of Content Area and Barriers of Adoption construct. Results of *Content Area* group comparisons within the *Barriers Adoption* construct are found in Table 37.

A one-way ANOVA test of variance within the construct and post hoc Tukey analysis indicated significant difference for Item 22, *F* = (4, 138) = 2.74, *p* = .031. Mean scores within the construct ranged from 3.53 (near statistically neutral) to 4.73 (*Agree*).

Table 37

ANOVA for Barriers of Adoption by Content Area (p = .05)

Item #		S	TE	M	E	NS	Paired Difference	*p* value
20. Integrative STEM education is not commonly understood by stakeholders.	*N:*	29	44	11	14	44	S/TE: .075	S/TE: .999
	M:	4.62	4.55	4.55	4.00	4.25	S/M: .075	S/M: 1.000
	SD:	1.08	1.11	1.04	1.24	1.37	S/E: .621	S/E: .505
							S/NS: .371	S/NS: .696
							TE/M: .000	TE/M: 1.000
							TE/E: .545	TE/E: .575
							TE/NS: .295	TE/NS: .776
							M/E: .545	M/E: .791
							M/NS: .295	M/NS: .949
							E/NS: .250	E/NS: .960
21. Teachers don't feel empowered to change teaching methods to include integrative STEM.	*N:*	30	45	11	15	45	S/TE: .033	S/TE: 1.000
	M:	4.30	4.33	4.36	4.07	3.93	S/M: .064	S/M: 1.000
	SD:	1.32	1.45	1.29	1.58	1.45	S/E: .233	S/E: .985
							S/NS: .367	S/NS: .811
							TE/M: .030	TE/M: 1.000
							TE/E: .267	TE/E: .970
							TE/NS: .400	TE/NS: .672
							M/E: .297	M/E: .985
							M/NS: .430	M/NS: .897
							E/NS: .133	E/NS: .998
22. Lack of support by administrators hinders implementation.	*N:*	29	44	11	15	44	S/TE: .348	S/TE: .892
	M:	4.38	4.73	4.27	3.53	3.77	S/M: .107	S/M: 1.000
	SD:	1.64	1.35	1.56	2.03	1.64	S/E: .846	S/E: .457
							S/NS: .607	S/NS: .507
							TE/M: .455	TE/M: .916
							TE/E: 1.194	TE/E: .096
							TE/NS: .955	TE/NS: *.045
							M/E: .739	M/E: .770
							M/NS: .500	M/NS: .885
							E/NS: .239	E/NS: .987

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported, NS=*Non-STEM* content background.

No significant differences were found between groups in Item 20 — *Integrative STEM education is not commonly understood by stakeholders.* The *Science, Technology and Engineering,* and *Mathematics* groups indicated agreement with the statement and the *Elementary* and *Non-STEM* groups indicated slight agreement.

Item 21 — *Teachers don't feel empowered to change teaching methods to include integrative STEM* realized no significance between groups in the construct. All groups in the construct indicated slight agreement with the statement.

A significant difference (p = .045) was indicated on Item 22 — *Lack of support by administrators hinders implementation* between the *Technology/Engineering* ($\bar{x}$ = 4.73) and *No STEM* ($\bar{x}$ = 3.77) groups indicating the *No STEM* group reported a slight agreement while the *Technology* and *Engineering* group indicated agreement with the statement.

Between group analysis of Content Area and Resource Barriers construct. Results of *Content Area* group comparisons within the *Resource Barriers* construct are found in Table 38. A one-way ANOVA test of variance within the construct and post hoc Tukey analysis indicated no significant difference between groups.

Mean scores within the construct ranged from 4.25 (*Slightly Agree*) to 5.36 (*Agree*). Item 24 — All grade level groups indicated agreement with the statement *Lack of needed resources (funding, equipment, supplies, etc.) causes issues for implementing integrative STEM education.* The high average means across all groups indicated perception of lack of resources as a significant issue regarding implementation.

Item 25 — Agreement levels varied by group with the *Technology and Engineering, Elementary, and Non-STEM* groups implying slight agreement with the statement and the *Science* and *Mathematics* groups indicating agreement.

The *Science, Technology and Engineering,* and *Mathematics* groups agreed with Item 26 — *Inadequate facilities limit STEM implementation.* The *Elementary* and *Non-STEM* groups had slight agreement with the statement.

Table 38

ANOVA for Resource Barriers by Content Area (p = .05)

Item #		S	TE	M	E	NS	Paired Difference	*p* value
24. Lack of needed resources (funding, equipment, supplies, etc.) causes issues for implementing integrative STEM education.	*N:*	30	45	11	16	46	S/TE: .167	S/TE: .984
	M:	5.17	5.00	5.36	4.63	5.00	S/M: .197	S/M: .993
	SD:	1.23	1.38	.92	1.36	1.41	S/E: .542	S/E: .684
							S/NS: .167	S/NS: .984
							TE/M: .364	TE/M: .927
							TE/E: .375	TE/E: .870
							TE/NS: .000	TE/NS: 1.000
							M/E: .739	M/E: .620
							M/NS: .364	M/NS: .927
							E/NS: .375	E/NS: .869
25. Reliance on textbooks and other outdated classroom resources hinder integrative STEM implementation.	*N:*	30	44	11	16	46	S/TE: .348	S/TE: .867
	M:	4.67	4.32	4.73	4.44	4.39	S/M: .061	S/M: 1.000
	SD:	1.47	1.51	1.35	1.15	1.68	S/E: .229	S/E: .988
							S/NS: .275	S/NS: .937
							TE/M: .409	TE/M: .930
							TE/E: .119	TE/E: .999
							TE/NS: .073	TE/NS: .999
							M/E: .290	M/E: .988
							M/NS: .336	M/NS: .964
							E/NS: .046	E/NS: 1.000
26. Inadequate facilities limit STEM implementation.	*N:*	30	45	11	16	46	S/TE: .067	S/TE: 1.000
	M:	4.73	4.80	4.55	4.25	4.39	S/M: .188	S/M: .996
	SD:	1.36	1.42	1.70	1.48	1.56	S/E: .483	S/E: .830
							S/NS: .342	S/NS: .862
							TE/M: .255	TE/M: .986
							TE/E: .550	TE/E: .707
							TE/NS: .409	TE/NS: .682
							M/E: .295	M/E: .986
							M/NS: .154	M/NS: .998
							E/NS: .141	E/NS: .997

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported*,* NS=*Non-STEM* content background.

Between group analysis of Content Area and Professional Development Barriers construct. Results of *Content Area* group comparisons within the *Professional Development Barriers* construct are found in Table 39.

A one-way ANOVA test of variance within the construct and post hoc Tukey analysis indicated no significant difference between groups. Mean scores within the construct ranged from 4.00 (*Slightly Agree*) to 5.20 (*Agree*).

Slight agreement was indicated by all content area groups on Item 28 — *Lack of perceived benefit of professional development for integrative STEM methodology limits implementation.* Item 29 — *Funding for professional development is an issue* had slight agreement from the *Science* and *Elementary* content areas while agreement was indicated by the *Technology and Engineering, Mathematics, and Non-STEM* groups.

All content areas agreed with Item 30 — A shortage of teachers trained in integrative STEM education limits implementation. Item 31 — Limited availability of professional development for in-service teachers is an issue was agreed to by the Science, Technology and Engineering, and Elementary groups, while the Mathematics and Non-STEM groups registered slight agreement with the statement. Item 32 — Lacking STEM certification at the State level is an issue was agreed to by the Elementary group and the Science, Technology and Engineering, Mathematics, and Non-STEM groups registering slight agreement.

Table 39

ANOVA for Professional Development Barriers by Content Area ($p = .05$)

Item #		S	TE	M	E	NS	Paired Difference	*p* value
28. Lack of perceived	*N:*	28	42	10	15	44	S/TE: .345	S/TE: .809
benefit of professional	*M:*	4.04	4.38	4.40	4.00	4.41	S/M: .364	S/M: .940
development for	*SD:*	1.48	1.01	1.08	1.60	1.34	S/E: .036	S/E: 1.000
integrative STEM							S/NS: .373	S/NS: .754
methodology limits							TE/M: .019	TE/M: 1.000
implementation.							TE/E: .381	TE/E: .864
							TE/NS: .028	TE/NS: 1.000
							M/E: .400	M/E: .942
							M/NS: .009	M/NS: 1.000
							E/NS: .409	E/NS: .827

(Continued)

Table 39

ANOVA for Professional Development Barriers by Content Area ($p = .05$ (continued)

Item #		S	TE	M	E	NS	Paired Difference	*p* value
29. Funding for professional development is an issue.	*N:*	30	44	9	15	44	S/TE: .567	S/TE: .398
	M:	4.43	5.00	4.67	4.20	4.66	S/M: .233	S/M: .991
	SD:	1.41	1.20	1.58	1.32	1.43	S/E: .233	S/E: .982
							S/NS: .226	S/NS: .955
							TE/M: .333	TE/M: .962
							TE/E: .800	TE/E: .284
							TE/NS: .341	TE/NS: .763
							M/E: .467	M/E: .925
							M/NS: .008	M/NS: 1.000
							E/NS: .459	E/NS: .789
30. A shortage of teachers trained in integrative STEM education limits implementation.	*N:*	30	44	11	16	46	S/TE: .018	S/TE: 1.000
	M:	5.20	5.18	4.91	5.13	4.72	S/M: .291	S/M: .944
	SD:	.89	1.00	1.22	.72	1.36	S/E: .075	S/E: .999
							S/NS: .483	S/NS: .337
							TE/M: .273	TE/M: .948
							TE/E: .057	TE/E: 1.000
							TE/NS: .464	TE/NS: .269
							M/E: .216	M/E: .987
							M/NS: .192	M/NS: .985
							E/NS: .408	E/NS: .705
31. Limited availability of professional development for in-service teachers is an issue.	*N:*	30	44	11	16	45	S/TE: .386	S/TE: .770
	M:	4.50	4.89	4.27	4.50	4.29	S/M: .227	S/M: .991
	SD:	1.43	1.22	1.62	1.41	1.47	S/E: .000	S/E: 1.000
							S/NS: .211	S/NS: .968
							TE/M: .614	TE/M: .690
							TE/E: .386	TE/E: .878
							TE/NS: .597	TE/NS: .263
							M/E: .227	M/E: .994
							M/NS: .016	M/NS: 1.000
							E/NS: .211	E/NS: .985
32. Lacking STEM certification at the State level is an issue.	*N:*	23	40	9	12	40	S/TE: .062	S/TE: 1.000
	M:	4.09	4.03	4.00	4.50	4.05	S/M: .087	S/M: 1.000
	SD:	1.41	1.59	1.80	1.45	1.60	S/E: .413	S/E: .946
							TE/NS: .025	TE/NS: 1.000
							M/E: .500	M/E: .951
							M/NS: .050	M/NS: 1.000
							E/NS: .450	E/NS: .906

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported, NS=*Non-STEM* content background.

Between group analysis of Content Area and Pre-Service Training Barriers construct. Results of *Content Area* group comparisons within the *Pre-Service Training Barriers* construct are found in Table 40. A one-way ANOVA test of variance within the construct indicated significant difference for Item 37, $F = (4, 114) = 3.71$, $p = .007$.

Table 40

ANOVA for Pre-Service Training Barriers by Content Area (p = .05)

Item#		S	TE	M	E	NS	Paired Difference	*p* value
34. Limited availability of professional development for pre-service teachers is an issue.	*N:*	21	37	9	13	42	S/TE: .206	S/TE: .984
	M:	4.52	4.73	4.56	4.23	4.26	S/M: .032	S/M: 1.000
	SD:	1.25	1.37	1.01	1.42	1.58	S/E: .293	S/E: .977
							S/NS: .262	S/NS: .957
							TE/M: .174	TE/M: .997
							TE/E: .499	TE/E: .808
							TE/NS: .468	TE/NS: .584
							M/E: .325	M/E: .984
							M/NS: .294	M/NS: .980
							E/NS: .031	E/NS: 1.000
35. Lack of integrative STEM methodology in elementary teacher education programs limits implementation.	*N:*	21	33	10	11	36	S/TE: .039	S/TE: 1.000
	M:	4.86	4.82	5.00	4.64	4.56	S/M: .143	S/M: .998
	SD:	1.24	1.36	1.16	1.03	1.36	S/E: .221	S/E: .991
							S/NS: .302	S/NS: .914
							TE/M: .182	TE/M: .995
							TE/E: .182	TE/E: .994
							TE/NS: .263	TE/NS: .916
							M/E: .364	M/E: .967
							M/NS: .444	M/NS: .871
							E/NS: .081	E/NS: 1.000
36. Lack of integrative STEM methodology in secondary teacher education programs limits implementation.	*N:*	24	39	8	9	39	S/TE: .266	S/TE: .906
	M:	4.71	4.97	4.75	5.00	4.51	S/M: .042	S/M: 1.000
	SD:	1.04	.99	1.04	.71	1.49	S/E: .292	S/E: .969
							S/NS: .196	S/NS: .968
							TE/M: .224	TE/M: .988
							TE/E: .026	TE/E: 1.000
							TE/NS: .462	TE/NS: .416
							M/E: .250	M/E: .992
							M/NS: .237	M/NS: .985
							E/NS: .487	E/NS: .795
37. Integrative STEM education is limited by low numbers of teacher education programs that include technological literacy as part of content and methods courses.	*N:*	22	39	8	11	39	S/TE: .080	S/TE: .999
	M:	5.23	5.31	4.88	4.18	4.49	S/M: .352	S/M: .953
	SD:	.61	.98	1.13	1.17	1.59	S/E: 1.045	S/E: .131
							S/NS: .740	S/NS: .144
							TE/M: .433	TE/M: .833
							TE/E: 1.126	TE/E: .051
							TE/NS: .821	TE/NS: *.024
							M/E: .693	M/E: .722
							M/NS: .388	M/NS: .918
							E/NS: .305	E/NS: .944

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported*,* NS=*Non-STEM* content background.

Additional post hoc Tukey analysis by item indicated significant difference (p = .024) between the *Technology and Engineering* ($\bar{x}$ = 5.31) and the *Non-STEM* ($\bar{x}$ = 4.49) groups. One group comparison in the construct just missed the research study test for significance: (p = .051) for the *Technology and Engineering* ($\bar{x}$ = 5.31) and *Elementary* ($\bar{x}$ = 4.18) groups. Mean scores within the construct ranged from 4.18 (*Slightly Agree*) to 5.31 (*Agree*).

The *Science, Technology and Engineering,* and *Mathematics* groups indicated agreement with Item 34 — *Limited availability of professional development for pre-service teachers is an issue* and Item 37 — *Integrative STEM education is limited by low numbers of teacher education programs that include technological literacy as part of content and methods courses.* The *Elementary* and *Non-STEM* groups intimated slight agreement with both statements.

For Item 35 — *Lack of integrative STEM methodology in elementary teacher education programs limits implementation* and Item 36 — *Lack of integrative STEM methodology in secondary teacher education programs limits implementation*, all groups indicated agreement with the statements.

Between group analysis of Content Area and No Child Left Behind Barriers construct. Results of *Content Area* group comparisons within the *No Child Left Behind* construct are found in Table 41. A one-way ANOVA test of variance and post hoc Tukey analysis found no significant difference on items in the construct. Mean ranges within all items in the construct ran from 4.60 to 5.38 (*Agree*).

All groups agreed with the following statements: Item 39 — Current standardized assessments are limited in measurement of mastery in project and problem-based learning; Item 40 — Assessment innovation is limited by Adequate Yearly Progress (AYP) indicator required by NCLB; and Item 41 — The requirements of NCLB limit time available for integrative STEM education.

Table 41

ANOVA for No Child Left Behind Barriers by Content Area (p = .05)

Item#		S	TE	M	E	NS	Paired Difference	*p* value
39. Current standardized assessments are limited in measurement of mastery in project and problem-based learning.	*N:*	29	40	11	14	43	S/TE: .131	S/TE: .989
	M:	5.07	5.20	5.09	5.36	4.60	S/M: .022	S/M: 1.000
	SD:	.96	.97	.83	.75	1.48	S/E: .288	S/E: .935
							S/NS: .464	S/NS: .432
							TE/M: .109	TE/M: .999
							TE/E: .157	TE/E: .992
							TE/NS: .595	TE/NS: .122
							M/E: .266	M/E: .977
							M/NS: .486	M/NS: .708
							E/NS: .752	E/NS: .200
40. Assessment innovation is limited by Adequate Yearly Progress (AYP) indicator required by NCLB.	*N:*	26	37	11	13	35	S/TE: .239	S/TE: .915
	M:	4.92	5.16	4.91	4.69	5.06	S/M: .014	S/M: 1.000
	SD:	1.20	.96	.83	1.18	1.21	S/E: .231	S/E: .972
							S/NS: .134	S/NS: .990
							TE/M: .253	TE/M: .963
							TE/E: .470	TE/E: .679
							TE/NS: .105	TE/NS: .994
							M/E: .217	M/E: .989
							M/NS: .148	M/NS: .995
							E/NS: .365	E/NS: .847
41. The requirements of NCLB limit time available for integrative STEM education.	*N:*	29	37	10	12	36	S/TE: .689	S/TE: .154
	M:	4.69	5.38	4.50	4.92	4.94	S/M: .190	S/M: .993
	SD:	1.37	.92	.97	1.31	1.35	S/E: .227	S/E: .982
							S/NS: .255	S/NS: .916
							TE/M: .878	TE/M: .255
							TE/E: .462	TE/E: .780
							TE/NS: .434	TE/NS: .544
							M/E: .417	M/E: .929
							M/NS: .444	M/NS: .842
							E/NS: .028	E/NS: 1.000

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported*,* NS=*Non-STEM* content background.

Between group analysis of Content Area and Technology and Engineering Standards Barriers construct. Results of *Content Area* group comparisons within the *Technology and Engineering Barriers* construct are found in Table 42. A one-way ANOVA test of variance and post hoc Tukey analysis found no significant difference on items in the construct. Mean ranges within all items in the construct ranged from 4.00 (*Slightly Agree*) to 4.82 (*Agree*).

Table 42

ANOVA for Technology and Engineering Standards Barriers by Content Area (p = .05)

Item#		S	TE	M	E	NS	Paired Difference	*p* value
43. Lack of required K-12 technology and engineering standards limits integrative STEM implementation.	*N:*	28	42	11	15	43	S/TE: .488	S/TE: .680
	M:	4.68	4.19	4.18	4.13	4.28	S/M: .497	S/M: .889
	SD:	1.25	1.74	1.33	1.25	1.56	S/E: .545	S/E: .794
							S/NS: .400	S/NS: .814
							TE/M: .009	TE/M: 1.000
							TE/E: .057	TE/E: 1.000
							TE/NS: .089	TE/NS: .999
							M/E: .048	M/E: 1.000
							M/NS: .097	M/NS: 1.000
							E/NS: .146	E/NS: .998
44. Lack of required K-12 technology and engineering standards limits professional development in integrative STEM curriculum.	*N:*	28	42	11	15	43	S/TE: .381	S/TE: .835
	M:	4.64	4.26	4.00	4.33	4.14	S/M: .643	S/M: .748
	SD:	1.25	1.67	1.18	1.11	1.64	S/E: .310	S/E: .967
							S/NS: .503	S/NS: .640
							TE/M: .262	TE/M: .986
							TE/E: .071	TE/E: 1.000
							TE/NS: .122	TE/NS: .996
							M/E: .333	M/E: .980
							M/NS: .140	M/NS: .999
							E/NS: .194	E/NS: .993
45. Lack of required K-12 technology and engineering standards limits student assessment in integrative STEM curriculum.	*N:*	28	41	10	15	44	S/TE: .382	S/TE: .801
	M:	4.82	4.44	4.00	4.20	4.39	S/M: .821	S/M: .509
	SD:	1.16	1.58	1.16	1.15	1.50	S/E: .621	S/E: .641
							S/NS: .435	S/NS: .704
							TE/M: .439	TE/M: .902
							TE/E: .239	TE/E: .980
							TE/NS: .053	TE/NS: 1.000
							M/E: .200	M/E: .997
							M/NS: .386	M/NS: .935
							E/NS: .186	E/NS: .992

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported, NS=*Non-STEM* content background.

The content groups were consistent in mean response across all items in the construct: Item 43 — *Lack of required K-12 technology and engineering standards limits integrative STEM implementation;* Item 44 — *Lack of required K-12 technology and engineering standards limits* *professional development in integrative STEM curriculum* and Item 45 — *Lack of required K-12 technology and engineering standards limits student assessment in integrative STEM curriculum.* The *Science* content group indicated agreement, and The *Technology and Engineering, Mathematics, Elementary* and *Non-STEM* groups implied slight agreement with the statements.

Between group analysis of Content Area and Barriers of Male-Oriented Content Construct. Results of *Content Area* group comparisons within the *Barriers of Male-Oriented Content* construct are found in Table 43. A one-way ANOVA test of variance within the construct indicated significant difference for Item 48, *F* = (4, 132) = 3.65, *p* = .007. Mean scores within the construct ranged from 2.79 (*Slightly Disagree*) to 3.86 (*Slightly Agree*).

Table 43

ANOVA for Barriers of Male-Oriented Content by Content Area (p = .05)

Item#		S	TE	M	E	NS	Paired Difference	*p* value
47. The perception of STEM as a male-oriented curriculum limits its significance.	*N:*	28	42	10	14	43	S/TE: .881	S/TE: .095
	M:	2.93	3.82	3.50	2.79	3.07	S/M: .571	S/M: .818
	SD:	1.61	1.27	1.72	1.42	1.42	S/E: .143	S/E: .998
							S/NS: .141	S/NS: .994
							TE/M: .310	TE/M: .973
							TE/E: 1.024	TE/E: .151
							TE/NS: .740	TE/NS: .131
							M/E: .714	M/E: .753
							M/NS: .430	M/NS: .914
							E/NS: .284	E/NS: .968
48. The perception of STEM as a male-oriented curriculum limits implementation.	*N:*	28	42	9	15	43	S/TE: 1.000	S/TE: *.039
	M:	2.86	3.86	3.44	2.80	2.84	S/M: .587	S/M: .822
	SD:	1.58	1.35	1.88	1.37	1.33	S/E: .057	S/E: 1.000
							S/NS: .020	S/NS: 1.000
							TE/M: .413	TE/M: .935
							TE/E: 1.057	TE/E: .108
							TE/NS: 1.020	TE/NS: *.011
							M/E: .644	M/E: .823
							M/NS: .607	M/NS: .776
							E/NS: .037	E/NS: 1.000

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported, NS=*Non-STEM* content background.

In Item 48 — *The perception of STEM as a male-oriented curriculum limits implementation*, post hoc Tukey analysis identified significant difference between *Technology and Engineering* ($\bar{x} = 3.86$) and two other groups: *Science* ($\bar{x} = 2.86$, $p = .039$) and *Non-STEM* ($\bar{x} = 2.84$, $p = .011$). The *Technology and Engineering* group indicated slight agreement and the *Science, Mathematics, Elementary* and *Non-STEM* content area groups indicated slight disagreement.

No significant difference was found in Item 47 — *The perception of STEM as a male-oriented curriculum limits its significance.* The *Science, Elementary,* and *Non-STEM* content groups slightly disagreed with the statement; the *Technology and Engineering* content area indicated slight agreement; and the *Mathematics* content group indicated a statistically neutral position ($\bar{x} = 3.50$)

Between group analysis of Content Area and Barriers of a Narrow View construct. Results of *Content Area* group comparisons within the *Barriers of a Narrow View* construct are found in Table 44. A one-way ANOVA test of variance within the construct indicated a value just missing significant difference for Items 51, $F = (4, 131) = 2.20$, $p = .072$; significant difference on Item 56, $F = (4, 125) = 4.57$, $p = .002$; and significant difference on Item 57, $F = (4, 120) = 4.55$, $p = .002$. Mean scores within the construct ranged from 3.30 to 5.15.

Three items in the construct yielded consistent levels of agreement by group: Item 50 — *Policy makers and leaders fail to recognize the equal importance of the full spectrum of integrative STEM education;* Item 52 — *For many stakeholders, STEM education consists only of science and mathematics;* and Item 54 — *Current education practices delivering separate and "siloed" instruction, limits implementation of integrative STEM.* In all three items, the *Elementary* group respondents indicated slight agreement with the statement and all other content area groups indicated agreement. No significant difference between groups was indicated through analysis on the three items.

Table 44

ANOVA for by Barriers of a Narrow View by Content Area (p = .05)

Item#		S	TE	M	E	NS	Paired Difference	*p* value
50. Policy makers and leaders fail to recognize the equal importance of the full spectrum of integrative STEM education.	*N:*	25	39	10	14	41	S/TE: .059	S/TE: 1.000
	M:	4.88	4.82	4.90	4.07	4.85	S/M: .020	S/M: 1.000
	SD:	.93	1.30	1.10	1.69	1.26	S/E: .809	S/E: .307
							S/NS: .026	S/NS: 1.000
							TE/M: .079	TE/M: 1.000
							TE/E: .749	TE/E: .315
							TE/NS: .033	TE/NS: 1.000
							M/E: .829	M/E: .504
							M/NS: .046	M/NS: 1.000
							E/NS: .782	E/NS: .266
51. For many educators, STEM education consists only of science and mathematics.	*N:*	30	39	11	14	42	S/TE: .321	S/TE: .855
	M:	4.83	5.15	4.91	4.00	4.62	S/M: .076	S/M: 1.000
	SD:	1.09	1.20	1.45	1.24	1.55	S/E: .833	S/E: .296
							S/NS: .214	S/NS: .961
							TE/M: .245	TE/M: .983
							TE/E: 1.154	TE/E: *.045
							TE/NS: .535	TE/NS: .365
							M/E: .909	M/E: .431
							M/NS: .290	M/NS: .967
							E/NS: .619	E/NS: .551
52. For many stakeholders, STEM education consists only of science and mathematics.	*N:*	26	38	10	13	39	S/TE: .117	S/TE: .996
	M:	4.96	5.08	5.30	4.00	4.67	S/M: .338	S/M: .953
	SD:	.72	1.24	.68	1.35	1.63	S/E: .962	S/E: .179
							S/NS: .295	S/NS: .891
							TE/M: .221	TE/M: .988
							TE/E: 1.079	TE/E: .070
							TE/NS: .412	TE/NS: .616
							M/E: 1.300	M/E: .116
							M/NS: .633	M/NS: .627
							E/NS: .667	E/NS: .479
53. For many educators computer literacy requirements serve as a barrier to integrative STEM implementation.	*N:*	28	40	11	15	44	S/TE: .061	S/TE: 1.000
	M:	4.04	3.98	4.36	4.27	3.82	S/M: .328	S/M: .971
	SD:	1.43	1.53	1.03	1.16	1.65	S/E: .231	S/E: .988
							S/NS: .218	S/NS: .974
							TE/M: .389	TE/M: .939
							TE/E: .292	TE/E: .966
							TE/NS: .157	TE/NS: .989
							M/E: .097	M/E: 1.000
							M/NS: .545	M/NS: .810
							E/NS: .448	E/NS: .849

(continued)

Table 44

ANOVA for Barriers of a Narrow View by Content Area (continued)

Item#		S	TE	M	E	NS	Paired Difference	*p* value
54. Current education practices delivering separate and "siloed" instruction, limits implementation of integrative STEM.	*N:*	24	40	10	14	40	S/TE: .117	S/TE: .997
	M:	4.83	4.95	5.00	4.00	4.78	S/M: .167	S/M: .997
	SD:	.97	1.41	.82	1.52	1.42	S/E: .833	S/E: .335
							S/NS: .058	S/NS: 1.000
							TE/M: .050	TE/M: 1.000
							TE/E: .950	TE/E: .146
							TE/NS: .175	TE/NS: .976
							M/E: 1.000	M/E: .361
							M/NS: .225	M/NS: .989
							E/NS: .775	E/NS: .328
55. The perception that technology and engineering education teachers cannot teach science or mathematics content is a barrier to implementation of integrative STEM education.	*N:*	22	41	10	14	42	S/TE: .637	S/TE: .413
	M:	4.05	4.68	4.70	4.21	4.24	S/M: .655	S/M: .729
	SD:	1.13	1.46	1.25	.98	1.56	S/E: .169	S/E: .997
							S/NS: .193	S/NS: .984
							TE/M: .017	TE/M: 1.000
							TE/E: .469	TE/E: .810
							TE/NS: .445	TE/NS: .588
							M/E: .486	M/E: .915
							M/NS: .462	M/NS: .878
							E/NS: .024	E/NS: 1.000
56. Science educators see no need to change methodology to include technology and engineering.	*N:*	30	37	11	14	38	S/TE: 1.376	S/TE: *.002
	M:	3.30	4.68	3.82	3.57	3.53	S/M: .518	S/M: .854
	SD:	1.39	1.18	1.60	1.51	1.70	S/E: .271	S/E: .979
							S/NS: .226	S/NS: .970
							TE/M: .857	TE/M: .436
							TE/E: 1.104	TE/E: .122
							TE/NS: 1.149	TE/NS: *.008
							M/E: .247	M/E: .994
							M/NS: .292	M/NS: .978
							E/NS: .045	E/NS: 1.000
57. Mathematics educators see no need to change methodology to include technology and engineering.	*N:*	25	37	11	14	38	S/TE: 1.225	S/TE: *.014
	M:	3.64	4.86	3.91	3.36	3.74	S/M: .269	S/M: .987
	SD:	1.41	1.25	1.51	1.78	1.57	S/E: .283	S/E: .978
							S/NS: .097	S/NS: .999
							TE/M: .956	TE/M: .327
							TE/E: 1.508	TE/E: *.012
							TE/NS: 1.128	TE/NS: *.010
							M/E: .552	M/E: .884
							M/NS: .172	M/NS: .997
							E/NS: .380	E/NS: .922

(continued)

Table 44

ANOVA for Barriers of a Narrow View by Content Area (continued)

Item#		S	TE	M	E	NS	Paired Difference	*p* value
58. The perception that inclusion of technology and engineering limits time for learning mathematics and science, limits implementation of integrative STEM curriculum.	*N:*	28	37	10	14	40	S/TE: .776	S/TE: .186
	M:	4.14	4.92	4.10	4.00	4.30	S/M: .043	S/M: 1.000
	SD:	1.33	1.23	1.73	1.11	1.60	S/E: .143	S/E: .998
							S/NS: .157	S/NS: .991
							TE/M: .819	TE/M: .479
							TE/E: .919	TE/E: .235
							TE/NS: .619	TE/NS: .308
							M/E: .100	M/E: 1.000
							M/NS: .200	M/NS: .994
							E/NS: .300	E/NS: .959

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported, NS=*Non-STEM* content background.

Additional post hoc analysis found significant difference between the *Technology and Engineering* ($\bar{x} = 5.15$) and *Elementary* content groups ($p = .045$) on Item 51 — *For many educators, STEM education consists only of science and mathematics.* Respondents within the *Elementary* group indicated slight agreement with the statement and all other content area groups inferred agreement.

All content areas reported slight agreement with Item 53 — *For many educators computer literacy requirements serve as a barrier to integrative STEM implementation.*

The *Technology and Engineering* and *Mathematics* groups implied agreement and the *Science, Elementary,* and *Non-STEM* groups indicated slight agreement with Item 55 — *The perception that technology and engineering education teachers cannot teach science or mathematics content is a barrier to implementation of integrative STEM education.*

Item 56 — *Science educators see no need to change methodology to include technology and engineering* had significant difference between the *Technology and Engineering* ($\bar{x} = 4.68$) and two groups; *Science* ($\bar{x} = 3.30$, $p = .002$) and *Non-STEM* ($\bar{x} = 3.53$, $p = .008$). The *Science* content group indicated slight disagreement with the statement. The Mathematics, Elementary, and Non-STEM groups implied slight agreement with the statement. The *Technology and Engineering* group agreed with the statement.

Item 57 — *Mathematics educators see no need to change methodology to include technology and engineering* resulted in significant difference between *Technology and Engineering* ($\bar{x}$ = 4.86) and three content area groups: *Science* ($\bar{x}$ = 3.64, p = .014); *Elementary* ($\bar{x}$ = 3.36, p = .012); and *Non-STEM* ($\bar{x}$ = 3.74, p = .010). The *Elementary* group indicated slight disagreement with the statement; the *Science, Mathematics,* and *Non-STEM* groups indicated slight agreement; and the *Technology and Engineering* group noted agreement.

Item 58 — *The perception that inclusion of technology and engineering limits time for learning mathematics and science, limits implementation of integrative STEM curriculum* had agreement from the *Technology and Engineering* content group and all other groups indicated slight agreement with the statement.

Between group analysis of Content Area and Barriers of Perception construct. Results of *Content Area* group comparisons within the *Barriers of Perception* construct are found in Table 45. A one-way ANOVA test of variance and post hoc Tukey analysis found no significant difference on items in the construct.

Item 60 — *STEM is perceived by educators as another "fad" that will soon go away* and Item 61 — *Negative perception of open-ended inquiry learning limits implementation of integrative STEM education* elicited slight disagreement from the *Elementary* content group and all other content areas maintained slight agreement with the statements.

The *Science*, *Elementary*, *Technology and Engineering* content groups intimated slight disagreement, *Mathematics* and *Non-STEM* groups indicated slight agreement with Item 62 —

There is a negative perception that integrative STEM education diminishes the individual importance of each content area.

Table 45

ANOVA for Barriers of Perception by Content Area (p = .05)

Item #		S	TE	M	E	NS	Paired Difference	*p* value
60. STEM is perceived by educators as another “fad” that will soon go away.	*N:*	28	38	10	14	37	S/TE: .235	S/TE: .970
	M:	3.61	3.84	4.20	3.21	3.97	S/M: .593	S/M: .820
	SD:	1.42	1.57	1.40	1.48	1.50	S/E: .393	S/E: .930
							S/NS: .366	S/NS: .867
							TE/M: .358	TE/M: .962
							TE/E: .628	TE/E: .668
							TE/NS: .131	TE/NS: .996
							M/E: .986	M/E: .509
							M/NS: .227	M/NS: .993
							E/NS: .759	E/NS: .493
61. Negative perception of open-ended inquiry learning limits implementation of integrative STEM education.	*N:*	29	38	10	15	40	S/TE: .322	S/TE: .883
	M:	3.86	4.18	4.40	3.40	3.85	S/M: .538	S/M: .832
	SD:	1.36	1.37	1.08	1.64	1.42	S/E: .462	S/E: .837
							S/NS: .012	S/NS: 1.000
							TE/M: .216	TE/M: .993
							TE/E: .784	TE/E: .356
							TE/NS: .334	TE/NS: .829
							M/E: 1.000	M/E: .406
							M/NS: .550	M/NS: .800
							E/NS: .450	E/NS: .825
62. There is a negative perception that integrative STEM education diminishes the individual importance of each content area.	*N:*	28	33	10	13	37	S/TE: .406	S/TE: .801
	M:	3.32	3.73	3.80	3.46	3.54	S/M: .479	S/M: .891
	SD:	1.12	1.42	1.55	1.66	1.50	S/E: .140	S/E: .998
							S/NS: .219	S/NS: .972
							TE/M: .073	TE/M: 1.000
							TE/E: .266	TE/E: .979
							TE/NS: .187	TE/NS: .982
							M/E: .338	M/E: .980
							M/NS: .259	M/NS: .986
							E/NS: .079	E/NS: 1.000
63. A perception that mathematics is not a significant part of science education is an issue.	*N:*	30	38	11	15	42	S/TE: .481	S/TE: .687
	M:	2.97	3.45	2.91	2.93	3.48	S/M: .058	S/M: 1.000
	SD:	1.52	1.47	1.22	1.34	1.64	S/E: .033	S/E: 1.000
							S/NS: .510	S/NS: .618
							TE/M: .538	TE/M: .834
							TE/E: .514	TE/E: .796
							TE/NS: .029	TE/NS: 1.000
							M/E: .024	M/E: 1.000
							M/NS: .567	M/NS: .800
							E/NS: .543	E/NS: .752

(continued)

Table 45

ANOVA for Barriers of Perception by Content Area (continued)

Item #		S	TE	M	E	NS	Paired Difference	*p* value
64. A perception that integrative STEM education addresses only workforce issues limits implementation.	*N:*	26	39	8	13	39	S/TE: .410	S/TE: .783
	M:	3.54	3.95	3.50	3.15	3.67	S/M: .038	S/M: 1.000
	SD:	1.27	1.49	1.41	1.41	1.44	S/E: .385	S/E: .930
							S/NS: .128	S/NS: .996
							TE/M: .449	TE/M: .925
							TE/E: .795	TE/E: .406
							TE/NS: .282	TE/NS: .904
							M/E: .346	M/E: .982
							M/NS: .167	M/NS: .998
							E/NS: .513	E/NS: .790

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported, NS=*Non-STEM* content background.

All groups slightly disagreed with Item 63 — *A perception that mathematics is not a significant part of science education is an issue.*

Item 64 — *A perception that integrative STEM education addresses only workforce issues limits implementation* elicited varying group responses. The *Elementary* group slightly disagreed; the *Mathematics* group indicated a neutral mean score; and the *Science, Technology and Engineering,* and *Non-STEM* groups slightly agreed.

Between group analysis of Content Area and Barriers of Regulation construct. Results of *Content Area* group comparisons within the *Barriers of Regulation* construct are found in Table 46. A one-way ANOVA test of variance and post hoc Tukey analysis found no significant difference on items in the construct. Mean ranges within all items in the construct ranged from 4.18 (*Slightly Agree*) to 4.90 (*Agree*).

On Item 66 — *State and federal regulatory boundaries are rigid and constrain local educational reform* received agreement from the *Science, Technology and Engineering,* and *Mathematics* content area groups. The Elementary and Non-STEM content groups registered slight agreement with the statement.

Slight agreement from the *Science, Mathematics,* and *Elementary* groups was indicated, with the *Technology and Engineering* and *Non-STEM* groups agreeing with Item 67 — *There is currently a lack of incentives to motivate key outcomes for improving educational quality.*

Table 46

ANOVA for Barriers of Regulation by Content Area (p = .05)

Item#		S	TE	M	E	NS	Paired Difference	*p* value
66. State and federal regulatory boundaries are rigid and constrain local educational reform.	*N:*	23	38	10	11	36	S/TE: .093	S/TE: .999
	M:	4.57	4.66	4.90	4.18	4.19	S/M: .335	S/M: .974
	SD:	1.53	1.32	1.10	1.40	1.64	S/E: .383	S/E: .952
							S/NS: .371	S/NS: .876
							TE/M: .242	TE/M: .990
							TE/E: .476	TE/E: .875
							TE/NS: .463	TE/NS: .650
							M/E: .718	M/E: .792
							M/NS: .706	M/NS: .659
							E/NS: .013	E/NS: 1.000
67. There is currently a lack of incentives to motivate key outcomes for improving educational quality.	*N:*	27	39	10	13	38	S/TE: .464	S/TE: .672
	M:	4.41	4.87	4.40	4.31	4.66	S/M: .007	S/M: 1.000
	SD:	1.47	1.24	1.51	1.38	1.46	S/E: .100	S/E: 1.000
							S/NS: .250	S/NS: .953
							TE/M: .472	TE/M: .874
							TE/E: .564	TE/E: .713
							TE/NS: .214	TE/NS: .962
							M/E: .092	M/E: 1.000
							M/NS: .258	M/NS: .985
							E/NS: .350	E/NS: .935
68. Class-periods and seat-time requirements constrain the use of integrative STEM methodologies.	*N:*	30	40	10	15	42	S/TE: .008	S/TE: 1.000
	M:	4.47	4.48	4.50	4.40	4.43	S/M: .033	S/M: 1.000
	SD:	1.28	1.52	1.35	1.96	1.60	S/E: .067	S/E: 1.000
							S/NS: .038	S/NS: 1.000
							TE/M: .025	TE/M: 1.000
							TE/E: .075	TE/E: 1.000
							TE/NS: .046	TE/NS: 1.000
							M/E: .100	M/E: 1.000
							M/NS: .071	M/NS: 1.000
							E/NS: .029	E/NS: 1.000

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported, NS=*Non-STEM* content background.

Item 68 — *Class-periods and seat-time requirements constrain the use of integrative STEM methodologies* had agreement from Mathematics, with all other content groups registering a slight level of agreement.

Qualitative analysis of open-ended responses within defined constructs. The research concept was based on the Embedded Design method utilizing a correlational model as per Creswell and Plano-Clark (2007). This embedded variant suggested collection of qualitative data to reinforce quantitative data as a method to further assist in explanation of construct analysis results. Each section of the iSTEMIBI allowed respondents open-ended responses to give further perspective within each construct area of the instrument. Twelve constructs were identified and were as follows: *Barriers Regarding Efficacy; Barriers of Integrative STEM Buy-In; Barriers of Adoption; Resource Barriers; Professional Development Barriers; Pre-Service Training Barriers; No Child Left Behind Barriers; Technology and Engineering Standards Barriers; Barriers of Male-Oriented Content; Barriers of a Narrow View; Barriers of Perception;* and *Barriers of Regulation.*

Open-end response analysis was completed to determine congruency with barriers identified in the instrument or to determine if additional barriers could be identified and considered for future barriers research. Typically results emerged as respondents' indicated support or disagreement with items or concepts in the instrument, and in some cases responses indicated philosophical views regarding iSTEM methodology or the education system in general.

It became apparent that respondents initially had input not necessarily tied to each open-ended barrier as was intended, but from a wide-range of identified barriers that could be connected conceptually to other barriers in the measure, or had potential to be identified as new concepts to consider in future research. The researcher determined a coding system was necessary to allow identification of concepts within and outside of the open-ended response portions of each construct to establish themes for consideration as barriers or items within identified barriers in future iterations of the instrument.

Open-ended response theme regarding Barriers of Efficacy. Analysis of the open-ended responses resulted in four responses that were determined to exemplify a concept of *Self-made fears of teachers* found in Table 47. In a further iteration of the instrument, this concept could be considered as an additional item within the construct. One respondent used this term stating: "The largest barriers to STEM implementation are the self made fears of the classroom teachers". The researcher retained this response as a theme as it exemplified an overarching issue. One respondent comment gave more insight to the issue indicating change created extra individual work so teachers would "drag their feet waiting for some one else to get the process started". The other indicated a willingness of the part of teachers to try iSTEM implementation, but there was a "nerve-racking" uncertainty due to being at the "ground-level" of implementation.

Table 47

Open-Ended Response Theme Regarding Barriers of Efficacy

Identified Theme	*n*
Self-made fears of teachers	4

Open-ended response themes regarding Barriers of iSTEM Buy-In. Six themes were identified within the open-ended responses with ties to the issue of integrative STEM buy-in. Results are found in Table 48.

Seven respondents indicated *General lack of knowledge* of *iSTEM* as a contributor to the buy-in issue. One respondent indicated an issue with having teachers who were qualified "knowledgeable and capable of teaching to these standards" and the comment supported the *Professional Development* and *Pre-Service Training* barriers constructs.

Teacher's resistance to change was identified by seven respondents as contributing to the buy-in issue. Factor analysis completed by this research study corroborated this issue. Issues such as: core teacher unwillingness to integrate with technology and engineering department; teachers unwillingness to "change or stretch themselves to include STEM education"; getting teachers with no hands-on education background from areas such as science or mathematics made for much pressure to perform. One last comment from a respondent was "Ignorance is a profound experience".

Five respondents noted *Lack of cooperation with other teachers* as a barrier and supported Item 16 — *Non-supportive teachers hinder implementation of integrative STEM education*. One response noted: "Negative co-teacher reactions interrupt my students' success and achievement as well as enthusiasm for weeks as a time". Another response indicated: "Our core teachers are not willing to include technology. The barrier is time and incentive. Why should they take on a new challenge when no one is forcing them?"

Table 48

Open-Ended Response Themes Regarding Barriers of Integrative STEM Buy-In

Identified Themes	*n*
General lack of knowledge of iSTEM	7
Teachers' resistance to change	7
Lack of cooperation with other teachers	5
Advocacy issues	4
Ambiguous nature of expectations	2
Issue of Special Education teachers needing orientation	2

Finally, *Advocacy issues* (*n* = 4)*, Ambiguous nature of expectations* (*n* = 2)*,* and *Issue of special education teachers needing orientation* (*n* = 2) were also indicated by respondents with regards to buy-in.

Open-ended response themes regarding Barriers of Adoption. Respondents indicated administration as a core theme issue with regards to adoption. Open-ended responses supported the original instrument Item 22: *Lack of support by administrators hinders implementation.* Results are found in Table 49.

Table 49

Open-Ended Response Themes Regarding Barriers of Adoption

Identified Themes	*n*
General administration issues	18
Administration focus on Advanced Placement, Honors, University Track	2

General administration issues were indicated by 18 respondents and two additional respondents noted an issue with *Administration focus on advanced placement, honors and university track* indicated by the following: “The focus and push for AP classes and academic elitism.” Improvement of scores tied to standards was predominant regarding issues of adoption tied to administration. Following is a comment indicative of this sentiment:

> Our district is short-sighted in failing to fund training if it is not DIRECTLY related to improving scores on common core standards that will be tested at the end of the year. The district does not realize that STEM could help improve these scores at all levels of students - not just the top students.

Another respondent stated “Getting approval for use in the curriculum. If it is not part of the curriculum and you teach it and a student does not do well on your assessment, you are asking for trouble from your administrators”. One respondent indicated “Administrative impotence when it comes to what STEM Ed really needs to be”. Finally one respondent indicated frustration with administrative decision making regarding “...how STEM resources are allocated without drawing on expertise of curriculum specialists or classroom teachers”.

Open-ended response themes regarding Resource Barriers. Responses emerged as five themes regarding *Resource Barriers* and supported statements in the construct. Results are found in Table 50. Four of the five themes were directly related to funding; whether a shortage of monetary funding (*n* = 18), professional development support (*n* = 3), facility/tool issues (*n* = 13), or lack of funds utilized for students supplies (*n* = 12). *Time requirements for STEM implementation* was indicated as an issue by two respondents. One respondent succinctly described the funding issue with regard to facilities:

> The content dictates the required facilities. On the whole, a quality and well-designed STEM program of study can be implemented without a huge investment in facilities. However, if the content requires it, such as automated materials joining, high-tech career investigation, or replicating real world work environments, then the facility including the required equipment can be a deal breaker due to need for funds to support and maintain.

Table 50

Open-Ended Response Themes Regarding Resource Barriers

Identified Themes	*n*
Lack of monetary funding	18
Lack of facilities and / or tools	13
Student supplies	12
Funding professional development	3
Time requirements for STEM implementation	2

Two respondents indicated *Barriers of Resources* may be negated by creative teaching by stating the following: “Good teachers do not need the biggest, best or the most current technology to implement STEM. Good teachers make due with the resources they have and are excited by the challenge”. The other respondent replied with regard to the resources barriers in the instrument: “While each of the above items can be an issue they do not have to be once again it is how much they want to put into it and or are willing to work out side their normal teaching box”.

Open-ended response themes regarding Professional Development Barriers. The predominant issue identified by respondents was *Time for training, curriculum development, and preparation time* (*n* = 24). Also indicated as issues were four responses each regarding *Need for more STEM workshops* and *Hands-on training for content area.* Themes identified regarding professional development are found in Table 51.

Respondents consistently indicated time for training on STEM-based project methodology and integration, lack of hands-on training to specific content areas as issues, or time for collaborative work to develop iSTEM curriculum as issues.

One respondent indicated belief in a considerable commitment from school districts for training:

> STEM teachers should be able to have a year of training—whether if it is being with other STEM teachers and doing what they are doing for a year and actively making/planning units or if they get a half of year to do so. I think teachers give up due to being overwhelmed and lessons flopping sometimes.

Table 51

Open-Ended Response Themes Regarding Professional Development Barriers

Identified Themes	*n*
Time for training, curriculum development, preparation time	24
Need for more STEM workshops	4
Hands-on training for content area	4

Open-ended response themes regarding Pre-Service Training Barriers. Two themes regarding pre-service teacher preparation were identified, both tied to the need for iSTEM methodology in teacher training programs: *Need for New Teachers Versed in STEM* (*n* = 12), and *Inability of Teacher Education System to Adopt Needed Changes Quickly* (*n* = 5). Both conceptually supported construct items regarding pre-service training. Results regarding *Pre-Service Training Barriers* are found in Table 52.

Respondents indicated issues such as the need for new teachers out of college “informed and passionate” about iSTEM education and capable of teaching with content and standards suitable for future success of students. One highlighted the issue of many iSTEM teachers being “crossover” teachers from other content areas, not trained in iSTEM methods.

University teacher education programs lagging in iSTEM methodology instruction for pre-service teacher candidates was suggested by one respondent:

> Besides a lack of understanding of what it is, at the university level there seems to be a great disconnect in understanding that the way university teachers teach, greatly affects how K-12 teachers teach. Somehow the traditional attitude that the role of university faculty is to be an expert dispensing information, needs to be changed to one that is focused significantly in guiding and mentoring teachers-in-training in effective iSTEM teaching methods. At our particular institution, I think the movement forward is also hindered because those leading change come from the tech and engineering side of things—often not recognized as a valuable or core subject area; rather than from more accepted core disciplines like math and science.

Table 52

Open-Ended Response Themes Regarding Pre-Service Training Barriers

Identified Themes	*n*
Need new teachers more versed in STEM	12
Inability of teacher education system to adopt needed changes quickly	5

Open-ended response themes regarding No Child Left Behind Barriers. Three themes regarding No Child Left Behind (NCLB) were identified with *Time* (*n* = 26) issues being the most common issue noted by respondents. Results are found in Table 53. The issues noted supported Item 41 — *The requirements of NCLB limit time available for integrative STEM education* from the iSTEMIBI.

Consistent issues of time contained references to *High Stakes Testing* (*n* = 9) being a barrier limiting iSTEM implementation as it limits time available for other instruction methods. One respondent stated “If my year-end evaluation depends on how my students score, STEM will fall by the wayside if I need to teach ‘to the test’ first”. The same problem with testing was indicated by an elementary teacher:

> There are so many Intermediate grade (3-5) teachers at my school who are so concerned with test scores that they don’t feel they have time to give STEM the focus it needs due to the fact it is not going to be on the test.

Another issue that surfaced was a change caused by NCLB when focus changed to *Diverting support from science to math and English language arts* (*n* = 4). The issue was iterated as follows by a respondent:

> NCLB immediately diverted resources from Science to ELA and Math. This included human capital (special ed co-teachers only) being assigned to math and ELA classes, fewer science electives offered so additional teaching units could be assigned for “double-dosing” math and ELA classes. (The students aren’t getting it so, lets give them twice as much!) Unfortunately this is usually drill and kill rather than giving student opportunities for problem solving and discourse.

A secondary teacher indicated the time constraint issue when implementing iSTEM methodology as an issue of time needed to change teaching methodology:

> My experience in the CIESE pilot project confirmed my initial perception that the iSTEM approach takes longer to execute compared with the traditional approach. I wholeheartedly agree with the new approach. But I am now already so pressed for time to get all the contents required by the state in. I just cannot image myself to allocate the instruction time I do not have to this new approach.

Table 53

Open-Ended Response Themes Regarding No Child Left Behind Barriers

Identified Themes	*n*
Time	26
High-stakes testing	9
Diverting support from science to math and English language arts	4

Open-ended response themes regarding Technology and Engineering Standards Barriers. Two themes emerged regarding *Technology and Engineering Standards Barriers*. Results of the theme analysis are found in Table 54.

Five respondents indicated issue with iSTEM curriculum based on standards. Comments included concepts of no standards relating to iSTEM methodology and lack of iSTEM implementation standards were noted.

Table 54

Open-Ended Response Themes Regarding Technology and Engineering Standards

Identified Themes	*n*
Curriculum based on standards/Need for implementation standards	5
Assessment issues	3

Assessment issues (*n* = 3) were also identified such as: AYP indicators not including STEM elements for assessment in math and science; end of year assessments “curtail STEM integration”; and iSTEM assessment of learning would take more time and resources. One indicated the individual’s state technology and engineering standards had only 14 of 28 standards assessed, “So having standards does not portend a requirement unfortunately”.

One respondent indicated requiring standards only made things worse, referencing the NCTM and NSTA standards. This respondent’s opinion indicated the standards actually weeded out students and was not a tool for student advancement. The respondent stated:

> We’ve forgotten the purpose of standards. They were a benchmark. A line in the sand of what we should not teach “below”! They were not designed to signal what we should attain, but what we should go beyond. If we limit the requirement to the listing as written when they were designed, we are stuck in the past and not becoming learners of innovation and invention. We stay with the status quo.

Open-ended response themes regarding Barriers of Male-Oriented Content. Open-ended responses called for movement to *Gender Neutral Curriculum* (*n* = 3) and the need for more *Female Role Models* (*n* = 2) in the classroom or laboratory. Also, there were indications by respondents that countered the issue of *Barriers of Male-Oriented Content* in iSTEM (*n* = 5). Results of themes identified are found in Table 55. In support of the gender barriers issue, one respondent stated:

> Sadly, this has not changed in the 37 years since I graduated as the first female in the IA program at (University removed to protect identity). The perception has moved to the female side slightly. But, many still do not understand the topical content needed for females to become interested in a career involving STEM. There are other issues, too.

> Such as salary, glass-ceiling issues, and the natural built-in barriers of a field being male dominated.

Three respondents indicated belief that the issue of gender was not an issue at their school, with one indicating potential for erosion of the issue: “If schools and states are marketing STEM for all students then this barrier should go away”. Additionally, one respondent indicated the potential issue of limited implementation or significance due to perception of STEM as a male-oriented curriculum may not be due to classroom curricular issues, but indicated the issue resided with counselors’ and parents’ perception.

One respondent took issue with the *Barriers of Male-Oriented Content* concept items as identified in the literature review stating: “Asking this questions is bias. Being male-oriented in any way is ridiculous. I can not believe it is even asked. I am truely (sic) offened (sic)”.

Another respondent questioned the issue: “Gender barriers are a false scapegoat among certain circles - I would strongly encourage better data collection!”

Table 55

Open-Ended Response Themes Regarding Barriers of Male-Oriented Content

Identified Themes	*n*
Discounting of gender issues	5
Gender neutral curriculum	3
Lack of female role models and/or female teachers	2

Open-ended response themes regarding Barriers of a Narrow View. Seven respondents indicated an overall perceptual issue of administrative and parent stakeholders regarding technology and engineering being vocational courses versus part of the general education program in secondary schools. Results are found in Table 56.

Four respondents noted the issue of what is commonly referred to as the “siloed” approach of STEM courses with no integrative activities. One respondent detailed this issue:

> Yes. Many teachers, including Tech Ed, do not always see the value of the “integration.” Jim Stone’s research has shown many examples. It is not just the “technology” knowledge skills teachers need, but also how to integrate the mathematics and the science and know the engineering correlations. Huge package for one person to know.

With regard to the siloed approach to STEM, one respondent indicated “...we are making a strong shift to CORE and STEM and we support all four letters of STEM and see them as a team that no letter can stand alone”.

One respondent gave detail of an experienced situation regarding differing views within disciplines regarding integration: “Math teacher saying that she doesn’t care what the science dept does with the math she teachers as it is irrelevant to what she does”.

STEM for geared only for the highest academic achievers was identified as a factor detailed later in this chapter and noted by one respondent as a poor use of resources: “Administration and therefore the parents do not see STEM helping the general population - only the top students. Therefore, STEM is a waste of taxpayer resources”.

Table 56

Open-Ended Response Themes Regarding Barriers of a Narrow View

Identified Themes	*n*
Technology and Engineering viewed as a vocational	7
Differing views of what engineering instruction should look like in K-12	4
S.T.E.M. vs integrated STEM, also referred to as the “siloed” approach	4
The missing T and E in STEM	2
STEM for some, not for all	1

Open-ended response themes regarding Barriers of Perception. Themes regarding *Barriers of Perception* are found in Table 57. Various statements were made regarding issues noted in the iSTEMIBI regarding *STEM as a Fad* (*n* = 2) and may be representative of the view of older teachers: “Some teachers think STEM is a fad, that we will be talking about something different in a year or two. The older teachers especially”. Another noted earlier integrated movements beginning in the 1980s and STEM was “...becoming a buzz word again”.

Also noted was an issue regarding an on-going perception within general school disciplines towards the technology education field being a *Dumping Ground* (*n* = 2) for students. This may also tie back to the *Narrow View* issue of technology education being viewed as a vocational discipline, and not a general education discipline within K-12.

Resistance due to perception of *Teacher-Centered* (*n* = 2) being an easier teaching method was noted: “Most core areas are used to teacher centered learning. It is easier to grade, if everyone is doing the same thing”.

Table 57

Open-Ended Response Themes Regarding Barriers of Perception

Identified Themes	*n*
STEM is just a fad	2
Technology education is a dumping ground	2
Teacher-centered vs student-centered	2

Open-ended response themes regarding Barriers of Regulation. Results regarding *Barriers of Regulation* open-ended responses are found in Table 58. *Mandates subverting local control* (*n* = 5), issues due to *Class size* (*n* = 2), and regulations regarding *Seat time* (*n* = 2) emerged as issues regarding *Barriers of Regulation*. A respondent noted the traditional seven-period day (Carnegie seat time) as a barrier and suggested the use of “modified block and block scheduling” would work better for project-based learning.

Table 58

Open-Ended Response Themes Regarding Barriers of Regulation

Identified Themes	*n*
Mandates subverting local control	5
Class size issues	2
Carnegie seat time requirements	2

Open-ended response theme emerging for future barriers consideration. Analysis of the open-ended responses identified a potential barrier for consideration in future research: *Student-Related Issues*. Results are found in Table 59. Within this theme several possible conceptual items were identified: *Student Interest/Discipline* (*n* = 4); *Student Preparedness* (*n* = 3); *Creating STEM curriculum for IEPs and 504 accommodations* (*n* = 1); and *Students pursuing engineering degrees without technology and engineering background* (*n* = 1).

Table 59

Open-Ended Response Theme Emerging for Future Barriers Research Consideration

Identified Themes	*n*
New Concept: Student-Related Issues	
Student Interest/Discipline	4
Student Preparedness	3
Creating STEM curriculum for IEPs and 504 accommodations	1
Students pursuing careers in STEM without any T and E background	1

Research Question 4

To answer Research Question 4 (*What factors contribute to iSTEM implementation?)* dimensionality of the 50 items in the iSTEMIBI measure were statistically analyzed utilizing principal component analysis (PCA). An initial item-by-item analysis yielded communality values ranging from .465 to .894. Communality values for each item in the iSTEMIBI are found in Appendix G.

Initially, the PCA was run with null values for those indicating *No Opinion/Don't know.* A second analysis was run with null values imputed by replacing null scores with the mean within the item. The process allowed a larger number of samples within each factor and the resulting output revealed negligible differences. Due to the initial strength of the communality values, .4 was established as the cut off for loadings using the direct oblique setting to create a pattern matrix output. Items with the highest correlations were analyzed conceptually to determine what underlying concept bound the items. Output indicated 11 component factors. Of the 11 factors identified, five were identical to the original constructs on an item-by-item item basis within each construct and thus titles were retained or slightly adapted: *Technology and Engineering Standards; Perception; No Child Left Behind; Male-Oriented Content* (originally Gender Barriers)*; and Resources.* In addition, six more factors were identified: *Teacher Education Gap in iSTEM Methodology; Resistance to iSTEM-Based Reform; Resistance to Changing Teaching Methodology; Limited View of iSTEM; The Missing "T and E" of iSTEM; and Status Quo Regarding Science and Mathematics.* Table 51 lists each factor, associated items and loading values.

Table 60

Factor Loadings by Item.

Factor 1: Teacher Education Gap in iSTEM Methodology

Item	Loadings
36. Lack of integrative STEM methodology in secondary teacher education programs limits implementation.	.814
34. Limited availability of professional development for pre-service teachers is an issue.	.706
35. Lack of integrative STEM methodology in elementary teacher education programs limits implementation.	.684
30. A shortage of teachers trained in integrative STEM education limits implementation.	.669
29. Funding for professional development is an issue.	.555
31. Limited availability of professional development for in-service teachers is an issue.	.545
37. Integrative STEM education is limited by low numbers of teacher education programs that include technological literacy as part of content and methods courses.	.529

(continued)

Factor 2: Technology and Engineering Education Standards (continued)

Item	Loadings
43. Lack of required K-12 technology and engineering standards limits integrative STEM implementation.	.958
45. Lack of required K-12 technology and engineering standards limits student assessment in integrative STEM curriculum.	.900
44. Lack of required K-12 technology and engineering standards limits professional development in integrative STEM curriculum.	.878
Factor 3: Resistance to iSTEM-Based Reform	
67. There is currently a lack of incentives to motivate key outcomes for improving educational quality.	.700
66. State and federal regulatory boundaries are rigid and constrain local educational reform.	.607
17. Without collaboration of educators and stakeholders, implementation is limited.	.598
16. Non-supportive teachers hinder implementation of integrative STEM education.	.520
68. Class-periods and seat-time requirements constrain the use of integrative STEM methods.	.452
Factor 4: Perception	
60. STEM is perceived by educators as another “fad” that will soon go away.	.696
61. Negative perception of open-ended inquiry learning limits implementation of integrative STEM education.	.655
64. A perception that integrative STEM education addresses only workforce issues limits implementation.	.629
63. A perception that mathematics is not a significant part of science education is an issue.	.627
62. There is a negative perception that integrative STEM education diminishes the individual importance of each content area.	.602
Factor 5: No Child Left Behind	
41. The requirements of NCLB limit time available for integrative STEM education.	.775
40. Assessment innovation is limited by Adequate Yearly Progress (AYP) indicator required by NCLB..	.705
39. Current standardized assessments are limited in measurement of mastery in project and problem-based learning.	.669
Factor 6: Male-Oriented Content	
47. The perception of STEM as a male-oriented curriculum limits its significance.	.969
48. The perception of STEM as a male-oriented curriculum limits implementation.	.926
Factor 7: Resistance to Changing Classroom Methodology	
9. Teachers are uncomfortable with their ability to deliver engineering content and concepts.	.843
8. Teachers are uncomfortable with implementing technology content and concepts.	.828
21. Teachers don't feel empowered to change teaching methods to include integrative STEM.	.417

(continued)

Factor 8: Resources (continued)

Item	Loadings
26. Inadequate facilities limit STEM implementation.	.807
24. Lack of needed resources (funding, equipment, supplies, etc.) causes issues for implementing integrative STEM education.	.698
25. Reliance on textbooks and other outdated classroom resources hinder integrative STEM implementation.	.626
Factor 9: Limited View of iSTEM	
54. Current education practices delivering separate and "siloed" instruction, limits implementation of integrative STEM.	-.708
55. The perception that technology and engineering education teachers cannot teach science or mathematics content is a barrier to implementation of integrative STEM education.	-.489
52. For many stakeholders, STEM education consists only of science and mathematics.	-.472
51. For many educators, STEM education consists only of science and mathematics.	-.437
Factor 10: The Missing "T and E" of STEM	
13. Buy-in of stakeholders regarding preparing students for careers in engineering is an issue.	.618
15. Implementation of integrative STEM education is negatively affected by lack of stakeholder involvement.	.576
50. Policy makers and leaders fail to recognize the equal importance of the full spectrum of integrative STEM education.	.500
14. Buy-in of teachers regarding preparing students for careers in engineering is an issue.	.475
52. For many stakeholders, STEM education consists only of science and mathematics.	.404
22. Lack of support by administrators hinders implementation.	.401
Factor 11: The Status Quo Regarding Science and Mathematics Methodology	
56. Science educators see no need to change methodology to include technology and engineering.	-.870
57. Mathematics educators see no need to change methodology to include technology and engineering.	-.840
58. The perception that inclusion of technology and engineering limits time for learning mathematics and science, limits implementation of integrative STEM curriculum.	-.797

Following the establishment of the 11 factors, each factor was analyzed utilizing a one-way ANOVA to determine if the factor contained significant mean difference between identified groups based on reported demographics: *Implementation Level; Grade Level;* and *Content Area.* A second analysis of factors by individual groups was conducted utilizing a post hoc Tukey HSD analysis. The Tukey analysis allowed the evaluation of paired differences among means within each identified factor. Results were determined to be significant at $p \leq .05$. The mean value in each table reflects a mean standardized score indicating the individual group variance from the standardized score.

Between group analysis of Implementation Level and Factor 1: Teacher Education Gap in iSTEM Methodology. Results of the *Implementation Level* group comparisons within the *Teacher Education Gap in iSTEM Methodology* are found in Table 61. No significant difference was indicated through the analysis, *F* = (3, 139) = 1.31, *p* = .273.

Table 61

ANOVA for Teacher Education Gap in iSTEM Methodology (Factor 1) by Implementation Level (p = .05)

		NI	P	PI	FI	Paired Difference	*p* value
Factor 1: Teacher	*N:*	45	21	59	18	NI/P: .136	NI/P: .955
Education Gap in	M^a:	.122	.258	-.107	-.255	NI/PI: .229	NI/PI: .653
in iSTEM	*SD:*	.995	.449	1.006	1.369	NI/FI: .377	NI/FI: .529
Methodology						P/PI: .365	P/PI: .476
						P/FI: .513	P/FI: .380
						PI/FI: .148	PI/FI: .946

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

^{a} Computed factor scores are standardized

Between group analysis of Grade Level and Factor 1: Teacher Education Gap in iSTEM Methodology. Results of the *Grade Level* group comparisons within the *Teacher Education Gap in iSTEM Methodology* are found in Table 62.

Table 62

ANOVA for Teacher Education Gap in iSTEM Methodology (Factor 1) by Grade Level (p = .05)

		ES	MS	HS	MSHS	Paired Difference	*p* value
Factor 1: Teacher	*N:*	29	30	61	23	ES/MS: .239	ES/MS: .787
Education Gap in	M^a:	-.004	-.244	-.056	.472	ES/HS: .052	ES/HS: .996
in iSTEM	*SD:*	.789	1.023	1.113	.762	ES/MSHS: .477	ES/MSHS: .310
Methodology						MS/HS: .188	MS/HS: .828
						MS/MSHS: .716	MS/ MSHS: *.047
						HS/MSHS: .529	HS/MSHS: .130

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

^{a} Computed factor scores are standardized

The overall one-way ANOVA test of variance indicated near significant difference in the *Grade Level* group, *F* = (3, 139) = 2.44, *p* = .067. Further post hoc Tukey analysis determined significant difference between the *Middle School* and *Middle School/High School* groups (*p* = .047).

Between group analysis of Content Area and Factor 1: Teacher Education Gap in iSTEM Methodology. Results of the *Content Area* group comparisons within the *Teacher Education Gap in iSTEM Methodology* are found in Table 63. No significant difference was indicated through analysis, *F* = (4, 138) = 0.86, *p* = .490.

Table 63

ANOVA for Teacher Education Gap in iSTEM Methodology (Factor 1) by Content Area (p = .05)

		S	TE	M	E	NS	Paired Difference	*p* value
Factor 1: Teacher Education Gap in in iSTEM Methodology	*N:*	30	42	11	15	45	S/TE: .239	S/TE: .856
	M^a:	-.030	.209	.013	.027	-.187	S/M: .043	S/M: 1.000
	SD:	.841	.874	.977	.575	1.284	S/E: .054	S/E: 1.000
							S/NS: .157	S/NS: .963
							TE/M: .196	TE/M: .978
							TE/E: .185	TE/E: .973
							TE/NS: .396	TE/NS: .353
							M/E: .012	M/E: 1.000
							M/NS: .200	M/NS: .976
							E/NS: .212	E/NS: .954

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported, NS=*Non-STEM* content background.
[a] Computed factor scores are standardized

Between group analysis of Implementation Level and Factor 2: Technology and Engineering Standards. Results of the *Implementation Level* group comparisons within the *Teacher Education Gap in iSTEM Methodology* are found in Table 64. A one-way ANOVA test of variance within *Factor 2: Technology and Engineering Standards* indicated a near significant difference within the *No Implementation* and *Full Implementation* groups, *F* = (3, 139) = 2.25, *p* = .086.

Table 64

ANOVA for Technology and Engineering Standards (Factor 2) by Implementation Level (p = .05)

		NI	P	PI	FI	Paired Difference	*p* value
Factor 2:	*N:*	45	21	59	18	NI/P: .432	NI/P: .351
Technology and	M^a:	.222	-.211	.038	-.431	NI/PI: .184	NI/PI: .782
Engineering	*SD:*	.926	1.157	.929	1.108	NI/FI: .653	NI/FI: .088
Standards						P/PI: .248	P/PI: .756
						P/FI: .221	P/FI: .898
						PI/FI: .469	PI/FI: .295

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

[a] Computed factor scores are standardized

Between group analysis of Grade Level and Factor 2: Technology and Engineering Standards. Results of the *Grade Level* group comparisons within the *Technology and Engineering Standards* factor are found in Table 65. A one-way ANOVA did not indicate significant difference, *F* = (3, 139) = 1.41, *p* = .242.

Table 65

ANOVA for Technology and Engineering Standards (Factor 2) by Grade Level (p = .05)

		ES	MS	HS	MSHS	Paired Difference	*p* value
Factor 2:	*N:*	29	30	61	23	ES/MS: .339	ES/MS: .561
Technology and	M^a:	.231	-.108	-.140	.220	ES/HS: .371	ES/HS: .354
Engineering	*SD:*	.952	.888	1.056	1.015	ES/MSHS: .011	ES/MSHS: 1.000
Standards						MS/HS: .032	MS/HS: .999
						MS/MSHS: .328	MS/ MSHS: 636
						HS/MSHS: .359	HS/MSHS: .455

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

[a] Computed factor scores are standardized

Between group analysis of Content Area and Factor 2: Technology and Engineering Standards. ANOVA and post hoc Tukey analysis on *Factor 2: Technology and Engineering Standards* indicated no significant difference within the *Content Area* groups, *F* = (4, 138) = 0.82, *p* = .517. Results are found in Table 66.

Table 66

ANOVA for Technology and Engineering Standards (Factor 2) by Content Area (p = .05)

		S	TE	M	E	NS	Paired Difference	*p* value
Factor 2: Technology and Engineering Standards	*N:*	30	42	11	15	45	S/TE: .322	S/TE: .663
	M^{a}:	.286	-.036	-.172	-.078	-.088	S/M: .459	S/M: .693
	SD:	.780	1.160	.809	.806	1.070	S/E: .365	S/E: .780
							S/NS: .375	S/NS: .509
							TE/M: .136	TE/M: .995
							TE/E: .042	TE/E: 1.000
							TE/NS: .052	TE/NS: .999
							M/E: .094	M/E: .999
							M/NS: .084	M/NS: .999
							E/NS: .010	E/NS: 1.000

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported, NS=*Non-STEM* content background.

[a] Computed factor scores are standardized

Between group analysis of Implementation Level and Factor 3: Resistance to iSTEM-Based Reform. ANOVA and post hoc Tukey analysis on *Factor 3: Resistance to iSTEM-Based Reform* indicated no significant difference within the *Implementation Level* groups, *F* = (3, 139) = 1.58, *p* = .197. Results are found in Table 67.

Table 67

ANOVA for Resistance to iSTEM-Based Reform (Factor 3) by Implementation Level (p = .05)

		NI	P	PI	FI	Paired Difference	*p* value
Factor 3: Resistance to iSTEM-Based Reform	*N:*	45	21	59	18	NI/P: .427	NI/P: .367
	M^{a}:	-.051	.376	-.004	-.298	NI/PI: .047	NI/PI: .995
	SD:	1.054	.827	943	1.166	NI/FI: .247	NI/FI: .810
						P/PI: .380	P/PI: .437
						P/FI: .674	P/FI: .155
						PI/FI: .294	PI/FI: .692

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

[a] Computed factor scores are standardized

Between group analysis of Grade Level and Factor 3: Resistance to iSTEM-Based Reform. Table 68 contains results of ANOVA and post hoc Tukey analysis on *Factor 3: Resistance to iSTEM-Based Reform* indicating no significant difference within the *Grade Level* groups, *F* = (3, 139) = 0.99, *p* = .400.

Table 68

ANOVA for Resistance to iSTEM-Based Reform (Factor 3) by Grade Level (p = .05)

		ES	MS	HS	MSHS	Paired Difference	*p* value
Factor 3:	*N:*	29	30	61	23	ES/MS: .149	ES/MS: .940
Resistance to	M^a:	.221	.072	-.054	-.229	ES/HS: .276	ES/HS: .614
iSTEM-Based	*SD:*	.677	.886	1.026	1.354	ES/MSHS: .451	ES/MSHS: .374
Reform						MS/HS: .126	MS/HS: .942
						MS/MSHS: .301	MS/ MSHS: .698
						HS/MSHS: .175	HS/MSHS: .891

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

[a] Computed factor scores are standardized

Between group analysis of Content Area and Factor 3: Resistance to iSTEM-Based Reform. ANOVA and post hoc Tukey analysis on *Factor 3: Resistance to iSTEM-Based Reform* indicated no significant difference within the *Content Area* groups, *F* = (4, 138) = 0.23, *p* = .923. Results are found in Table 69.

Table 69

ANOVA for Resistance to iSTEM-Based Reform (Factor 3) by Content Area (p = .05)

		S	TE	M	E	NS	Paired Difference	*p* value
Factor 3:	*N:*	30	42	11	15	45	S/TE: .192	S/TE: .932
Resistance to	M^a:	-.144	.048	.105	.076	.000	S/M: .249	S/M: 956
iSTEM-Based	*SD:*	1.059	.939	.653	1.002	1.108	S/E: .220	S/E: .959
Reform							S/NS: .144	S/NS: .974
							TE/M: .057	TE/M: 1.000
							TE/E: .028	TE/E: 1.000
							TE/NS: .047	TE/NS: .999
							M/E: .029	M/E: 1.000
							M/NS: .105	M/NS: .998
							E/NS: .075	E/NS: .999

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported, NS=*Non-STEM* content background.

[a] Computed factor scores are standardized

Between group analysis of Implementation Level and Factor 4: Perception. ANOVA and post hoc Tukey analysis on *Factor 4: Perception* indicated no significant difference within the *Implementation Level* groups, *F* = (3, 139) = 0.28, *p* = .838. Results are found in Table 70.

Table 70

ANOVA for Perception (Factor 4) by Implementation Level (p = .05)

		NI	P	PI	FI	Paired Difference	*p* value
Factor 4:	*N:*	45	21	59	18	NI/P: .197	NI/P: .881
Perception	M^a:	-.068	.129	.040	-.109	NI/PI: .108	NI/PI: .949
	SD:	1.003	.935	.968	1.215	NI/FI: .040	NI/FI: .999
						P/PI: .089	P/PI: .986
						P/FI: .237	P/FI: .884
						PI/FI: .148	PI/FI: .948

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.
[a] Computed factor scores are standardized

Between group analysis of Grade Level and Factor 4: Perception. Table 71 contains ANOVA and post hoc Tukey analysis regarding *Factor 4: Perception* indicating no significant difference within the *Grade Level* groups, *F* = (3, 139) = 0.97, *p* = .409.

Table 71

ANOVA for Perception (Factor 4) by Grade Level (p = .05)

		ES	MS	HS	MSHS	Paired Difference	*p* value
Factor 4:	*N:*	29	30	61	23	ES/MS: .033	ES/MS: .999
Perception	M^a:	.164	.132	-.160	.044	ES/HS: .325	ES/HS: .477
	SD:	1.042	.982	.989	1.001	ES/MSHS: .121	ES/MSHS: .973
						MS/HS: .291	MS/HS: .561
						MS/MSHS: .087	MS/ MSHS: .989
						HS/MSHS: .204	HS/MSHS: .839

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.
[a] Computed factor scores are standardized

Between group analysis of Content Area and Factor 4: Perception. ANOVA and post hoc Tukey analysis on *Factor 4: Perception* indicated no significant difference within *Content Level*, *F* = (4, 138) = 0.71, *p* = .584. Results are found in Table 72.

Table 72

ANOVA for Perception (Factor 4) by Content Area (p = .05)

		S	TE	M	E	NS	Paired Difference	*p* value
Factor 4:	*N:*	30	42	11	15	45	S/TE: .216	S/TE: .897
Perception	*M*^{a}*:*	-.174	.041	.126	-.252	.131	S/M: .300	S/M: .915
	SD:	.840	1.020	1.167	1.054	1.032	S/E: .078	S/E: .999
							S/NS: .305	S/NS: .699
							TE/M: .084	TE/M: .999
							TE/E: .293	TE/E: .868
							TE/NS: .089	TE/NS: .994
							M/E: .377	M/E: .878
							M/NS: .005	M/NS: 1.000
							E/NS: .383	E/NS: .705

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported*,* NS=*Non-STEM* content background.

[a] Computed factor scores are standardized

Between group analysis of Implementation Level and Factor 5: No Child Left Behind. ANOVA and post hoc Tukey analysis on *Factor 5: No Child Left Behind* indicated no significant difference within the *Implementation Level* groups, *F* = (3, 139) = 1.09, *p* = .356. Results are found in Table 73.

Table 73

ANOVA for No Child Left Behind (Factor 5) by Implementation Level (p = .05)

		NI	P	PI	FI	Paired Difference	*p* value
Factor 5: NCLB	*N:*	45	21	59	18	NI/P: .300	NI/P: .669
	M^{a}*:*	.219	-.081	-.086	-.172	NI/PI: .305	NI/PI: .416
	SD:	1.012	1.342	.929	.667	NI/FI: .391	NI/FI: .500
						P/PI: .005	P/PI: 1.000
						P/FI: .091	P/FI: .992
						PI/FI: .086	PI/FI: .989

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

[a] Computed factor scores are standardized

Between group analysis of Grade Level and Factor 5: No Child Left Behind. Table 74 contains ANOVA and post hoc Tukey analysis on *Factor 5: No Child Left Behind* indicated no difference within the *Grade Level* groups, *F* = (3, 139) = 0.26, *p* = .854.

Table 74

ANOVA for No Child Left Behind (Factor 5) by Grade Level (p = .05)

		ES	MS	HS	MSHS	Paired Difference	*p* value
Factor 5: NCLB	*N:*	29	30	61	23	ES/MS: .142	ES/MS: .949
	M^a:	.034	-.109	-.012	.132	ES/HS: .046	ES/HS: .997
	SD:	1.047	.934	1.087	.807	ES/MSHS: .098	ES/MSHS: .985
						MS/HS: .097	MS/HS: .973
						MS/MSHS: .240	MS/ MSHS: .825
						HS/MSHS: .144	HS/MSHS: .937

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

[a] Computed factor scores are standardized

Between group analysis of Content Area and Factor 5: No Child Left Behind.

ANOVA and post hoc Tukey analysis on *Factor 5: No Child Left Behind* indicated no significant difference, *F* = (4, 138) = 0.75, *p* = .561. Results are found in Table 75.

Table 75

ANOVA for No Child Left Behind (Factor 5) by Content Area (p = .05)

		S	TE	M	E	NS	Paired Difference	*p* value
Factor 5: NCLB	*N:*	30	42	11	15	45	S/TE: .332	S/TE: .639
	M^a:	-.110	.222	-.136	-.040	-.088	S/M: .027	S/M: 1.000
	SD:	1.108	.765	.848	.907	1.174	S/E: .069	S/E: .999
							S/NS: .022	S/NS: 1.000
							TE/M: .359	TE/M: .829
							TE/E: .263	TE/E: .908
							TE/NS: .310	TE/NS: .603
							M/E: .096	M/E: .999
							M/NS: .049	M/NS: 1.000
							E/NS: .048	E/NS: 1.000

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*,
E= *Elementary* specialization/generalist reported, NS=*Non-STEM* content background.

[a] Computed factor scores are standardized

Between group analysis of Implementation Level and Factor 6: Male-Oriented Content. ANOVA and post hoc Tukey analysis on *Factor 6: Male-Oriented Content* indicated no significant difference within the *Implementation Level* groups, *F* = (3, 139) = 2.17, *p* = .094. Results are found in Table 76.

Table 76

ANOVA for Male-Oriented Content (Factor 6) by Implementation Level (p = .05)

		NI	P	PI	FI	Paired Difference	*p* value
Factor 6:	*N:*	45	21	59	18	NI/P: .029	NI/P: 1.000
Male-Oriented Content	*M*[a]*:*	.228	.199	-.144	-.329	NI/PI: .372	NI/PI: .231
	SD:	1.001	.977	.986	.973	NI/FI: .558	NI/FI: .184
						P/PI: .343	P/PI: .522
						P/FI: .528	P/FI: .346
						PI/FI: .185	PI/FI: .899

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

[a] Computed factor scores are standardized

Between group analysis of Grade Level and Factor 6: Male-Oriented Content.

Table 77 contains ANOVA and post hoc Tukey analysis regarding *Factor 6: Male-Oriented Content* indicating no significant difference within the *Grade Level* groups, *F* = (3, 139) = 0.55, *p* = .651.

Table 77

ANOVA for Male-Oriented Content (Factor 6) by Grade Level (p = .05)

		ES	MS	HS	MSHS	Paired Difference	*p* value
Factor 6:	*N:*	29	30	61	23	ES/MS: .094	ES/MS: .984
Male-Oriented	*M*[a]*:*	-.076	-.169	.081	.100	ES/HS: .157	ES/HS: .900
Content	*SD:*	.997	.982	1.042	.940	ES/MSHS: .176	ES/MSHS: .923
						MS/HS: .250	MS/HS: .679
						MS/MSHS: .269	MS/ MSHS: .769
						HS/MSHS: .019	HS/MSHS: 1.000

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

[a] Computed factor scores are standardized

Between group analysis of Content Area and Factor 6: Male-Oriented Content. A one-way ANOVA test of variance within *Factor 6: Male-Oriented Content* indicated significant difference within the *Content Area* groups, *F* = (4, 138) = 3.04, *p* = .019. Further post hoc Tukey analysis found significant difference between the *Technology and Engineering* and *Non-STEM* groups (*p* = .042). Also near significant differences were found between the *Technology and*

Engineering and *Science* groups (*p* = .081), and the *Technology and Engineering* and *Elementary* groups (*p* = .092). Results are found in Table 78.

Table 78

ANOVA for Male-Oriented Content (Factor 6) by Content Area (p = .05)

		S	TE	M	E	NS	Paired Difference	*p* value
Factor 6:	*N:*	30	42	11	15	45	S/TE: .598	S/TE: .081
Male-Oriented	M^a:	-.192	.407	.167	-.330	-.183	S/M: .358	S/M: .834
Content	*SD:*	1.034	.933	1.105	1.011	.921	S/E: .138	S/E: .991
							S/NS: .009	S/NS: 1.000
							TE/M: .240	TE/M: .949
							TE/E: .737	TE/E: .092
							TE/NS: .590	TE/NS: *.042
							M/E: .496	M/E: .700
							M/NS: .350	M/NS: .822
							E/NS: .147	E/NS: .987

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported, NS=*Non-STEM* content background.
[a] Computed factor scores are standardized

Between group analysis of Implementation level and Factor 7: Resistance to Changing Teaching Methodology. A one-way ANOVA test of variance within *Factor 7: Resistance to Changing Teaching Methodology* indicated significant difference within the *Implementation Level* groups, *F* = (3, 139) = 4.24, *p* = .007. Results are found in Table 79. Further post hoc Tukey analysis indicated significant differences in the following: *No Implementation* and *Full Implementation* (*p* = .004); *Preparation* and *Full Implementation* (*p* = .029); and *Partial Implementation* and *Full Implementation* (*p* = .042).

Table 79

ANOVA for Resistance to Changing Teaching Methodology (Factor 7) by Implementation Level (p = .05)

		NI	P	PI	FI	Paired Difference	*p* value
Factor 7: Resistance to	*N:*	45	21	59	18	NI/P: .064	NI/P: .994
Changing Teaching	*M*^{a}*:*	.227	.162	-.014	-.708	NI/PI: .241	NI/PI: .591
Methodology	*SD:*	1.010	.937	.908	1.080	NI/FI: .935	NI/FI: *.004
						P/PI: .177	P/PI: .889
						P/FI: .871	P/FI: *.029
						PI/FI: .694	PI/FI: *.042

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

^{a} Computed factor scores are standardized

Between group analysis of Grade level and Factor 7: Resistance to Changing Teaching Methodology. A one-way ANOVA test of variance within *Factor 7: Resistance to Changing Teaching Methodology* indicated a value approaching significant difference, *F* = (3, 139) = 2.29, *p* = .081. Further post hoc Tukey analysis indicated near difference in means between the *Elementary School* and *Middle School* (*p* = .103) and the *Elementary School* and *High School* (*p* = .089) groups. Results are found in Table 80.

Table 80

ANOVA for Resistance to Changing Teaching Methodology (Factor 7) by Grade Level (p = .05)

		ES	MS	HS	MSHS	Paired Difference	*p* value
Factor 7:	*N:*	29	30	61	23	ES/MS: .591	ES/MS: .103
Resistance to	*M*^{a}*:*	.420	-.171	-.105	-.028	ES/HS: .528	ES/HS: .089
Changing Teaching	*SD:*	.842	.992	1.023	1.048	ES/MSHS: .478	ES/MSHS: .367
Methodology						MS/HS: .065	MS/HS: .991
						MS/MSHS: .143	MS/ MSHS: .953
						HS/MSHS: .078	HS/MSHS: .988

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

^{a} Computed factor scores are standardized

Between group analysis of Content Area and Factor 7: Resistance to Changing Teaching Methodology. A one-way ANOVA test of variance within *Factor 7: Resistance to*

Changing Teaching Methodology indicated no significant difference between groups by *Content Area*, *F* = (4, 138) = 0.64, *p* = .634). Refer to Table 81 for results.

Table 81

ANOVA for Resistance to Changing Teaching Methodology (Factor 7) by Content Area (p = .05)

		S	TE	M	E	NS	Paired Difference	*p* value
Factor 7:	*N:*	30	42	11	15	45	S/TE: .241	S/TE: .853
Resistance to	M^a:	.104	-.137	.068	.293	-.056	S/M: .036	S/M: 1.000
Changing Teaching	*SD:*	.907	.981	.728	.939	1.152	S/E: .188	S/E: .976
Methodology							S/NS: .160	S/NS: .961
							TE/M: .205	TE/M: .974
							TE/E: .430	TE/E: .615
							TE/NS: .081	TE/NS: .996
							M/E: .224	M/E: .980
							M/NS: .124	M/NS: .996
							E/NS: .349	E/NS: .772

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported, NS=*Non-STEM* content background.
[a] Computed factor scores are standardized

Between group analysis of Implementation Level and Factor 8: Resources. A one-way ANOVA test of variance within *Factor 8: Resources* indicated no significant difference by *Implementation Level*, *F* = (3, 139) = 1.15, *p* = .330. See Table 82.

Table 82

ANOVA for Resources (Factor 8) by Implementation Level (p = .05)

		NI	P	PI	FI	Paired Difference	*p* value
Factor 8:	*N:*	45	21	59	18	NI/P: .120	NI/P: .969
Resources	M^a:	.081	.201	-.026	-.354	NI/PI: .107	NI/PI: .949
	SD:	.963	.684	1.077	1.113	NI/FI: .436	NI/FI: .402
						P/PI: .227	P/PI: .808
						P/FI: .556	P/FI: .311
						PI/FI: .329	PI/FI: .613

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.
[a] Computed factor scores are standardized

Between group analysis of Grade Level and Factor 8: Resources. A one-way ANOVA test of variance between groups in *Factor 8: Resources* indicated no significant difference, *F* = (3, 139) = 1.77, *p* = .156. Within group analysis indicated a value approaching significant difference between the *Elementary School* and *Middle School* groups (*p* = .108). Results are found in Table 83.

Table 83

ANOVA for Resources (Factor 8) by Grade Level (p = .05)

		ES	MS	HS	MSHS	Paired Difference	*p* value
Factor 8:	*N:*	29	30	61	23	ES/MS: .589	ES/MS: .108
Resources	M^a:	.330	-.260	-.013	-.042	ES/HS: .343	ES/HS: .421
	SD:	.753	1.200	1.025	.864	ES/MSHS: .371	ES/MSHS: .539
						MS/HS: .246	MS/HS: .681
						MS/MSHS: .218	MS/ MSHS: .858
						HS/MSHS: .029	HS/MSHS: .999

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

^{a} Computed factor scores are standardized

Between group analysis of Content Area and Factor 8: Resources. A one-way ANOVA test of variance within *Factor 8: Resources* indicated no significant difference between groups, *F* = (4, 138) = 0.39, *p* = .818. Results are found in Table 84.

Table 84

ANOVA for Resources (Factor 8) by Content Area (p = .05)

		S	TE	M	E	NS	Paired Difference	*p* value
Factor 8:	*N:*	30	42	11	15	45	S/TE: .096	S/TE: .995
Resources	M^a:	.147	.051	.033	-.126	-.112	S/M: .115	S/M: .998
	SD:	1.003	1.081	.766	.951	1.010	S/E: .273	S/E: .912
							S/NS: .259	S/NS: .811
							TE/M: .019	TE/M: 1.000
							TE/E: .177	TE/E: .977
							TE/NS: .163	TE/NS: .943
							M/E: .158	M/E: .995
							M/NS: .144	M/NS: .993
							E/NS: .014	E/NS: 1.000

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported*,* NS=*Non-STEM* content background.

^{a} Computed factor scores are standardized

Between group analysis of Implementation Level and Factor 9: Limited View of iSTEM. A one-way ANOVA test of variance within *Factor 9: Limited View of iSTEM* indicated significant difference between groups by *Implementation Level, F* = (3, 139) = 2.82, *p* = .041. Refer to Table 85. Post hoc Tukey analysis revealed significant difference between the *No* Implementation and *Full* Implementation (*p* = .035) groups. One comparison indicated near significance: *Partial* Implementation and *Full Implementation* (*p* = .052).

Table 85

ANOVA for Limited View of iSTEM (Factor 9) by Implementation Level (p = .05)

		NI	P	PI	FI	Paired Difference	*p* value
Factor 9: Limited View of iSTEM	*N:*	45	21	59	18	NI/P: .023	NI/P: 1.000
	M[a]:	-.125	-.102	-.059	.625	NI/PI: .067	NI/PI: .986
	SD:	1.110	1.031	.810	1.093	NI/FI: .750	NI/FI: *.035
						P/PI: .044	P/PI: .998
						P/FI: .727	P/FI: .101
						PI/FI: .683	PI/FI: .052

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

[a] Computed factor scores are standardized

Between group analysis of Grade Level and Factor 9: Limited View of iSTEM. A one-way ANOVA test of variance within *Factor 9: Limited View of iSTEM* indicated no significant difference between groups by *Grade Level, F* = (3, 139) = 0.86, *p* = .465. Results are found in Table 86.

Table 86

ANOVA for Limited View of iSTEM (Factor 9) by Grade Level (p = .05)

		ES	MS	HS	MSHS	Paired Difference	*p* value
Factor 9: Limited View of iSTEM	*N:*	29	30	61	23	ES/MS: .009	ES/MS: 1.000
	M[a]*:*	.103	.112	-.155	.137	ES/HS: .258	ES/HS: .664
	SD:	.950	.840	.997	1.244	ES/MSHS: .034	ES/MSHS: .999
						MS/HS: .267	MS/HS: .631
						MS/MSHS: .025	MS/ MSHS: 1.000
						HS/MSHS: .292	HS/MSHS: .633

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

[a] Computed factor scores are standardized

Between group analysis of Content Area and Factor 9: Limited View of iSTEM. A one-way ANOVA test of variance within *Factor 9: Limited View of iSTEM* indicated no significant difference by *Content Area Level, F* = (4, 138) = 1.57, *p* = .185. Results are found in Table 87.

Table 87

ANOVA for Limited View of iSTEM (Factor 9) by Content Area (p = .05)

		S	TE	M	E	NS	Paired Difference	*p* value
Factor 9: Limited View of iSTEM	*N:*	30	42	11	15	45	S/TE: .133	S/TE: .981
	M^a:	-.193	-.060	-.307	.480	.099	S/M: .114	S/M: .998
	SD:	.830	1.200	.386	.929	.991	S/E: .673	S/E: .208
							S/NS: .292	S/NS: .723
							TE/M: .247	TE/M: .948
							TE/E: .540	TE/E: .372
							TE/NS: .159	TE/NS: .945
							M/E: .787	M/E: .273
							M/NS: .406	M/NS: .742
							E/NS: .381	E/NS: .699

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported, NS=*Non-STEM* content background.

[a] Computed factor scores are standardized

Between group analysis of Implementation Level and Factor 10: The Missing T and E of iSTEM. A one-way ANOVA test of variance within *Factor 10: The Missing T and E of iSTEM* indicated no difference between groups*, F* = (3, 139) = 1.60, *p* = .191. See Table 88.

Table 88

ANOVA for The Missing "T and E" of iSTEM (Factor 10) by Implementation Level (p = .05)

		NI	P	PI	FI	Paired Difference	*p* value
Factor 10: The Missing "T and E" of iSTEM	*N:*	45	21	59	18	NI/P: .232	NI/P: .813
	M^a:	.221	-.011	-.054	-.363	NI/PI: .275	NI/PI: .502
	SD:	.981	.980	1.062	.778	NI/FI: .584	NI/FI: .156
						P/PI: .043	P/PI: .998
						P/FI: .352	P/FI: .689
						PI/FI: .309	PI/FI: .656

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

[a] Computed factor scores are standardized

Between group analysis of Grade Level and Factor 10: The Missing T and E of iSTEM. A one-way ANOVA test of variance within *Factor 10: The Missing T and E of iSTEM* indicated no significant difference between groups by *Grade Level* $F = (3, 139) = 2.11$, $p = .102$. Further post hoc Tukey analysis did indicate a near significant difference between the *Elementary* School and *Middle* School groups ($p = .092$). Results are found in Table 89.

Table 89

ANOVA for The Missing "T and E" of iSTEM (Factor 10) by Grade Level (p = .05)

		ES	MS	HS	MSHS	Paired Difference	*p* value
Factor 10: The	*N:*	29	30	61	23	ES/MS: .605	ES/MS: .092
Missing "T and E" of	M^a:	273	-.332	-.030	.169	ES/HS: .303	ES/HS: .528
iSTEM	*SD:*	.764	1.088	1.010	1.043	ES/MSHS: .104	ES/MSHS: .982
						MS/HS: .302	MS/HS: .520
						MS/MSHS: .501	MS/ MSHS: .265
						HS/MSHS: .199	HS/MSHS: .844

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

[a] Computed factor scores are standardized

Between group analysis of Content Area and Factor 10: The Missing T and E of iSTEM. A one-way ANOVA test of variance within *Factor 10: The Missing T and E of iSTEM* indicated no significant difference between groups, $F = (4, 138) = 1.23$, $p = .302$, in Table 90.

Table 90

ANOVA for The Missing "T and E" of iSTEM (Factor 10) by Content Area (p = .05)

		S	TE	M	E	NS	Paired Difference	*p* value
Factor 10: The	*N:*	30	42	11	15	45	S/TE: .041	S/TE: 1.000
Missing "T and E" of	M^a:	.086	.045	.250	-.509	.009	S/M: .164	S/M: .990
iSTEM	*SD:*	.980	.986	.897	1.322	.915	S/E: .595	S/E: .329
							S/NS: .077	S/NS: .997
							TE/M: .205	TE/M: .974
							TE/E: .554	TE/E: .350
							TE/NS: .037	TE/NS: 1.000
							M/E: .759	M/E: .313
							M/NS: .241	M/NS: .952
							E/NS: .518	E/NS: .412

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported, NS=*Non-STEM* content background.

[a] Computed factor scores are standardized

Between group analysis of Implementation Level and Factor 11: Status Quo Regarding Science and Mathematics. A one-way ANOVA test of variance within *Factor 11:*

Status Quo Regarding Science and Mathematics indicated no significant difference between groups by *Implementation Level,* $F = (3, 139) = 0.57$, $p = .638$. Results are found in Table 91.

Table 91

ANOVA for Status Quo Regarding Science and Mathematics (Factor 11) by Implementation Level (p = .05)

		NI	P	PI	FI	Paired Difference	*p* value
Factor 11: Status Quo Regarding Science and Mathematics	*N:*	45	21	59	18	NI/P: .061	NI/P: .996
	M^a:	-.042	-.104	-.016	.278	NI/PI: .027	NI/PI: .999
	SD:	.810	1.039	1.071	1.170	NI/FI: .321	NI/FI: .663
						P/PI: .088	P/PI: .986
						P/FI: .382	P/FI: .639
						PI/FI: .294	PI/FI: .698

Note. Implementation Level Reported: NI=*No Implementation*, P=*Preparation*, PI=*Partial Implementation*, FI=*Full Implementation*.

[a] Computed factor scores are standardized

Between group analysis of Grade Level and Factor 11: Status Quo Regarding Science and Mathematics. A one-way ANOVA test of variance $F = (3, 139) = 2.25$, $p = .086$, and follow up post hoc Tukey analysis within *Factor 11: Status Quo Regarding Science and Mathematics* indicated near significant difference between the *Middle School* and *Middle School/High School* groups ($p = .106$) indicated in Table 92.

Table 92

ANOVA for Status Quo Regarding Science and Mathematics (Factor 11) by Grade Level (p = .05)

		ES	MS	HS	MSHS	Paired Difference	*p* value
Factor 11: Status Quo Regarding Science and Mathematics	*N:*	29	30	61	23	ES/MS: .181	ES/MS: .895
	M^a:	.141	.322	-.111	-.304	ES/HS: .252	ES/HS: .672
	SD:	1.086	1.090	.988	.653	ES/MSHS: .445	ES/MSHS: .374
						MS/HS: .433	MS/HS: .206
						MS/MSHS: .626	MS/ MSHS: .106
						HS/MSHS: .193	HS/MSHS: .854

Note. Grade Level Reported: ES=*Elementary School*, MS=*Middle School*, HS=*High School*, MSHS=*Middle/High School*.

[a] Computed factor scores are standardized

Between group analysis of Content Area and Factor 11: Status Quo Regarding Science and Mathematics. A one-way ANOVA test of variance within *Factor 11: Status Quo*

Regarding Science and Mathematics indicated significant difference within the *Content Area* groups, *F* = (4, 138) = 4.22, *p* = .003. Further post hoc Tukey analysis indicated significant difference between the *Science* and *Technology and Engineering* (*p* = .008) groups; the *Technology and Engineering* and *Elementary* (*p* = .035) groups; the *Technology and Engineering* and *Non-STEM* (*p* = .018) groups. Results are found in Table 93.

Table 93

ANOVA by Status Quo Regarding Science and Mathematics (Factor 11) by Content Area (p = .05)

		S	TE	M	E	NS	Paired Difference	*p* value
Factor 11: Status	*N:*	30	42	11	15	45	S/TE: .776	S/TE: *.008
Quo Regarding	M^{a}:	.278	-.498	.095	.337	.144	S/M: .183	S/M: .983
Science and	*SD:*	.915	.769	1.27	.988	1.048	S/E: .059	S/E: 1.000
Mathematics							S/NS: .134	S/NS: .976
							TE/M: .593	TE/M: .361
							TE/E: .835	TE/E: *.035
							TE/NS: .642	TE/NS: *.018
							M/E: .242	M/E: .969
							M/NS: .049	M/NS: 1.000
							E/NS: .192	E/NS: .962

Note. Content Area Reported: S=*Science*, TE=*Technology and Engineering*, M=*Mathematics*, E= *Elementary* specialization/generalist reported*,* NS=*Non-STEM* content background.

[a] Computed factor scores are standardized

Research Question 5

To answer Research Question 5 (*What barriers and contributing factors have the greatest impact on implementation?*) mean scores for each instrument item were calculated for all respondents. The six-point Likert scale developed for the iSTEMIBI contained the following statements with corresponding value: *Strongly Disagree* = 1.00; *Disagree* = 2.00; *Slightly Disagree* = 3.00; *Slightly Agree* = 4.00; *Agree* = 5.00; *Strongly Agree* = 6.00. Respondents were also given a response option to limit effect on central tendency with the *No Opinion/Don't know* statement. Scores above the statistical mean ($\bar{x}$ = 3.50) indicated a level of agreement with the statement, and means below the statistical mean indicated a level of disagreement with the statement. Throughout the research, to define a descriptive base for mean values, the following mean ranges were established: *Strongly Disagree* ($\bar{x}$ = 1.00 to 1.49); *Disagree* ($\bar{x}$ = 1.50 to 2.49); *Slightly Disagree* ($\bar{x}$ = 2.50 to 3.49); *Slightly Agree* ($\bar{x}$ = 3.51 to 4.49); *Agree* ($\bar{x}$ = 4.50 to 5.49); *Strongly Agree* ($\bar{x}$ = 5.50 to 6.00).

To determine what barriers and factors had the most perceived impact on implementation across all implementation groups, means were ranked from highest to lowest to indicate strength of level of agreement. For this phase of analysis mean scores above 4.0, indicating a level of agreement with item statements within a factor, were analyzed for perceived impact and were set as minimum baseline for consideration.

While analysis of the mean across all reported implementations gave a general view of the perception of barriers and factors that impact iSTEM integration, the analysis did not allow determination of the impact of factors within each *Implementation Level* group. Hence, the need for further analysis by each *Implementation Level* group was indicated. Means and factor rankings for all 50 Likert items are reported as follows: *No Implementation:* Appendix H; *Preparation:* Appendix I; *Partial Implementation:* Appendix J; *Full Implementation:* Appendix K.

Factors and impact rankings for No Implementation levels. Factor rankings, with average score means for the *No Implementation* group (N = 45) are found in Table 94. Results indicated 42 of the 50 items (Appendix H) met the minimum score criteria ($\bar{x} \geq$ 4.0) for consideration. The top seven factors by ranking had mean scores indicating *Agree* with items in the factor ($\bar{x} \geq$ 4.5). Comparison of individual average item ranks for the *No Implementation* group indicated Factor 5: *No Child Left Behind* (3 Likert items) had the highest factor mean ($\bar{x}$ =

5.2) and registered a 2.3 on the average item rank within the factor. Factor 1: *Teacher Education Gap in iSTEM Methodology* (7 items) ranked second by both average item rank (4.6) and factor mean score ($\bar{x}$ = 4.9). Factor 8: *Resources* (3 items) ranked third by item mean rank (5.0) and factor mean ($\bar{x}$ = 4.9). Factor 3: *Resistance to iSTEM-Based Reform* (5 items) had fourth highest ranking by average item rank (5.6) and factor mean ($\bar{x}$ = 4.7). Factor 9: *Limited View of iSTEM* (3 items) ranked fifth by average item rank (5.0) and factor mean ($\bar{x}$ = 4.8). Factor 2: *Technology and Engineering Standards* (3 items) had sixth place by average item rank (6.0) and factor mean ($\bar{x}$ = 4.7). Factor 10: *The Missing T and E of iSTEM* (6 items) ranked seventh with an average item rank (7.5) and factor mean Factor 3: *Resistance to iSTEM-Based Reform* (5 items) had fourth place by average item rank (5.6) and factor mean ($\bar{x}$ = 4.6).

Table 94

Factors and Mean Score Rankings for No Implementation Group

Factor	Factor Mean	Avg. Item Rank	Rank
Factor 5: No Child Left Behind	5.2	2.3	1
Factor 1: Teacher Education Gap in iSTEM Methodology	4.9	4.6	2
Factor 8: Resources	4.9	5.0	3
Factor 3: Resistance to iSTEM-Based Reform	4.7	5.6	4
Factor 9: Limited View of iSTEM	4.8	5.8	5
Factor 2: Technology and Engineering Standards	4.7	6.0	6
Factor 10: The Missing T and E of iSTEM	4.6	7.5	7
Factor 7: Resistance to Changing Teaching Methodology	4.4	8.7	8
Factor 11: Status Quo Regarding Science and Mathematics	4.3	10.3	9
Factor 4: Perception	3.6	14.8	10
Factor 6: Male-Oriented Content	3.6	15.5	11

Note: Items 10, 11, 18, 20, 28, 32,and 53 did not load to any factor.

Six additional items found in Appendix H that did not load as factors had means meeting the criteria— Item 20: *Integrative STEM education is not commonly understood by stakeholders* ($\bar{x}$ = 4.8), Item 28: *Lack of perceived benefit of professional development for integrative STEM methodology limits implementation* ($\bar{x}$ = 4.6), Item 10: *Access to professional development* *regarding integrative STEM education is limited* ($\bar{x}$ = 4.5), Item 11: *Without training in integrative STEM methodology it is difficult to understand the goals and concepts* ($\bar{x}$ = 4.5); Item 32: Lacking STEM certification at the state level is an issue ($\bar{x}$ = 4.4), and Item 53: *For many educators computer literacy requirements serve as a barrier to integrative STEM implementation* ($\bar{x}$ = 4.1).

Factors and impact rankings for Preparation levels. Factor rankings, with average score means for the *Preparation* group (N = 21) are found in Table 95.

Results indicated 43 of the 50 items (Appendix I) met the minimum score criteria ($\bar{x} \geq$ 4.0) for consideration. The top six factors by ranking had mean scores indicating *Agree* with items in the factor ($\bar{x} \geq$ 4.5). Comparison of individual average item ranks by *Preparation* group indicated Factor 1: *Teacher Education Gap in iSTEM Methodology* (7 items) ranked first by both average item rank (4.7) and factor mean ($\bar{x}$ = 5.0). Factor 3:*Resistance to iSTEM-Based Reform* (5 items) had second place by average item rank (4.8) and factor mean ($\bar{x}$ = 5.0). Factor 8: *Resources* (3 items) ranked third by item mean rank (5.7) and factor mean ($\bar{x}$ = 4.9). Factor 9: *Limited View of iSTEM* (3 items) ranked fourth by average item rank (6.0) and factor mean ($\bar{x}$ = 4.9). Factor 5: *No Child Left Behind* (3 Likert items) was in fifth place with a factor mean ($\bar{x}$ = 4.8) and registered a 6.7 on the average item rank within the factor.

Four additional items found in Appendix I that did not load as factors had means meeting the criteria— Item 11: *Without training in integrative STEM methodology it is difficult to understand the goals and concepts* ($\bar{x}$ = 5.0); Item 28: *Lack of perceived benefit of professional development for integrative STEM methodology limits implementation* ($\bar{x}$ = 4.8), Item 20: *Integrative STEM education is not commonly understood by stakeholders* ($\bar{x}$ = 4.7), and Item 10: *Access to professional development regarding integrative STEM education is limited* ($\bar{x}$ = 4.6).

Table 95

Factors and Mean Score Rankings for Preparation Group

Factor	Factor Mean	Avg. Rank	Rank
Factor 1: Teacher Education Gap in iSTEM Methodology	5.0	4.7	1
Factor 3: Resistance to iSTEM-Based Reform	5.0	4.8	2
Factor 8: Resources	4.9	5.7	3
Factor 9: Limited View of iSTEM	4.9	6.0	4
Factor 5: No Child Left Behind	4.8	6.7	5
Factor 10: The Missing T and E of iSTEM	4.4	11.3	6
Factor 11: Status Quo Regarding Science and Mathematics	4.4	11.3	7
Factor 7: Resistance to Changing Teaching Methodology	4.3	11.7	8
Factor 2: Technology and Engineering Standards	4.1	13.7	9
Factor 4: Perception	3.8	16.0	10
Factor 6: Male-Oriented Content	3.5	18.0	11

Note: Items 10, 11, 18, 20, 28, 32,and 53 did not load to any factor.

Factors and impact rankings for Partial Implementation levels. Factor rankings, with average score means for the *Partial Implementation* group (*N* = 59) are found in Table 96. Results indicated 37 of the 50 items (Appendix J) met the minimum score criteria ($\bar{x} \geq 4.0$) for consideration. The top five factors by ranking had mean scores indicating *Agree* with items in the factor ($\bar{x} \geq 4.5$). Comparison of individual average item ranks for the *Partial Implementation* group indicated Factor 5: *No Child Left Behind* (3 items) had the highest perceived impact on iSTEM implementation within the group with a factor mean ($\bar{x} = 5.0$) and registered a 2.3 on the average item rank within the factor. Factor 9: *Limited View of iSTEM* (3 items) ranked second by average item rank (4.5) and factor mean ($\bar{x} = 4.9$). Factor 1: *Teacher Education Gap in iSTEM Methodology* (7 items) ranked third by both average item rank (5.6) and factor mean ($\bar{x} = 4.6$). Factor 8: *Resources* (3 items) ranked fourth by item mean rank (5.7) and factor mean ($\bar{x} = 4.6$). Factor 3: *Resistance to iSTEM-Based Reform* (5 items) was fifth by average item rank (6.2) and factor mean ($\underline{\bar{x}} = 4.6$).

Table 96

Factors and Mean Score Rankings for Partial Implementation Group

Factor	Factor Mean	Avg. Rank	Rank
Factor 5: No Child Left Behind	5.0	2.3	1
Factor 9: Limited View of iSTEM	4.8	4.5	2
Factor 1: Teacher Education Gap in iSTEM Methodology	4.6	5.6	3
Factor 8: Resources	4.6	5.7	4
Factor 3: Resistance to iSTEM-Based Reform	4.6	6.2	5
Factor 2: Technology and Engineering Standards	4.3	8.7	6
Factor 10: The Missing T and E of iSTEM	4.3	9.2	7
Factor 11: Status Quo Regarding Science and Mathematics	4.1	11.3	8
Factor 7: Resistance to Changing Teaching Methodology	4.0	11.7	9
Factor 4: Perception	3.7	15.4	10
Factor 6: Male-Oriented Curriculum	3.1	19.5	11

Note: Items 10, 11, 18, 20, 28, 32,and 53 did not load to any factor.

One additional item found in Appendix J that did not load in a factor had a mean meeting the criteria— Item 11: *Without training in integrative STEM methodology it is difficult to understand the goals and concepts* ($\bar{x}$ = 4.9).

Factors and impact rankings for Full Implementation levels. Factor rankings, with average score means for the *Full Implementation* group (*N* = 18) are found in Table 97.

Results indicated 20 of the 50 items (Appendix K) met the minimum score criteria ($\bar{x} \geq$ 4.0) for consideration. The top five factors by ranking had mean scores indicating *Agree* with items in the factor ($\bar{x} \geq$ 4.5). Comparison of individual average item ranks for the *Full Implementation* group indicated Factor 5: *No Child Left Behind* (3 items) had the highest impact on iSTEM implementation within the group with a factor mean ($\bar{x}$ = 4.8) and registered a 2.7 on the average item rank within the factor. Factor 1: *Teacher Education Gap in iSTEM Methodology* (7 items) ranked second by both average item rank (57) and factor mean average ($\bar{x}$ = 4.4). Factor 8: *Resources* (3 items) ranked third by item mean rank (7.0) and factor mean ($\bar{x}$ = 4.2). Factor 9: *Limited View of iSTEM* (3 items) ranked second by average item rank (8.3) and factor mean ($\bar{x} = 4.1$). Factor 3: *Resistance to iSTEM-Based Reform* (5 items) was fifth by average item rank (8.6) and factor mean ($\bar{x} = 4.1$). One additional item found in Appendix K that did not load in a factor had a mean meeting the criteria— Item 11: *Without training in integrative STEM methodology it is difficult to understand the goals and concepts* ($\bar{x} = 4.7$) and tied for third place in impact.

Table 97

Factors and Mean Score Rankings for Full Implementation Group

Factor	Factor Mean	Avg. Rank	Rank
Factor 5: No Child Left Behind	4.8	2.7	1
Factor 1: Teacher Education Gap in iSTEM Methodology	4.4	5.7	2
Factor 8: Resources	4.2	7.0	3
Factor 9: Limited View of iSTEM	4.1	8.3	4
Factor 3: Resistance to iSTEM-Based Reform	4.1	8.6	5
Factor 2: Technology and Engineering Standards	3.7	12.3	6
Factor 10: The Missing T and E of iSTEM	3.6	13.3	7
Factor 11: Status Quo Regarding Science and Mathematics	3.5	14.3	8
Factor 4: Perception	3.4	15.2	9
Factor 7: Resistance to Changing Teaching Methodology	3.1	18.3	10
Factor 6: Male-Oriented Curriculum	2.9	20.5	11

Note: Items 10, 11, 18, 20, 28, 32, and 53 did not load to any factor.

Path analysis of identified factors. A latent-variable structural model was developed using the 50 items from the iSTEMIBI. The chi-square was significant (C = 1751.086, $df = 793$, $p < .001$), yet the ratio of the chi square and the degrees of freedom was 2.2, which indicated an acceptable fit as it was below 5.0 (Kline, 2005).

As per Kline (2005) the recommended criteria for the RMSEA and SRMR indicate a value of <.08 to indicate a good fit. Values and greater than .10 are considered a poor fit. Based on these criteria, the RMSEA (.095) and SRMR (.091) values computed for this model were acceptable. This may be due to the relatively small sample size for this type of analysis and instrument being an attitude survey.

Figure 1 shows the eleven factors previously identified and model data fit values between individual factors. Throughout the initial factor analysis and subsequent descriptive analysis for Research Question 5 (*What barriers and contributing factors have the greatest impact on implementation?*), two exogenous factors were consistently among the highest rank factors regarding barriers to implementation levels; Factor 1—*Teacher Education Gap in iSTEM Methodology* and Factor 5—*No Child Left Behind.* These two factors served as a starting point to build the conceptual model.

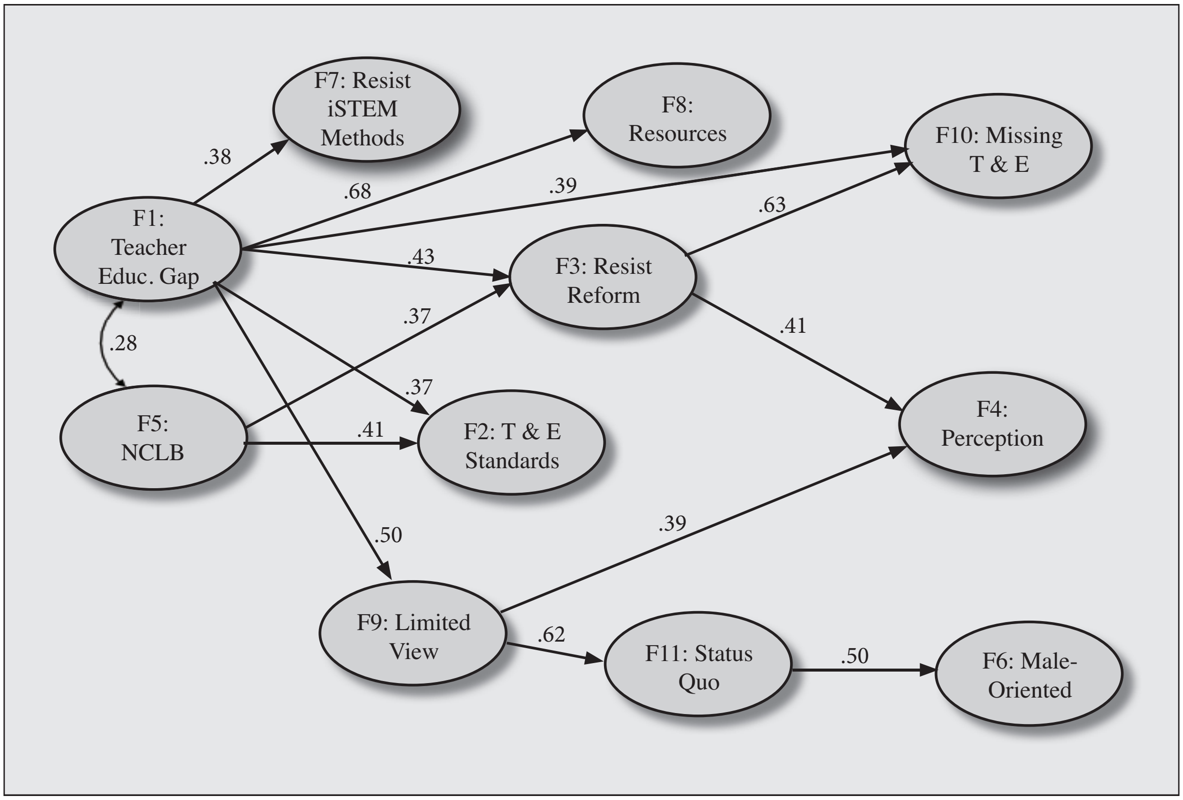

Figure 1. Path analysis of factors from the iSTEMIBI.

Effect of Factors 1 and 5 on Factor 2. With regard to Factor 2: *Technology and Engineering Standards*, Factor 1 was shown to have moderate effect on Factor 2 ($r = .485$, $R^2 = .235$). Factor 5 had a moderate to strong effect on Factor 2 ($r = .514$, $R^2 = .264$). Items in the factor dealt with lack of engineering standards affecting iSTEM implementation, student assessment, and professional development.

Effect of Factors 1 and 5 on Factor 3. Moderate effect of Factor 1 was indicated on Factor 3: *Resistance to iSTEM-Based Reform* (r = .430, R^2 = .185) and Factor 5 had a moderate effect (r = .490, R^2 = .240). Factor 3 was a top five factor across all implementation levels. The factor included items dealing with collaborative issues relative to non-supportive teachers and lack of collaboration between the education community and stakeholders (defined as parents, business/industry, and government leaders this study). Additional issues tied to Factor 3 included regulatory issues from the state and federal level perceived to limit effective implementation due to requirements of Carnegie seat time and associated credit system in place. This was a factor with consistent levels of agreement across all *Content Area* groups.

Effect of Factor 1 on Factor 4. Factor 1 had a moderate effect on Factor 4: *Perception* (r = .415, R^2 = .172). Items within the factor included iSTEM being perceived as a fad that would eventually go away, negative perceptions of open-ended inquiry limiting implementation, a perception of iSTEM addressing only workforce issues, mathematics not being perceived as a significant part of science, and a negative perception of iSTEM diminishing the individual importance of each content area.

Effect of Factor 1 on Factor 7. Factor 1 was shown to have a near moderate effect on Factor 7: *Resistance to Changing Classroom Methodology* (r = .380, R^2 = .133). Factor 7 hinged on two main issues: teacher comfort in delivery of technology and engineering content, and lack of perceived empowerment to effectively change teaching methods.

Effect of Factor 1 on Factor 8. Another top five-ranked factor for all implementation levels, Factor 8: *Resources* was identified as a factor with strong effect from Factor 1 (r = .680,

R^2 = .462). Items within Factor 8 noted inadequate facilities; lack of needed resources including funding, equipment, and supplies; and reliance on outdated textbooks and classroom materials as issues regarding implementation.

Effect of Factor 1 on Factor 9. Factor 1 had a moderate to strong effect on Factor 9 concerning *Limited View of iSTEM* (r = .500, R^2 = .250). Factor nine had a top five ranking with regard to impact on implementation. Factor included items indicating issues of "siloed" instruction, STEM programs that only focus on mathematics and/or science, and a perception by some educational leaders and practitioners that technology and engineering teachers lack content knowledge and content to teach mathematics and science concepts.

Effect of Factors 1 and 5 on Factor 10. Factor 1 had strong effect on Factor 10: *The Missing "T and E" of iSTEM* (r = .726, R^2 = .527). Factor 5 had a moderate effect on Factor 10 (r = .418, R^2 = .175). Factor 10 had strong ties to policy makers, stakeholders and educators not recognizing need for pre-engineering content provided through content involving technological literacy and engineering design.

Summary

Data results for Research Question 3 (*Do Factors that affect iSTEM adoption vary between groups?*) were detailed in Chapter 4. Group comparisons were run in SPSS utilizing ANOVA and Tukey post hoc procedures to identify differences between groups using the following demographic parameters: (a) by implementation level indicated; (b) by grade level taught; (c) by content area training.

Open-ended responses were analyzed and reported to provide additional triangulation of data found throughout the research project. Results were used to support the quantitative data.

Statistical procedures and resulting data with regard to Research Question 4 (*What factors contribute to iSTEM implementation?*) were also reported. Principal component analysis (PCA) was run to compute communality values and results are found in Appendix G. Initially, the iSTEMIBI was structured around 12 researcher developed constructs. The PCA identified 11 factors that served as a basis for the remaining elements of the research project. Of the 11 factors identified, five factors were identical item by item with earlier developed constructs. After the development of factors, ANOVA and post hoc analysis were run between groups by identified factors to determine differences between groups.

Chapter 4 also detailed the analysis designed to answer Research Question 5 (*What barriers and contributing factors have the greatest impact on implementation?*) The researcher developed a ranking system to determine which factors were ranked the highest by average mean scores by items in each factor. The results indicated strength of level of agreement.

The final analysis included structural equation modeling to establish a path model to conceptualize impact or fit between factors identified in the research with regard to implementation level reported.

CHAPTER 5. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Purpose of the Study

The purpose of the study was to determine factors that serve as barriers to integrative STEM (iSTEM) implementation in K-12 schools. The researcher developed the Integrative STEM Implementation Barriers Instrument (iSTEMIBI) to gain insight regarding barriers to implementation from the perspective of K-12 practitioners with understanding and/or experience in iSTEM methods and content.

Research Questions

To complete the research, the following research questions were identified:

1. In what ways is the STEM movement similar to previous educational reform movements in the United States?
2. What do stakeholders perceive to be barriers to implementation?
3. Do barriers and factors that affect STEM adoption vary between groups?
4. What factors contribute to STEM implementation?
5. What barriers and contributing factors have the greatest impact on implementation?

Introduction

This chapter includes a summary of the study including identified similarities and issues germane to the current iSTEM movement and earlier educational movements, methodology and procedures in the development procedures of the iSTEMIBI instrument, significant findings of the data regarding within group comparisons by construct items and derived factors, recommendations regarding practice and implementation, and recommendations for future study. As noted in Chapter 1, the purpose of the study was to determine factors that served as barriers to STEM implementation the K-12 setting.

Literature Review

To complete the study, a comprehensive literature review was conducted to determine similarities of the current iSTEM movement to earlier education reform movements in the United States to serve as a reference frame for the researcher as the iSTEMIBI development process was initiated. Results of this aggregation of similarities are found later in this chapter under findings.

Additionally, the literature review was utilized to identify potential barriers item concepts for the iSTEMIBI. An Informal STEM Experts Group (ISEG) was convened to evaluate the barriers identified in the literature review and from an unpublished study by the researcher of issues regarding implementation from the perspective of practicing K-12 educators who completed iSTEM-based professional development workshops. The results of this portion of the literature review answered Research Question 2 (*What do stakeholders perceive to be barriers to implementation?*) and results are found in Chapter 3.

Likert Scale Item Development and Pilot Study

As detailed in Chapter 3, a six-point Likert scale was developed to determine agreement levels with statements in the iSTEMIBI. Likert descriptors and scale value included *Strongly Disagree* = 1*, Disagree* = 2*, Slightly Disagree* = 3*, Slightly Agree* = 4*, Agree* = 5*,* and *Strongly Agree* = 6*.* To limit the effect on central tendency *No Opinion/Don't Know* was included as an option and was consider a null value statistically. After initial development of the iSTEMIBI, 26 K-12 educators completed the pilot study. The pilot contained the 50 Likert items recommended by the ISEG, plus an optional open-ended response for each item. The open-ended responses were utilized to determine if items in the scale were conceptually supported or change was required following evaluation. After analyzing the results, adjustments were made to six Likert statements. Also the researcher determined defined implementation levels for between groups analysis was needed and the ISEG was convened a second time to create definitions for each implementation level (*No Implementation, Preparation, Partial Implementation, Full Implementation)* for the purpose of the research study. The demographics section allowed the researcher to gather data for group comparisons by *Implementation Level* indicated, primary *Content Area* endorsement (*Science, Technology and Engineering, Mathematics, Elementary* specialization/generalist, and *Non-STEM* content background), and *Grade Level* taught (*Elementary, Middle School, High School, Middle School/High School*). Cronbach's Alpha analysis was utilized to determine reliability and subsequent alignment with 12 researcher-defined constructs. In the final version of the iSTEMIBI, respondents had the option for an open-ended response within each construct as a method of using qualitative data to support a quantitative study as per the Embedded Design correlational model (Creswell & Plano-Clark, 2007). The open-ended statements allowed the researcher to determine if additional comments supported the scale item concepts or if additional items or constructs may be considered for future iterations of a similar instrument.

One-way ANOVA and post hoc Tukey analysis were utilized as statistical measures. Initially, ANOVA was used to determine significant differences ($p \leq .05$) between groups within construct items or derived factors. If the ANOVA indicated significant difference, additional post hoc Tukey analysis was utilized to evaluate pairwise differences between group means within each item or factor.

Qualitative analysis of open-ended responses by construct was completed based on the Embedded Design correlational method. The researcher utilized the open-ended responses to determine congruency, disagreement, or identification of potential new barriers items for future iterations. Details of this portion of the research are found in Chapter 4.

To answer Research Question 4 (*What factors contribute to STEM implementation?*) principal component analysis was utilized to create a correlation matrix. Initially, due to strength of communality values, .4 was established as a minimum value for loadings. Eleven factors regarding implementation were identified and results are detailed in Chapter 4 and in Appendix G.

Following the establishment of the 11 factors, each factor was analyzed utilizing a one-way ANOVA to determine if the factor contained significant mean difference based on variance from mean standardized scores between identified groups by reported demographics: *Implementation Level; Grade Level;* and *Content Area.* A second analysis of factors by individual groups was conducted utilizing a post hoc Tukey HSD analysis. The Tukey analysis allowed the evaluation of paired differences among means within each identified factor. Results were determined to be significant at $p \leq .05$. Details of the findings with regard to significant differences between groups related to mean standardized scores are found in Chapter 4.

To answer Research Question 5 (*What barriers and contributing factors have the greatest impact on implementation?*) a ranking system was developed to aid in description of the level of impact of each factor on implementation. Results of impact ranking are found in Chapter 4, and Appendices H, I, J, K.

In the final analysis Structural Equation Modeling (SEM) was utilized to establish a path analysis to determine a latent-variable structural model based on iSTEMIBI factors. Details of the Principal Component Analysis and SEM/Path Analysis process are found in Chapter 4.

Summary of Findings

Results with regard to findings follow. Where appropriate, reference to table and figures with ties to the narrative will be provided for the reader.

Research Question 1 Findings

Similarity between iSTEM and previous reform movements. Analysis indicated iSTEM methodologies and practices have strong ties to constructivism. Applied methods in elementary were called for in the early 1900s, just as in the current iSTEM movement, to bring relevancy and real-life scenarios in problem-based education. The importance of an inclusive curriculum was indicated, for all students, regardless of educational track or diverse background. Table 98 lists benefits or issues common to the iSTEM movement and earlier curricular movements.

Earlier attempts at interdisciplinary educational methods proved to be similar to methodological practices of the current STEM movement, with the purpose of serving as means of supporting other curricular and content areas, and as a means of supporting business, industry, economy, and security of the United States.

Once again, as in earlier reform movements, educational change was driven by achievement scores and was further exacerbated in a global economy. There was diversity of opinion in this regard as there were those in the minority who questioned the reliability of comparing standardized assessment scores from the United States versus other countries. While education practice in the United States tested a majority of students, common practice in other countries was to track students into disciplines of strength, and hence only the top students in discipline concentration areas such as mathematics and science were tested (Bracey, 2003; Rotberg, 1984).

Table 98

Identified Benefits or Issues Common to Earlier Practice and the iSTEM Movement

Benefit or Issue	Authors
Applied educational practices lacking acceptance, perceived value, or stature by other general education disciplines.	Bennett, 1937; Boe, 2010; Kelley, 2010
Lack of research based assessment to support applied educational methodologies as part of general education.	Bennett, 1926; Katehi, 2009; Katehi, Pearson, & Feder, 2009; Kelley, 2010; Peterson, 2009
Importance of hands-on applied components of curriculum in K-12.	Bennett, 1926; Bennett, 1937; Bragg, 2000b; Cantor, 1999; Farmer & Honeycutt, 1999; Hedberg, n.d.; SEDL, 1998;
The influence of Dewey/Pragmatism/Constructivism regarding students making sense of the world they live in to make subjects relevant.	Bennett, 1937; Bohan, 2003; BSCS, n.d.; Foster, 1997; Hedberg, n.d.; MMoS, 2001; NASA, n.d.; OSLN, n.d.; SEDL, 1998; Sewell, 1994
The continuing influence of the "Committee of 10" and the "Cardinal Principles".	Bennett, 1937; CSMC, 2004; Helton, n.d.; Pulliam, 1991; Sewell, 1994; Weidner, n.d.
Industry desire for specific students' skill sets.	Atkinson & Mayo, 2010; Bennett, 1926; Feldman, 2005; Harvard Graduate School of Education, 2011; Lauda, 2002; Pines, 2009
Perceptions of education needing to meet the needs of business and industry, national economy, and national security.	Atkinson & Mayo, 2010; Bennett, 1937; Foster 1997; Herrera and Owens, 2001; Kelley, 2010; Lauda, 2002; Moore, 1993; Pulliam, 1991
Vocational/applied methods in elementary called for in the early 1900s similar to methods called for by STEM proponents.	Bennett, 1926; Bennett, 1937; Foster, 1997; Foster, 1999; Mitchell and Miller, 1995
Lack of knowledge of elementary teachers in content/methodology in mathematics, science and technological literacy.	Moore, 1993; Skophammer, 2009
Importance of inclusive curriculum.	Bennett, 1926; Bennett, 1937; Bragg, 2000b; Dugger, 2010b; OSLN, n.d.; Sanders, 2009; San Diego County Office of Education (n.d.); Wright State University, n.d.
Vocational/technical programs serving as connecting activities for general education subjects.	Bennett, 1926; Bennett, 1937; Feldman 2005; Foster, 1999; Wright State University, n.d
Ongoing "pendulum swings" of education stressing traditional general education for all students or more inclusion of industrial-oriented and/or interdisciplinary curriculum for non post-secondary bound students.	Bennett, 1926; Bennett,1937; Bragg, 2000a; Bragg, 2000b; CSMC, 2004; Evans, 1993; Foster, 1995; Foster, 1997; Foster, 1999; ITEA, 2007; Kelley, 2010; Pollard, 1991; Pulliam, 1991

(continued)

Table 98

Identified Benefits or Issues Common to Earlier Practice and the iSTEM Movement (continued)

Benefit or Issue	Authors
Motivational issues for students	Bennett, 1926; Atkinson and Mayo, 2010
Benefits of interdisciplinary approaches.	Bennett, 1926; Crayton, 2010; Farmer & Honeycutt, 1999; Foster, 1995; Katehi, 2009; Kelley; 2010; Kolstad & Briggs, 1995; Moore, 1993; Morrison, 2006; OSLN, n.d.; Pearson & Young, 2002
Actual or perceived achievement driving change.	Augustine, 2007; Bracey, 2003; Evans, 1983; Herrera and Owens, 2001; Moore, 1993; Rotberg, 1984
Relevant/real-life problems throughout U.S. educational history as important components of several reform movements.	Atkinson & Mayo, 2010; Bragg, 2000a; Feldman, 2005; Foster, 1997; Foster 1999; Foster & Bartow, 1994; Snyder, 2004
Importance of student-centered versus teacher-centered educational practices.	Bennett, 1926; Feldman, 2005; Freire, 2007; Kolstad & Briggs, 1995; Snyder, 2004; Wright State University, n.d.
Disagreement whether Industrial/Technical/Vocational education should be part of general education.	Bennett, 1937; Foster, 1997; Foster, 1999; ITEA, 2007; Kelley, 2010
To fund, or not to fund: Various aspects of industrial, technical, vocational and interdisciplinary movements.	Bennett, 1937; Kelley, 2010; Moore, 1993; Pulliam, 1991

Also indicated were issues with lack of research-based assessment to document and support applied educational methods as part of general education. Thus disciplines such as manual arts, manual training, industrial arts, and vocational training were not widely accepted as core components of a comprehensive education system. The same continues in current times, as technology and engineering education struggle to gain a foothold and relevancy with other long-standing disciplines. This issue was supported by in the open-ended portion of the study.

Research Question 2 Findings

Potential instrument items identified through the literature. As detailed in Chapter 3, the literature review coupled with unpublished survey results of iSTEM workshop participants from the Great Plains STEM Education Center (Gjøvik, 2010) identified 94 potential items for use in the iSTEMIBI instrument. The original list of potential items is found in Appendix E. An Informal STEM Experts Group (ISEG) was convened and 50 items were compiled and condensed from the original 94 items. The final instrument and items are found in Appendix D.

Research Question 3 Findings

Perception of barriers issues waned as implementation level increased. There were 22 instances of significant mean differences identified when ANOVA and post hoc Tukey analysis were conducted on implementation level groups by construct and results are detailed in Tables 11, 12, 13, 14, 16, 18, 20, and 22 in Chapter 4. Of those instances, 21 differences included the *Full Implementation* group and generally reflected a drop in mean scores compared to means of lower levels of implementation. Results indicate perceived impact of barriers decreased as respondents reported full implementation of iSTEM methods. The other case of significant difference was indicated between the *Preparation* and *Partial Implementation* groups. The result indicates those reporting implementation levels at *Preparation* considered a regulatory issue relative to a perception of lack of incentives to motivate teachers to improve educational quality as a powerful barrier to implementation.

Significant differences regarding grade level. Teachers indicating responsibilities in *Middle School* through *High School* when compared to other *Grade Level* groups had the highest average means regarding perceived issues related to professional development and pre-service training. Additional data in this regard are found in Tables 27 and 28 in Chapter 4. This was also supported in analysis of grade level taught with regard to the *Teacher Education Gap in iSTEM Methodology* factor. This factor was composed of items from two constructs dealing with professional development and pre-service training issues. Refer to Table 62, Chapter 4**.**

Issues regarding training and professional development concerns were also consistent concerns for those reporting responsibilities at the elementary school level. Refer to Tables 27 and 28, Chapter 4.

The consistent levels of agreement across most groups in the *Professional Development Barriers* and *Pre-Service Training Barriers* constructs indicated concern by respondents regarding content and methodology knowledge and resulting desired training options for practicing and pre-service teacher candidates. The results supported barriers concepts due to professional development and pre-service training issues noted by Ashida and Hunter (2009, a-f); Gjøvik (2010); Sandlin (2009),

Significant differences in technology and engineering. Significant differences were identified 10 times in the *Content Area* analysis and the *Technology and Engineering* group figured into every instance. In each case, the *Technology and Engineering* group had the highest mean score compared to other groups. Issues for this group included lack of support by administrators (Gjøvik, 2010; Miaoulis, 2009), perception of a narrow view of iSTEM implementation only including science and mathematics (Lantz, 2009; Miaoulis, 2009), a siloed approach to iSTEM lacking integration between disciplines (Ashida & Hunter, 2009 a-f), a perception that technology and education teachers can not teach science and mathematics (Lantz, 2009), science and mathematics teachers seeing no need to change methods (Gjøvik, 2010), and the inclusion of technology and engineering limiting time for mathematics and science instruction (Atkinson & Mayo, 2010; Miaoulis, 2009). Lower scores across all groups on Item 53 regarding computer literacy requirements serving as a barrier may indicate the question was not reflective of the intent of the statement by the ISEG (Lantz, 2009). Refer to Tables 37, 40, 43 and 44 in Chapter 4.

Another item of interest regarding *Male-Oriented Content Barriers* occurred between the *Technology and Engineering* and *Science* groups and also with the *Non-STEM* group. Differing perceptions were indicated as the *Technology and Engineering* group slightly agreed, while the *Science* and *Non-STEM* groups slightly disagreed conceptually with implementation being limited by perception of iSTEM as a male-oriented curriculum (Sandlin, 2009). Information in this regard is found in Table 43, Chapter 4.

Items with unanimous agreement within all groups. All groups agreed with three items regarding the barriers due to impact of No Child Left Behind. The items included: a perception regarding standardized assessments limiting measurement of mastery in project and problem-based learning (Ashida & Hunter, 2009 a-f); innovation in assessment strategies being limited by Adequate Yearly Progress (AYP) requirements (Ashida and Hunter, 2009 a-f); and requirements of NCLB limiting time available for integrative STEM education (Atkinson & Mayo, 2010; Gjøvik, 2010; Miaoulis, 2009). Refer to Tables 17, 29, and 41 in Chapter 4.

There were three additional barriers items receiving unanimous agreement from all groups. These included: concerns with a lack of training in integrative STEM methodology making it difficult to understand the goals and concepts of iSTEM (Gjøvik, 2010), see results in Tables 11, 23, 35; implementation being limited if educators and stakeholders don’t collaborate (Gjøvik, 2010), see results found in Tables 12, 24, 36; and limitations due to a shortage of teachers trained in integrative STEM education (Tables 15, 27, 39) as identified in the literature by Ashida and Hunter (2009 a-f).

Three items had consistent agreement across most groups. Other barriers items were identified that, although were not unanimous in agreement across all group comparisons, still indicated the associated construct was of importance to the research and identified areas of concern regards barriers to implementation within a majority of groups.

Implementation being limited by non-supportive teachers (Gjøvik, 2010; Sandlin, 2009) was indicated by the *No Implementation, Preparation* and *Partial Implementation* groups; the *Elementary School, Middle School* and *Middle School/High School* grade level groups; and the *Science, Technology and Engineering, Mathematics* and *Elementary* content areas. Refer to Tables 12, 24, and 36 in Chapter 4.

All groups, with the exception of the *Full Implementation* group, indicated perception of lack of resources (funding, equipment, supplies) creating issues for implementation (Ashida & Hunter, 2009; Atkinson & Mayo, 2010; Gjøvik, 2010; Miaoulis, 2009). The results indicated all other groups considered resources a significant concern, and those who were fully vested in implementing an iSTEM program received adequate resources to practice methods and content. Concerns regarding inadequacy of facilities for iSTEM implementation were indicated in lower levels of implementation or indicated content area concentrations in the *Science, Technology and Engineering,* and *Mathematics* disciplines. Refer to Tables 14, 26, and 38 in Chapter 4.

Barriers of a narrow view had perceived effect on implementation. Four items within the *Barriers of a Narrow View* construct garnered consistent agreement across a majority of groups: The *Full Implementation, Middle School,* and *Elementary* groups_slightly agreed with concerns regarding issues of failure by policy makers and leaders to recognize the equal importance of the full spectrum of integrative STEM education (Miaoulis, 2009; Sandlin, 2009). Lantz's (2009) identified concern that for many educators and stakeholders iSTEM only consists of science and mathematics was supported by the *Full Implementation, Middle School,* and *Elementary* groups; Limited integration or a “siloed” (Ashida & Hunter, 2009, a-f) approach resulted in slight agreement by the *Full Implementation* and *Elementary* groups. See Tables 20, 32 and 44 for details.

Regulation barriers were indicated by several groups. The *No Implementation* and *Preparation* implementation groups, the *Elementary School* and *High School* grade level groups, and the *Technology and Engineering* content group indicated all items regarding regulation were perceived as barriers with regard to implementation. The construct contained items with the following concepts: state and federal regulatory boundaries are rigid and constrain local educational reform (Ashida & Hunter, 2009); there is currently a lack of incentives to motivate key outcomes for improving educational quality (Ashida & Hunter, 2009); and class periods and seat time requirements constrain the use of integrative STEM methodologies (Ashida & Hunter, 2009; Atkinson & Mayo, 2010; Miaoulis, 2009). See Tables 22, 34, and 46 regarding perceived *Barriers of Regulation.*

Regulation barriers means dropped to slight agreement or slight disagreement once respondents indicated *Partial Implementation* or *Full Implementation.* Also of interest was the congruency of scale means within the *Content Area* group as all means were at or just below the established mean agreement value regarding class periods and seat time requirements having effect on iSTEM implementation.

Open-ended responses. While most responses supported items and constructs of the study, a number of items emerged that were important to research participants.

An overarching issue that exemplified the uncertainty teachers experience prior to implementing an iSTEM program was what one respondent referred to as the “Self-made fears of teachers”. These fears may have been indicative of underlying issues with perceived barriers of implementation such as resistance to reform, resistance to methodological change, perception of the iSTEM movement, concerns over high-stakes testing due to NCLB and the ease of remaining with the status quo—as noted by one respondent it was simply easier to continue in one’s comfort zone.

Participants conceptually supported administrative issues within the *Barriers of Adoption* construct. General administrative issues and concerns regarding administrators only focusing on advanced placement, honors, or university track were noted. These results further detailed identified administrative issues from the perspective of teachers and add to the issues identified by authors in this regard.

Resource Barriers also were significant in open-ended responses. Lack of monetary funding (Atkinson & Mayo, 2010; Gjøvik, 2010), lack of adequate facilities, tools, and student supplies (Miaoulis, 2009), lack of commitment for funding professional development (Ashida & Hunter, 2009 a-f; Gjøvik, 2010; Miaoulis, 2009; Sandlin, 2009), and time requirements for iSTEM implementation were identified (Ashida & Hunter, 2009 a-f; Atkinson & Mayo, 2010; Gjøvik, 2010).

Lack of time emerged throughout the open-ended portion of the study as the most commonly referred to issue. Time issues were perceived in several areas: time to collaborate, prepare, attend STEM methodology workshops and trainings, curriculum development, and the inherent requirements of NCLB. Also time issues surfaced with regard to regulation requirements regarding seat time and standard period days limiting a comprehensive iSTEM program. Suggested was the move to block scheduling, and moving away from set class period times.

Another idea expressed was the need for more teachers versed in iSTEM methods and content and supported the issue as identified by Ashida and Hunter (2009 a-f). This view was supported by results of ANOVA within the professional development and pre-service constructs.

Regarding *Male-Oriented Content* (Sandlin, 2009) respondents iterated the need for more female role models, more female teachers in STEM-related disciplines, and movement towards gender-neutral curriculum.

Potential concepts for future barriers research emerged regarding student-related issues affecting implementation. Indicated were issues of student preparedness, student interest, student discipline, difficulty of creating iSTEM curriculum that works with Individualized Education Programs (IEPs) and 504 accommodations.

Perceived differences by groups within identified factors. While the *Teacher Education Gap in iSTEM Methodology* (Ashida & Hunter, 2009 a-f; Gjøvik, 2010; Sandlin, 2009) became a leading contributor to perceived impact regarding implementation barriers, the ANOVA did identify one significant difference between the *Middle School* and *Middle School/High School* reporting groups. The *Middle School/High School* group indicated a higher level of agreement with items in the factor and the results may indicate teachers in smaller districts perceive the gap in iSTEM training as a more significant issue regarding implementation. See Table 62 in Chapter 4.

Curricular issues regarding *Male-Oriented Content* (Sandlin, 2009) were perceived as a more powerful issue by the *Technology and Engineering* group. The *Science, Elementary, and Non-STEM* groups had lower levels of agreement than *Technology and Engineering.* Refer to Table 70, Chapter 4.

Change of perception regarding *Resistance to Changing Teaching Methodology* (Atkinson & Mayo, 2010; Gjøvik, 2010; Sandlin, 2009; Miaoulis, 2009) was evident from results of the ANOVA. Significant difference was identified between the *Full Implementation* group and all other implementation levels. The results supported change in perception regarding comfort levels with content and methodology and an empowerment issue regarding ability to change methods. Refer to Table 79, Chapter 4.

Teachers reporting *Full Implementation* indicated *Limited View of iSTEM* was perceived to be less of an issue when compared to the *No Implementation* group. Items in the factor included perception of “siloed” delivery where disciplines are taught as completely separate content areas with no integrative methods (Ashida & Hunter, 2009 a-f), resistance regarding technology and engineering educators’ abilities to teach mathematics and science content (Lantz, 2009), and the limited view of iSTEM that excludes technological literacy and engineering design content (Miaoulis, 2009). See Table 85 in Chapter 4.

The *Technology and Engineering* group regarded impact of items within the *Status Quo Regarding Science and Mathematics* as larger issues than other groups in the content area demographic. Items regarding the status quo of science and mathematics were issues of inclusion of technological literacy and engineering content in mathematics and science (Lantz, 2009), plus implementation issues due to perception of lost time for mathematics and science content if technology and engineering was introduced (Miaoulis, 2009). Refer to Table 92 in Chapter 4.

Research Question 4 Findings

Five factors consistently had highest impact rankings. Impact ranking analysis of item response by *Implementation Level* group indicated five factors consistently attained highest rankings regarding impact on iSTEM implementation: (a) *Teacher Education Gap in iSTEM*

Methodology; (b) *Resistance to iSTEM-Based Reform;* (c) *No Child Left Behind;* (d) *Resources;* and (e) *Limited View of iSTEM.* Further Structural Equation Modeling (SEM) and path analysis identified *Teacher Education Gap in iSTEM Methodology* and *No Child Left Behind* as exogenous variables that had direct impact on a number of factors. Refer to Tables 94, 95, 96, and 97, and Figure 1 in Chapter 4 regarding said impact.

The *No Implementation* group ranked factor concepts in the following order of impact:

1. *No Child Left Behind*
2. *Teacher Education Gap in iSTEM Methodology*
3. *Resources*
4. *Resistance to iSTEM-Based Reform*
5. *Limited View of iSTEM*

All factors had a level of agreement by the *No Implementation* group with the exception of two factors, *Perception* and *Male-Oriented Curriculum* that were near a neutral view.

Those who reported implementation level at *Preparation* ranked the top five factors as:

1. *Teacher Education Gap in iSTEM Methodology*
2. *Resistance to iSTEM-Based Reform*
3. *Resources*
4. *Limited View of iSTEM*
5. *No Child Left Behind.*

Once again, *Perception* and *Male-Oriented Curriculum* were at or approaching statistically neutral values.

The *Partial Implementation* group placed the top five rankings as follows:

1. *No Child Left Behind*

2. *Limited View of iSTEM*
3. *Teacher Education Gap in iSTEM Methodology*
4. *Resources*
5. *Resistance to iSTEM-Based Reform.*

Again, *Perception* approached statistical neutrality and *Male-Oriented Curriculum* migrated to a level of slight disagreement.

Finally, those reporting *Full Implementation* revealed the following factor rankings:

1. *No Child Left Behind*
2. *Teacher Education Gap in iSTEM Methodology*
3. *Resources*
4. *Limited View of iSTEM*
5. *Resistance to iSTEM-Based Reform.*

This level had the most pronounced change regarding factor value rankings as only the top five factors met the criteria for consideration with a minimum *Agree* scale level. *Technology and Engineering Standards*, *The Missing T and E of iSTEM,* and *Status Quo Regarding Science and Mathematics* were at or approaching a neutral value. *Perception, Resistance to Changing Teaching Methodology,* and *Male-Oriented Curriculum* had means indicating slight disagreement with the factors.

The results indicate the NCLB barrier had the most perceived impact on implementation for three groups: *No Implementation, Partial Implementation* and *Full Implementation.* The *Preparation* group ranked NCLB in the fifth position regarding impact and results indicate concerns regarding content and methodology knowledge, resistance to iSTEM-based reform and resource concerns were a larger concern for participants in this sample group.

Research Question 5 Findings

The Teacher Education Gap and NCLB factors emerged as predictors. The path analysis detailed in Chapter 4 identified two factors, *Teacher Education Gap in iSTEM Methodology* and *No Child Left Behind* as having direct effect on other factors with regard to iSTEM implementation. The results of the SEM indicated a moderate to strong fit on six factors impacted by the *Teacher Education Gap in iSTEM Methodology. No Child Left Behind* had moderate or moderate to strong effect on three factors.

Conclusions

Reform and Reinventing the Educational Wheel

When evaluating earlier interdisciplinary movements it is apparent recent perceived benefits or issues identified regarding STEM methodology are, at a minimum, related or similar to benefits or issues identified in earlier educational movements. Thus, the current iSTEM movement has close ties regarding methods and underlying issues driving recent education reform efforts.

Much like an apple tree, iSTEM has been grafted onto rootstock of curricular concepts and education paradigms of the past. Thus iSTEM is drawing from proven reform and change movements to establish current methodological practice. Now only time will tell if STEM will gain enough momentum to become a long-term solution to nationally perceived educational issues. Refer to Table 98, Chapter 4 regarding authors and concepts identified.

As Higher Implementation Levels are Reached, Scores Generally Drop

These results are an indication of perception changing once teachers became more vested in iSTEM implementation. This may be due to realization barriers are not as pronounced as once thought, or reality changes due to school district increases in commitment levels. Familiarity and understanding of the inherent methodological change required by iSTEM typically lessens what one respondent termed as the “self-made fears” of teachers. The indicated differences are across a broad range of items within constructs regarding *Efficacy, Buy-In, Adoption, Resources, Professional Development, Standards, Narrow View,* and *Regulation.* Results indicate a range of perceptual change as respondents reported increasing levels of implementation. As an example, exclusionary views of items in the *Limited View of iSTEM* became less pronounced when respondents reported *Full Implementation.* The results support the views of Miaoulis (2009) who indicated that after attending iSTEM-based training, participants were excited to implement change in their local school.

The Technology and Engineering Discipline had Differing Views

Areas of concern for the discipline include: perceived lack of support or educational value by administration (Gjøvik, 2010; Sandlin, 2009); perception that many purported iSTEM school implementations lack technological literacy components, commonly referred to in technology and engineering literature as the *“Missing T & E in STEM”* or a *“Narrow View”* of iSTEM (Lantz, 2009); concerns of male-oriented curriculum impacting number of female students taking technology-based content (Sandlin, 2009); and the *Science* and *Mathematics* content areas indicating no need to change methodology and content practice (Gjøvik, 2010; Lantz, 2009) .

Additional Areas of Concern

Consistent levels of agreement across most groups are noted with the following indicated issues: non-supportive teachers (Gjøvik 2010); lack of needed resources (all except the *Full Implementation* group) as per Ashida & Hunter (2009 a-f) and Miaoulis, (2009); perception of inadequate facilities for *Science, Technology and Engineering, Mathematics*, *No Implementation,* *Preparation,* and *Partial Implementation* groups (Gjøvik, 2010; Miaoulis, 2009). All of the aforementioned concerns were supported throughout the open-ended portion of the study.

Impact on Smaller Districts

Mean scores of teachers reporting responsibilities of both middle and high school in the *Grade Level* group have the highest mean scores regarding the teacher education gap in iSTEM content. This may indicate teachers in smaller school districts, where teachers' responsibilities encompass a broader range of grade levels within secondary education, perceive the items relating to lack of knowledge of iSTEM methods and content as a pervasive issue.

Recognition of Narrow View Issues by Mathematics and Science

Science and mathematics respondents with experience or training in iSTEM methods recognized the issue regarding the *Narrow View* of K-12 STEM programs that don't utilize integrative practices across disciplines, failing to teach interrelatedness (Ashida & Hunter, 2009; Lantz, 2009; Miaoulis, 2009).

Factor Impact on Implementation

Five factors have the most impact on implementation. *Teacher Education Gap in iSTEM Methodology* (moderate to strong effect on six factors) and *No Child Left Behind* (moderate or moderate to strong effect on three factors) have effect on other identified factors. The remaining top factors are *Resistance to iSTEM-Based Reform, Resources,* and *Limited View of iSTEM.*

Science Respondents Perceive a Lack of Engineering Standards

There appears to be some perception of a lack of standards from the engineering field to drive K-12 iSTEM education (Miaoulis, 2009) by educators reporting *Science* as a content area. In all instances, *Science* is the only group consistently indicating agreement with items in the factor. In fact, there are well-established K-12 standards with regard to technological literacy and pre-engineering from the ITEEA found in the *Standards for Technological Literacy* (ITEEA, 2007). Also recently developed standards for science known as the *Next Generation Science Standards* (NGSS) attempt to include engineering design and technological literacy. Starkweather (2010), former Executive Director/CEO of the ITEEA, critically analyzed the early work of the *Framework for K-12 Science Education* (the framework that became the NGSS) from the lens of the International Technology and Engineering Teacher Association (ITEEA). The NGSS recognizes the need for inclusion of engineering design and technological literacy to begin addressing needs for pre-engineering content and practice in K-12. At the time of the study, the NGSS had not been released and may have influenced the results.

Mitigating Barriers and Factor Impact

With the broad identification of barriers and impact factors in the study, intervention tied to barriers identified in *the Teacher Education Gap in iSTEM Methodology* emerged as having the most potential to mitigate barriers to iSTEM implementation. It is the opinion of the researcher that alleviating impact of the identified factors and barriers may be accomplished by narrowing the *Teacher Education Gap*. This will need to be accomplished in two ways. Districts need to commit to support of required resources focusing on continued growth and exposure to the latest in methods, curriculum, and practices in iSTEM. This support needs to go far beyond the common practice of one-and-done workshops. Second, significant changes in teacher preparation programs are needed at the university level to make iSTEM methodology and content cornerstone components of elementary and secondary education programs. Even better would be certifications or endorsements in iSTEM. Universities will need to ensure teacher education programs are steeped in technological literacy and engineering design methods and content including applied practices lending support to other traditional disciplines.

The Impact of NCLB

This is the only construct where every group agreed with each statement in a construct and indicates the requirements of *NCLB* are considered major barriers to iSTEM implementation. .

It appears NCLB will be a contributing factor to perceived implementation barriers for some time. Districts will need to continue to innovate and work within the requirements and constraints of the Act. Whether real or perceived, there are pervasive issues for practicing teachers regarding implications of the Act. Well designed and placed iSTEM programs will enable students with the requisite skill sets and knowledge to succeed in the era of high-stakes assessment, but results indicate the underlying issue is lack of momentum due to fear of consequences of the Act.

Recommendations for Practice

Considerations for Administrators

Administrators should take steps to ensure mechanisms and programs are in place or available to help allay fears of teachers as iSTEM programs are considered, initiated or evolve to higher levels of implementation. It would be advisable to survey district teachers to determine perceived issues of implementation. District administrators may want to refer to the identified factors to determine items to measure that are identified as impact factors by different groups in the study.

An overarching issue that may exemplify the uncertainty teachers experience prior to implementing an iSTEM program is what one respondent referred to as the “self-made fears of teachers”. These fears may be a significant underlying issue with perceived barriers of implementation such as resistance to reform, resistance to methodological change, perception of the iSTEM movement, concerns over high-stakes testing due to NCLB and the ease of remaining with the status quo—it is simply easier to continue in one's comfort zone.

One and done workshops aren't the answer for long-term success of iSTEM programs. Effective change requires commitment to ongoing support through resource allocation, commitment to ongoing training in best practices, and making proven iSTEM-based curriculum available. Decision makers should be cognizant of issues consistently identified in open-ended responses as lack of funding, adequate facilities, and supplies.

Administrative issues and time issues are significant concerns from participants in the open-ended portion of the study. Indicated may be a need for administrators to vest time in gaining a better understanding of iSTEM and subsequent support of an integrative program in local districts. Administrators should consider attending iSTEM workshops and trainings to better understand not only specifics of running a successful iSTEM program, but also to realize there are creative ways to teach iSTEM methods and content on tight budgets. Also, lack of time emerged throughout the open-ended portion of the study as the most significant issue. Time issues are perceived in several venues: time to collaborate, prepare, attend STEM methodology workshops and trainings, curriculum development, and the inherent requirements of NCLB.

Administrators should develop measures to ensure stakeholders, education and business leaders and traditional general education discipline teachers are exposed to the value of technology and engineering curriculum as enhancement components of a fully integrated STEM program. Historically, these have been considered expensive programs to run and unfortunately in some cases have been eliminated. If a district doesn't have a well-entrenched technology and engineering program delivering content based on the *Standards for Technological Literacy*, this may be the best time to put a program in place to support and enhance traditional disciplines through iSTEM methods.

With the recent deployment of the *Next Generation Science Standards* administrators should consider supporting district teachers in obtaining robust professional development, certification, endorsement or degrees in iSTEM methodology and content based on the *Standards for Technological Literacy* (ITEA, 2007).

Considerations for Educational Regulation Agencies

Educational agencies may want to consider alternatives to Carnegie units and traditional credits and seat time with regard to iSTEM implementation. Block scheduling has been proven to be more conducive to effective implementation of iSTEM programs.

Agencies should support local districts and education programs with regard to role models, more female teachers in STEM-related disciplines, and movement towards gender-neutral curriculum.

Finally, state and local education agencies should consider comprehensive inclusive iSTEM curriculum for all students. Although much of the focus is on pre-engineering concepts, the skills learned may be beneficial for all students, regardless of future career direction. If federal, state, and local educational agencies are committed to reform including iSTEM methodology, said educational regulatory agencies need to consider reworking policies to reward and empower districts and teachers to be innovative and subsequently lessen potential negative results from requirements such as high stakes testing and Adequate Yearly Progress.

Mitigating the Effect of Factors on iSTEM Implementation

If leaders were asked to identify one concept to concentrate on regarding issues of implementation, closing the iSTEM gap in pre-service training and professional development for practicing teachers may be the most significant area to focus resources for solution. The impact path model suggests a strong case can be made for attacking implementation barriers issues by concentrating efforts to mitigate the gap in teacher training in iSTEM methodology and content. Solutions need to be dual faceted and universities will need to answer the call in this regard through changes at the university level regarding pre-service teacher methodology and content in iSTEM methods and through comprehensive, increasingly robust professional development programs for practicing education professionals. In addition, organizations providing iSTEM workshop training may want to consider opportunities for pre-service teacher candidates at reduced cost through outright discounts or scholarships from supportive agencies and corporations to assist in transition.

Recommendations for Future Study

A potential theme to consider for future barriers research items emerged regarding student-related issues affecting implementation. Indicated are issues of student preparedness, student interest, student discipline, difficulty of creating iSTEM curriculum that works with Individualized Education Programs (IEPs) and 504 accommodations, and issues with students pursuing careers in STEM-related fields without any technology and engineering background.

In future iterations of iSTEM implementation barriers research Item 53 should be reworked or enhanced with additional items as a construct to better reflect the documented issue of computers perceived as meeting technological literacy requirements by some districts. The issue with technological literacy may be exacerbated in 2014 when the National Assessment of Educational Progress assesses technological literacy for first time. Integrated STEM practices may gain more traction in districts if technological literacy assessment scores are low.

A future deployment of the research concept would benefit from a larger sample of all group areas. In particular, a larger representation of teachers with specialization and experience in mathematics content and methodology would be desired.

A research study should be initiated to survey fully implemented iSTEM programs to determine methods and practices used to limit identified barriers. These methods would be of benefit to programs initiating higher levels of implementation and would shorten the time needed to implement a fully vested iSTEM program by detailing successful practices.

There is need for a study to determine how fully implemented programs deal with requirements of NCLB. This would be of significant assistance to other developing iSTEM programs. The research may be able to identify innovative solutions to working within the requirements of the Act.

A study of university teacher education programs should be initiated to determine status of what changes have been made or are in the planning stages to implement reform programs to infuse iSTEM methods and content in elementary and secondary degree options. Additionally the research could include determination of professional development initiatives implemented or being considered for practicing teachers by universities.

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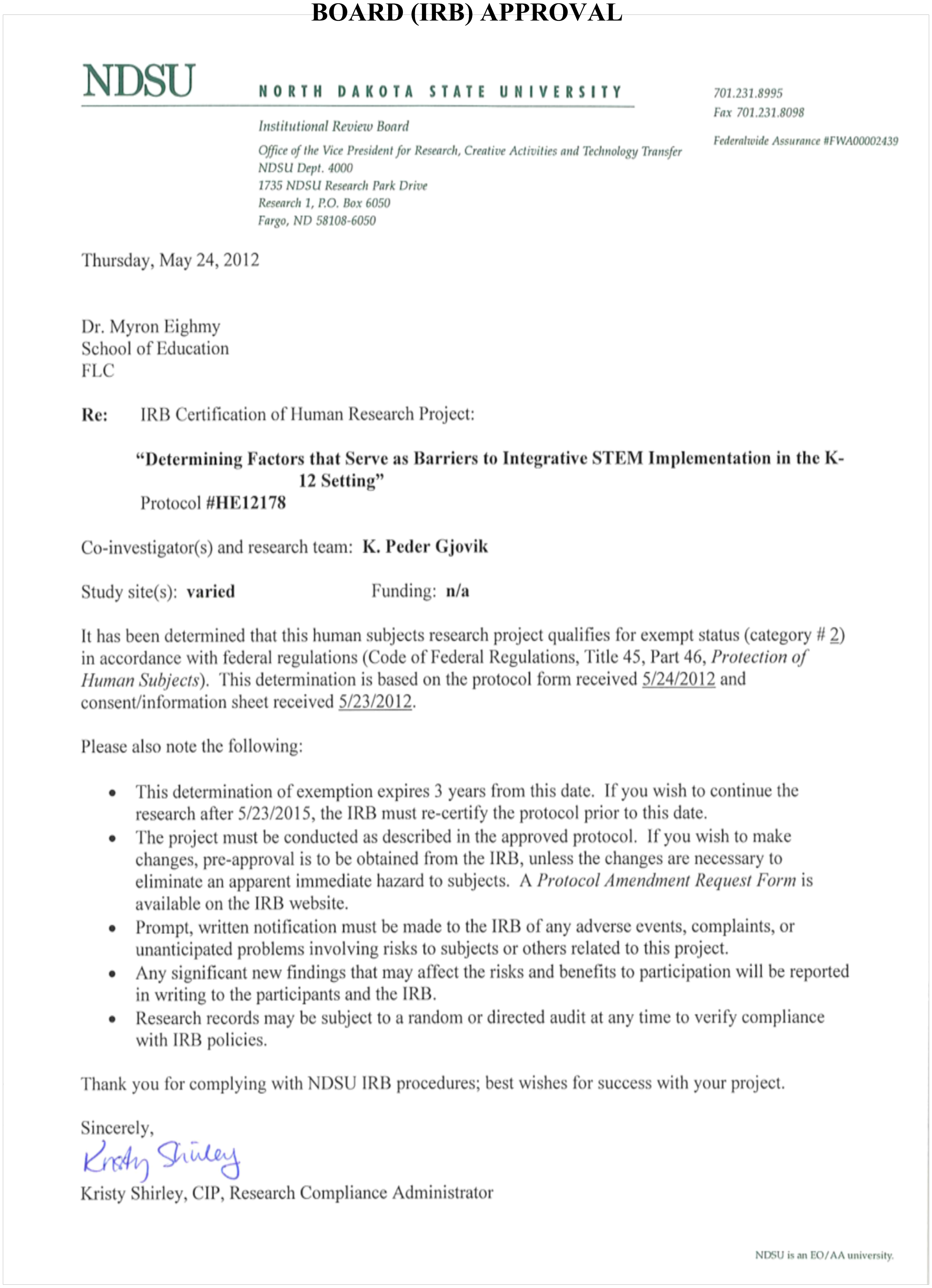
APPENDIX A. NORTH DAKOTA STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD (IRB) APPROVAL



NDSU NORTH DAKOTA STATE UNIVERSITY

Institutional Review Board

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Federalwide Assurance #FWA00002439

Thursday, May 24, 2012

Dr. Myron Eighmy
School of Education
FLC

Re: IRB Certification of Human Research Project:

"Determining Factors that Serve as Barriers to Integrative STEM Implementation in the K-12 Setting"
Protocol **#HE12178**

Co-investigator(s) and research team: **K. Peder Gjovik**

Study site(s): **varied** Funding: **n/a**

It has been determined that this human subjects research project qualifies for exempt status (category # 2) in accordance with federal regulations (Code of Federal Regulations, Title 45, Part 46, *Protection of Human Subjects*). This determination is based on the protocol form received 5/24/2012 and consent/information sheet received 5/23/2012.

Please also note the following:

- This determination of exemption expires 3 years from this date. If you wish to continue the research after 5/23/2015, the IRB must re-certify the protocol prior to this date.
- The project must be conducted as described in the approved protocol. If you wish to make changes, pre-approval is to be obtained from the IRB, unless the changes are necessary to eliminate an apparent immediate hazard to subjects. A *Protocol Amendment Request Form* is available on the IRB website.
- Prompt, written notification must be made to the IRB of any adverse events, complaints, or unanticipated problems involving risks to subjects or others related to this project.
- Any significant new findings that may affect the risks and benefits to participation will be reported in writing to the participants and the IRB.
- Research records may be subject to a random or directed audit at any time to verify compliance with IRB policies.

Thank you for complying with NDSU IRB procedures; best wishes for success with your project.

Sincerely,
Kristy Shirley
Kristy Shirley, CIP, Research Compliance Administrator

APPENDIX B. PAPER-BASED CONSENT

NDSU North Dakota State University
School of Education
216C FLC, P.O. Box 6050
Fargo, ND 58108-6050
Phone: 701.231.5775 Fax: 701.231.7416

Title of Research Study:
Determining Factors that Serve as Barriers to Integrative STEM Implementation in the K-12 Setting.

This study is being conducted by:
The researcher conducting this study is K. Peder Gjovik. If you have questions regarding this study, please contact him at peder.gjovik@vcsu.edu or the VCSU Department of Technology, 101 College Street, Valley City, ND 58072. Phone: 701.845.7448. Also you may contact his advisor, Dr. Myron Eighmy, at 701.231.5775 or email myron.eighmy@ndsu.edu .

Why am I being asked to take part in this research study?
Since you have completed integrative STEM methodology-based workshops, trainings, or courses; or because you have experience delivering integrative STEM content, we are interested in your perceptions regarding barriers to integrative STEM implementation.

What is the reason for doing the study?
We are conducting a research project to identify barriers that have the most bearing on integrative Science, Technology, Engineering and Mathematics (STEM) methodology implementation in the K-12 setting. The focus of this project is to learn about the level of effect of various barriers to STEM implementation. The results of this study will be utilized in doctoral research.

What will I be asked to do?
By clicking on the link to the browser-based Barriers survey you agree to participate in the research, and you are giving consent to utilizing data gathered from your responses. The first section will request demographic information necessary for group analysis such as years of teaching experience, gender, grade levels taught, degrees and content specializations held, and information on any STEM-based workshops, trainings, or coursework completed. Once you answer the demographics section, you will be prompted to answer approximately 50 Likert-based statements as to your level of agreement. With each statement, you will also have the option of giving additional information regarding your scale answer. Any additional information you feel is necessary to explain your scale response will be helpful to the research, but is not required.

Where is the study going to take place, and how long will it take?
If you agree to participate by clicking on the link, all data will be collected via browser-based survey software. In preliminary testing, the average time to complete is 25-30 minutes.

What are the risks and discomforts?
It is not possible to identify all potential risks in research procedures, but the researcher(s) have taken reasonable safeguards to minimize any known risks to the participant.

What are the benefits to me?
You are not expected to get any benefit from being in this research study. You will not receive any compensation for participating in this research.

What are the benefits to other people? Benefits to others are likely to include advancement of knowledge, and /or possible benefits to persons in the STEM-related education fields.

Do I have to take part in the study? Your participation in this research is your choice. If you decide to participate in the study, you may change your mind and stop participating at any time without penalty or loss of benefits to which you are already entitled.

What are the alternatives to being in this research study?
Instead of being in this research study, you can choose not to participate.

Who will see the information that I give?
We will keep private all research records. Your information will be combined with information from other people taking part in the study. When we write about the study, we will write about the combined information that we have gathered. We may publish the results of the study; however, we will keep identifying demographic information private.

We will make every effort to prevent anyone who is not on the research team from knowing that you gave us information, or what that information is.

What if I have questions?
Before you decide whether to accept this invitation to take part in the research study, please ask any questions by contacting K. Peder Gjovik at peder.gjovik@vcsu.edu or the VCSU Department of Technology, 101 College St. W, Valley City, ND 58072. Phone: 701.845.7448.

What are my rights as a research participant?
You have rights as a participant in research. If you have questions about your rights, or complaints about this research you may talk to the researcher or contact the NDSU Human Research Protection Program by:

- Telephone: 701.231.8908
- Email: ndsu.irb@ndsu.edu
- Mail: NDSU HRPP Office, NDSU Dept. 4000, PO Box 6050, Fargo, ND 58108-6050.

The role of the Human Research Protection Program is to see that your rights are protected in this research; more information about your rights can be found at: www.ndsu.edu/research/irb .

Documentation of Informed Consent:
You are freely making a decision whether to be in this research study. By clicking the link to the survey, you affirm that:

1. you have read and understood this consent form
2. you have had your questions answered, and
3. you have decided to be in the study.

K. Peder Gjovik

Signature of researcher explaining study

April 1, 2012
Date

K. Peder Gjovik
Printed name of researcher explaining study

APPENDIX C. BROWSER-BASED EMAIL INVITATION TO PARTICIPATE FOR FORWARDING BY PARTICIPATING ORGANIZATIONS

Dear STEM Educator:

My name is Peder Gjøvik and I am a graduate student in the School of Education at North Dakota State University. I am conducting research to determine factors that serve as barriers to implementing integrative science, technology, engineering and mathematics (iSTEM) in K-12 schools. Regardless of your school system's level of iSTEM implementation, your opinions and experiences are critical to the success of the study. The intent of the research is to determine what barriers and contributing factors have the most influence regarding iSTEM implementation adoption level.

So, what is Integrative STEM (iSTEM)? Historically science, technology, engineering and mathematics (STEM) instruction in the United States has been separated by discipline with varying degrees of integration across subjects. Recently, a more student-centered approach evolved. iSTEM is a meta-disciplinary approach to instruction that includes thematic units or blocks where groups of students utilize STEM content to design and solve a problem. The implementation of iSTEM programs may be broader than the standard STEM disciplines and include content such as English Language Arts (ELA), history, and fine arts.

You are being asked to participate due to past experience in STEM-based professional development and/or your experience teaching STEM content. You can provide unique insight into implementing STEM programs in K-12 classrooms. Participation in this study is voluntary and you may quit the study at any time. If you decide to complete this survey, print off this email and keep it for your information.

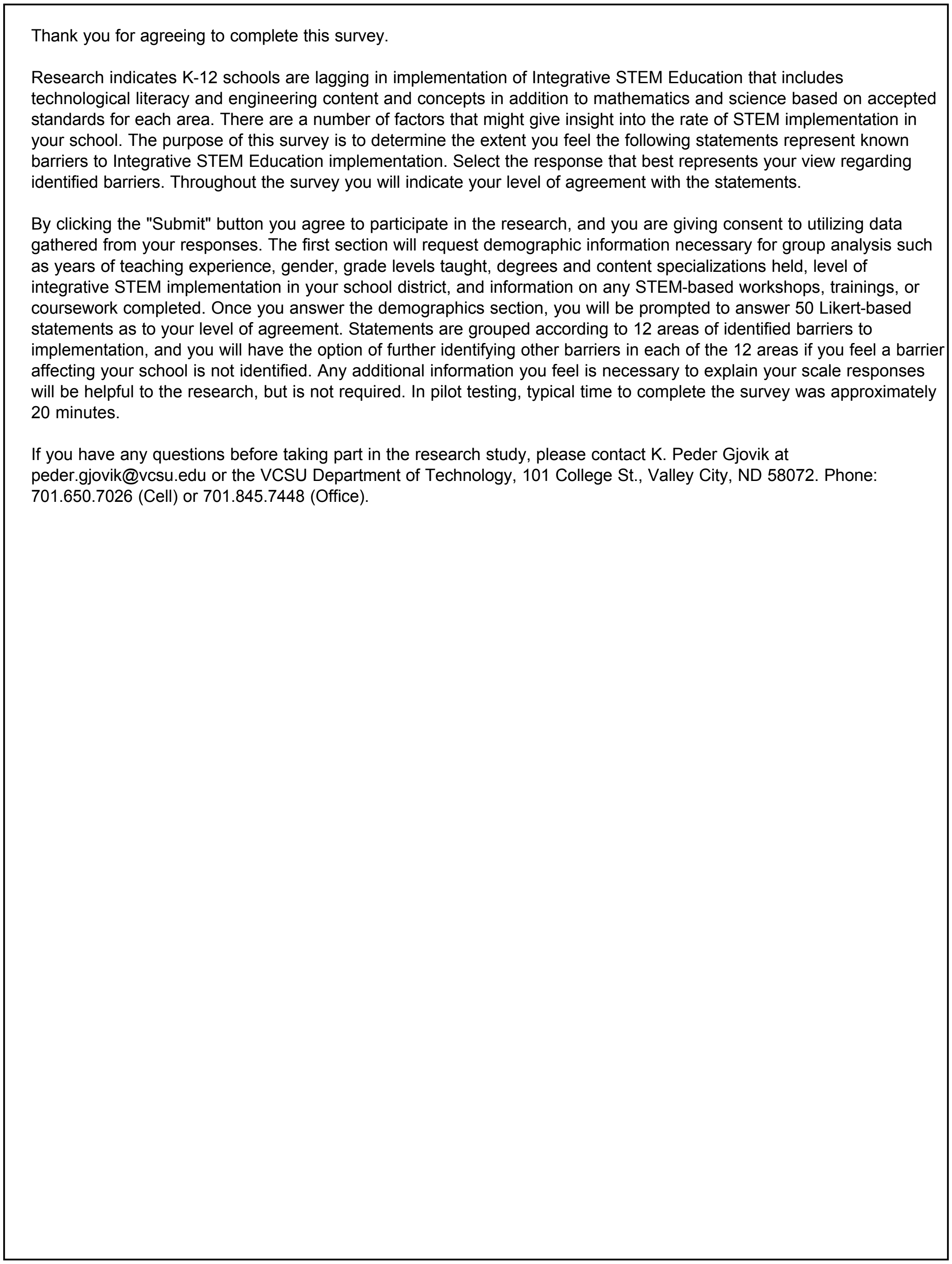
By completing the online survey entitled *"Barriers to Integrative STEM Implementation in the K-12 School"*, you are giving consent to utilize all data gathered through the instrument. The survey takes 20-30 minutes to complete. To participate, click on the link on the bottom of this page.

No identifiable personal information will be gathered, all responses will be anonymous, any demographic information gathered will be combined with other people participating in the survey and we will write about the combined information. We may publish the results of the study.

If you have any questions about this project, please contact me at 701.845.7448, peder.gjovik@vcsu.edu, or contact my advisor, Dr. Myron Eighmy at 701.231.5775, myron.eighmy@ndsu.edu. If you have questions about the rights of human participants in research, or to report a problem, contact the NDSU Institutional Review Board (IRB) office, at 701-231-8908, or ndsu.irb@ndsu.edu.

Thank you for your participation in this study. To proceed, please click here.

APPENDIX D. ISTEMIBI INSTRUMENT

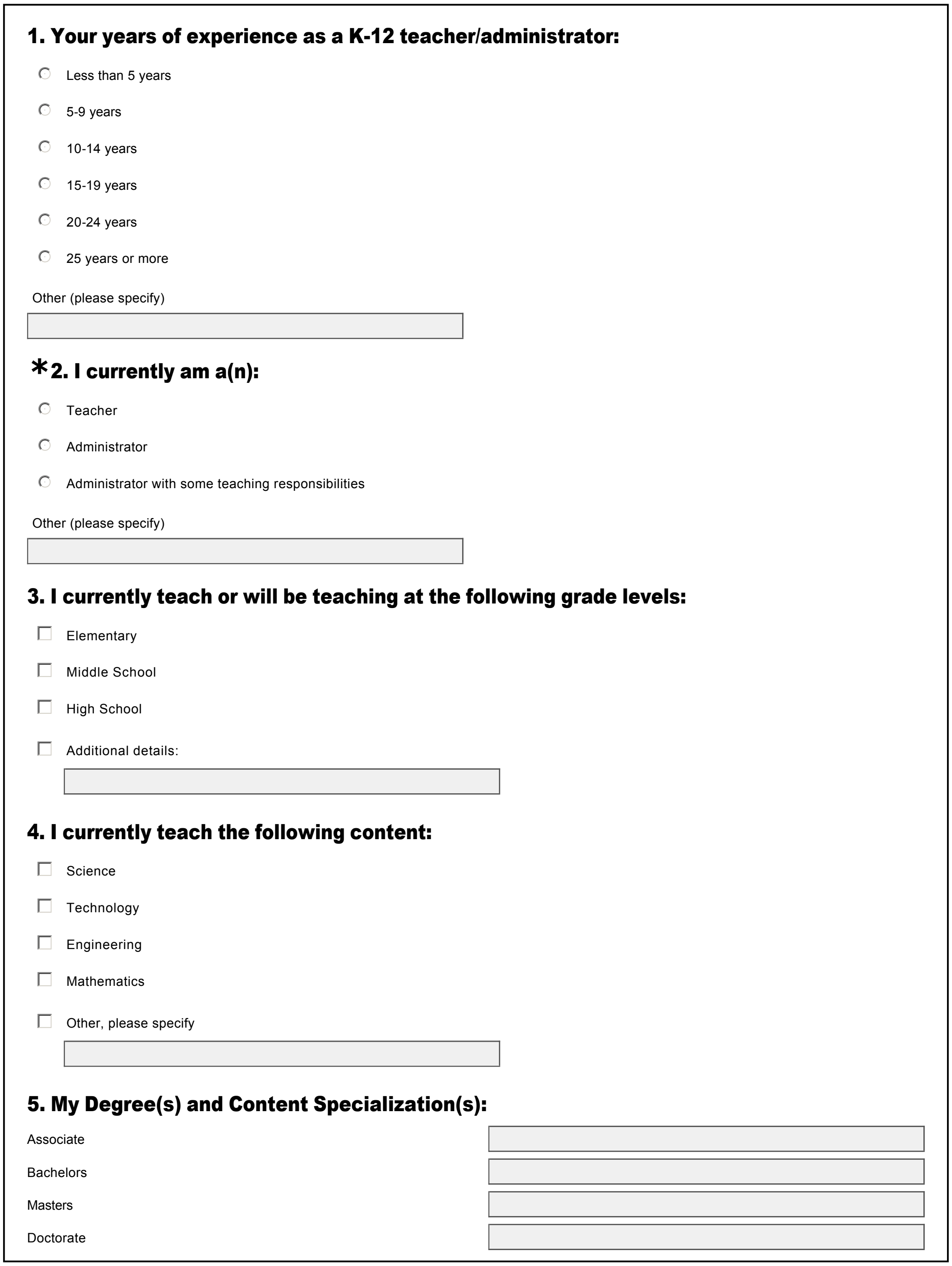


Thank you for agreeing to complete this survey.

Research indicates K-12 schools are lagging in implementation of Integrative STEM Education that includes technological literacy and engineering content and concepts in addition to mathematics and science based on accepted standards for each area. There are a number of factors that might give insight into the rate of STEM implementation in your school. The purpose of this survey is to determine the extent you feel the following statements represent known barriers to Integrative STEM Education implementation. Select the response that best represents your view regarding identified barriers. Throughout the survey you will indicate your level of agreement with the statements.

By clicking the "Submit" button you agree to participate in the research, and you are giving consent to utilizing data gathered from your responses. The first section will request demographic information necessary for group analysis such as years of teaching experience, gender, grade levels taught, degrees and content specializations held, level of integrative STEM implementation in your school district, and information on any STEM-based workshops, trainings, or coursework completed. Once you answer the demographics section, you will be prompted to answer 50 Likert-based statements as to your level of agreement. Statements are grouped according to 12 areas of identified barriers to implementation, and you will have the option of further identifying other barriers in each of the 12 areas if you feel a barrier affecting your school is not identified. Any additional information you feel is necessary to explain your scale responses will be helpful to the research, but is not required. In pilot testing, typical time to complete the survey was approximately 20 minutes.

If you have any questions before taking part in the research study, please contact K. Peder Gjovik at peder.gjovik@vcsu.edu or the VCSU Department of Technology, 101 College St., Valley City, ND 58072. Phone: 701.650.7026 (Cell) or 701.845.7448 (Office).



1. Your years of experience as a K-12 teacher/administrator:

○ Less than 5 years
○ 5-9 years
○ 10-14 years
○ 15-19 years
○ 20-24 years
○ 25 years or more

Other (please specify)

***2. I currently am a(n):**

○ Teacher
○ Administrator
○ Administrator with some teaching responsibilities

Other (please specify)

3. I currently teach or will be teaching at the following grade levels:

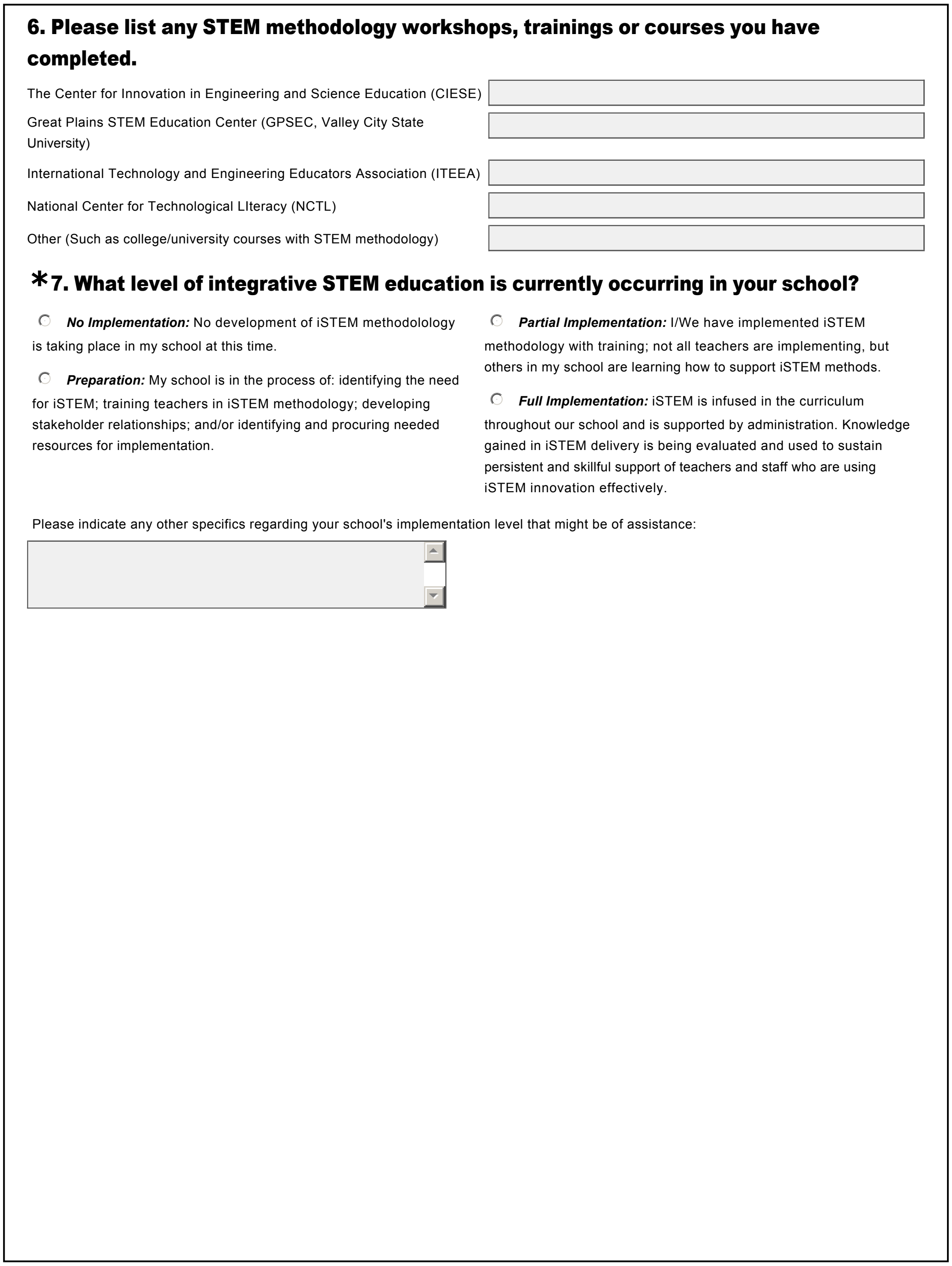
☐ Elementary
☐ Middle School
☐ High School
☐ Additional details:

4. I currently teach the following content:

☐ Science
☐ Technology
☐ Engineering
☐ Mathematics
☐ Other, please specify

5. My Degree(s) and Content Specialization(s):

Associate	
Bachelors	
Masters	
Doctorate	



6. Please list any STEM methodology workshops, trainings or courses you have completed.

The Center for Innovation in Engineering and Science Education (CIESE)

Great Plains STEM Education Center (GPSEC, Valley City State University)

International Technology and Engineering Educators Association (ITEEA)

National Center for Technological LIteracy (NCTL)

Other (Such as college/university courses with STEM methodology)

***7. What level of integrative STEM education is currently occurring in your school?**

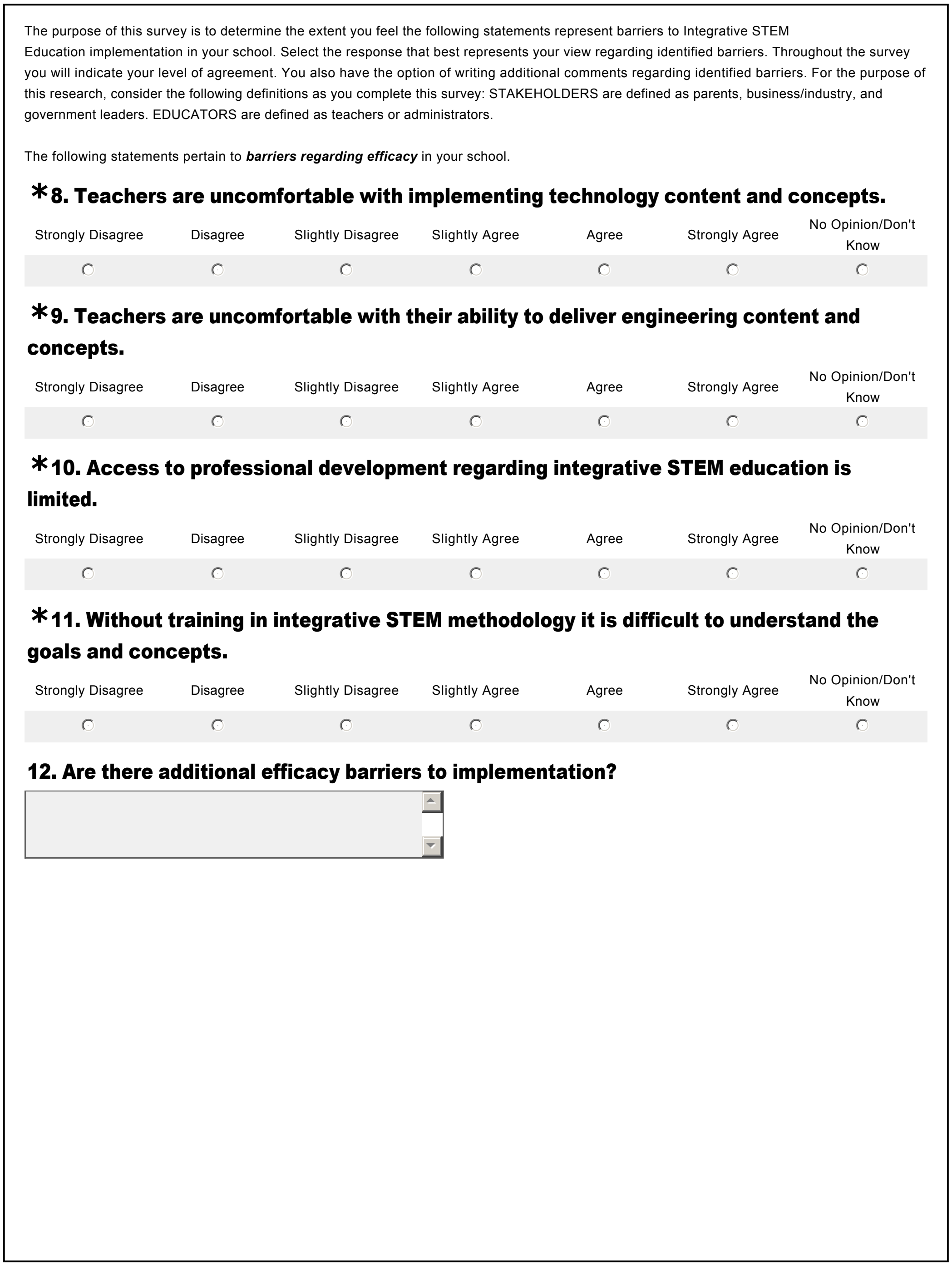
○ ***No Implementation:*** No development of iSTEM methodolology is taking place in my school at this time.

○ ***Preparation:*** My school is in the process of: identifying the need for iSTEM; training teachers in iSTEM methodology; developing stakeholder relationships; and/or identifying and procuring needed resources for implementation.

○ ***Partial Implementation:*** I/We have implemented iSTEM methodology with training; not all teachers are implementing, but others in my school are learning how to support iSTEM methods.

○ ***Full Implementation:*** iSTEM is infused in the curriculum throughout our school and is supported by administration. Knowledge gained in iSTEM delivery is being evaluated and used to sustain persistent and skillful support of teachers and staff who are using iSTEM innovation effectively.

Please indicate any other specifics regarding your school's implementation level that might be of assistance:



The purpose of this survey is to determine the extent you feel the following statements represent barriers to Integrative STEM Education implementation in your school. Select the response that best represents your view regarding identified barriers. Throughout the survey you will indicate your level of agreement. You also have the option of writing additional comments regarding identified barriers. For the purpose of this research, consider the following definitions as you complete this survey: STAKEHOLDERS are defined as parents, business/industry, and government leaders. EDUCATORS are defined as teachers or administrators.

The following statements pertain to ***barriers regarding efficacy*** in your school.

***8. Teachers are uncomfortable with implementing technology content and concepts.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***9. Teachers are uncomfortable with their ability to deliver engineering content and concepts.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

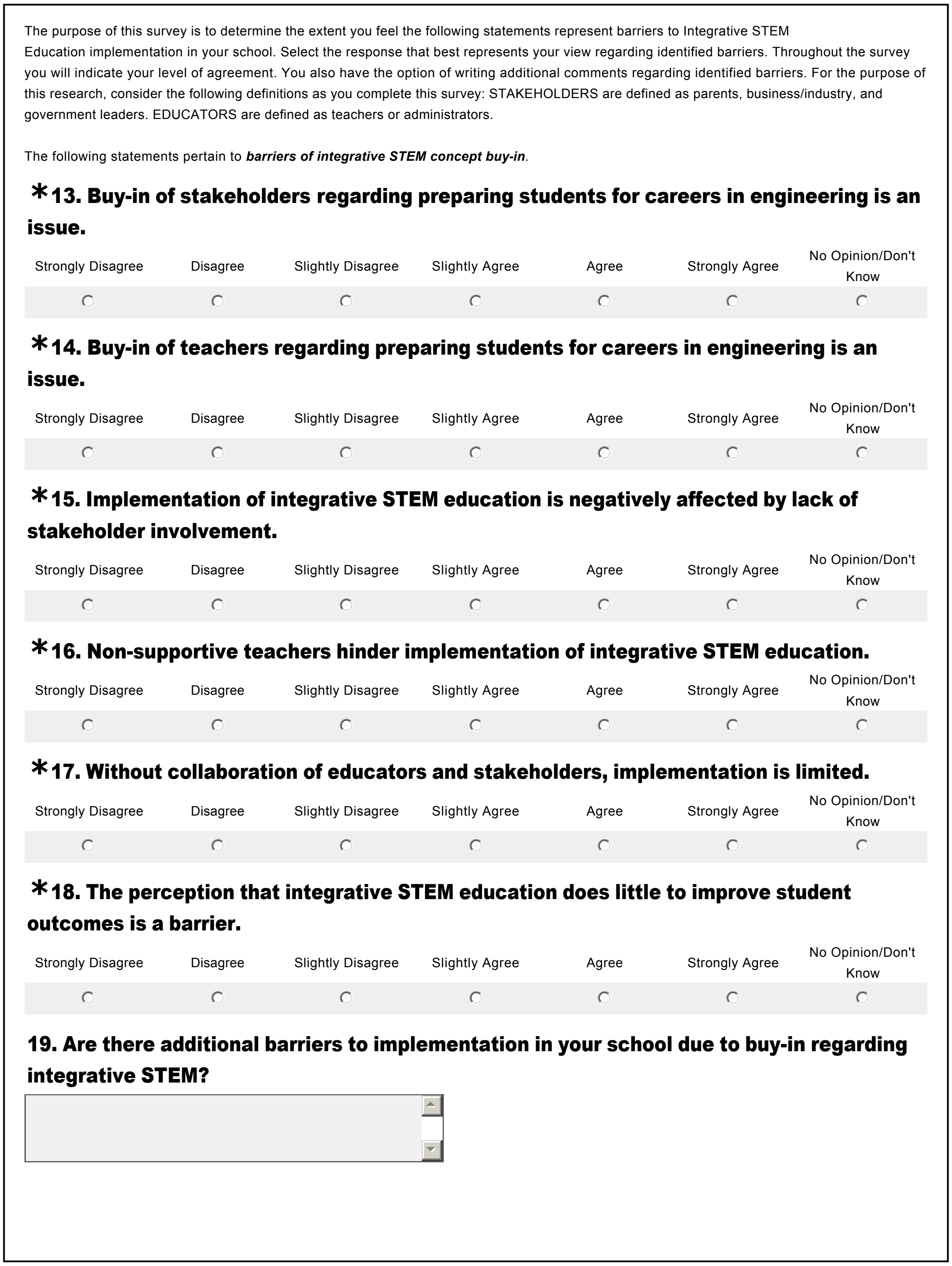
***10. Access to professional development regarding integrative STEM education is limited.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***11. Without training in integrative STEM methodology it is difficult to understand the goals and concepts.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

12. Are there additional efficacy barriers to implementation?



The purpose of this survey is to determine the extent you feel the following statements represent barriers to Integrative STEM Education implementation in your school. Select the response that best represents your view regarding identified barriers. Throughout the survey you will indicate your level of agreement. You also have the option of writing additional comments regarding identified barriers. For the purpose of this research, consider the following definitions as you complete this survey: STAKEHOLDERS are defined as parents, business/industry, and government leaders. EDUCATORS are defined as teachers or administrators.

The following statements pertain to ***barriers of integrative STEM concept buy-in***.

***13. Buy-in of stakeholders regarding preparing students for careers in engineering is an issue.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***14. Buy-in of teachers regarding preparing students for careers in engineering is an issue.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***15. Implementation of integrative STEM education is negatively affected by lack of stakeholder involvement.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***16. Non-supportive teachers hinder implementation of integrative STEM education.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

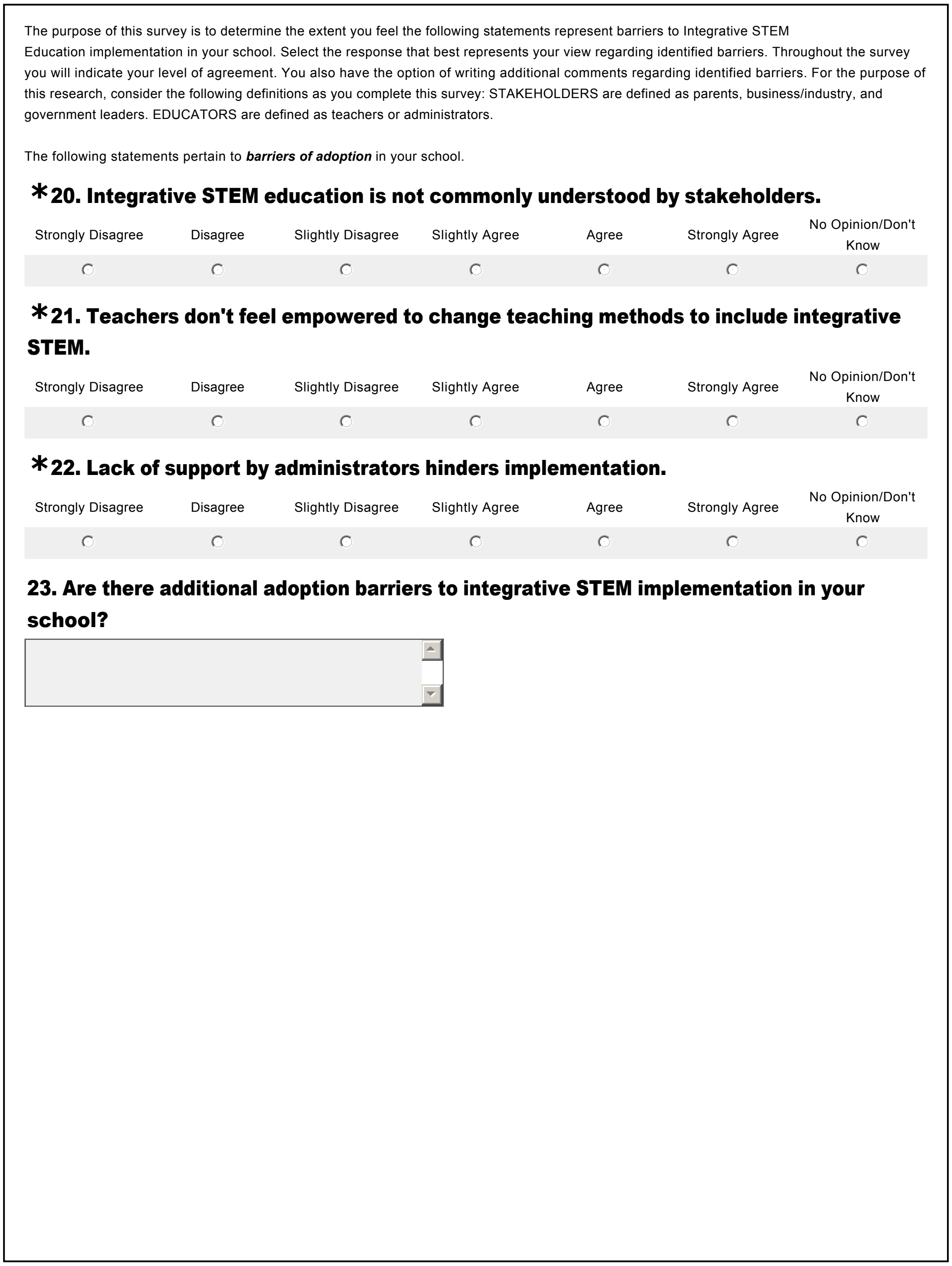
***17. Without collaboration of educators and stakeholders, implementation is limited.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***18. The perception that integrative STEM education does little to improve student outcomes is a barrier.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

19. Are there additional barriers to implementation in your school due to buy-in regarding integrative STEM?



The purpose of this survey is to determine the extent you feel the following statements represent barriers to Integrative STEM Education implementation in your school. Select the response that best represents your view regarding identified barriers. Throughout the survey you will indicate your level of agreement. You also have the option of writing additional comments regarding identified barriers. For the purpose of this research, consider the following definitions as you complete this survey: STAKEHOLDERS are defined as parents, business/industry, and government leaders. EDUCATORS are defined as teachers or administrators.

The following statements pertain to ***barriers of adoption*** in your school.

***20. Integrative STEM education is not commonly understood by stakeholders.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

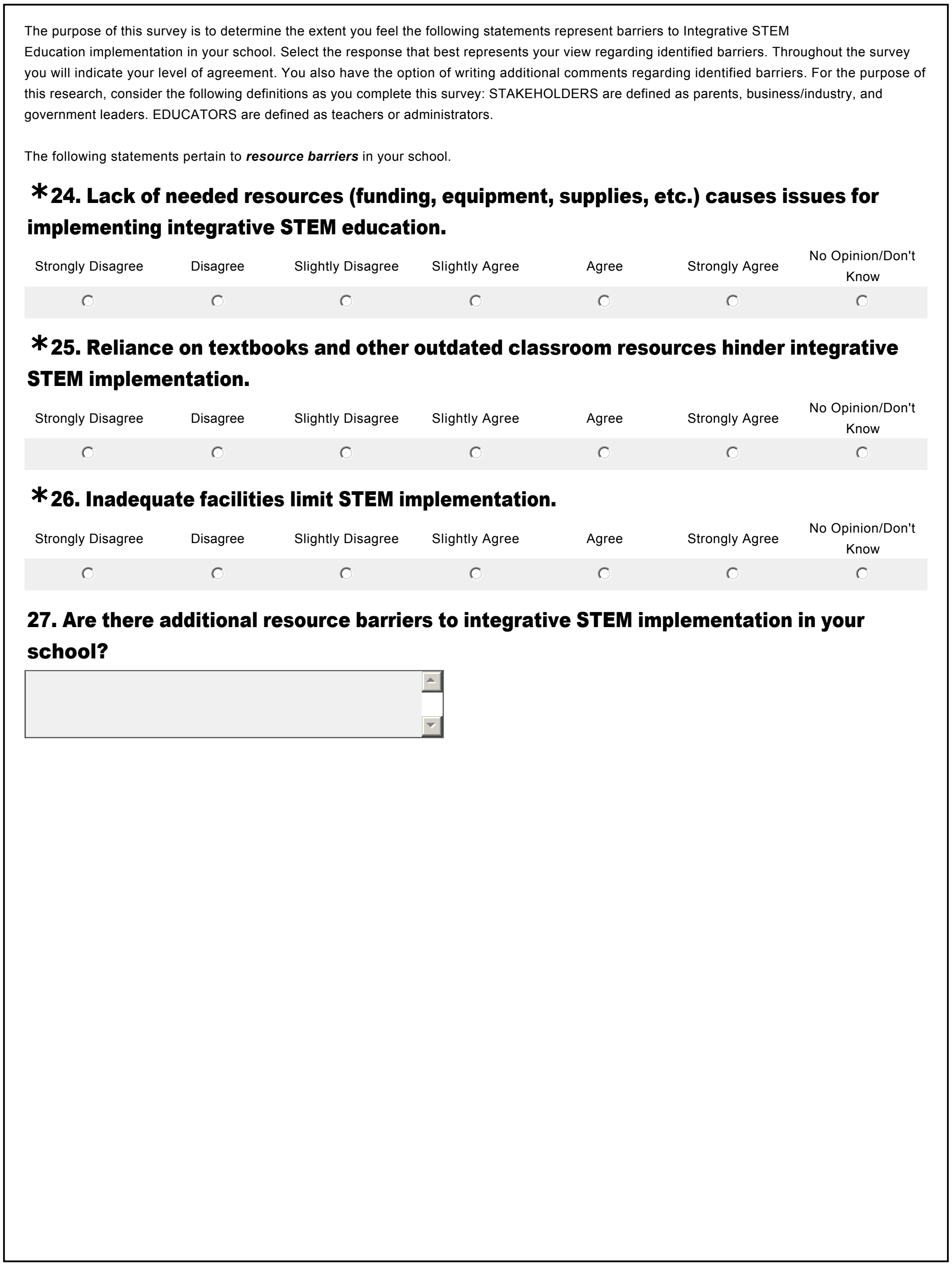
***21. Teachers don't feel empowered to change teaching methods to include integrative STEM.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***22. Lack of support by administrators hinders implementation.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

23. Are there additional adoption barriers to integrative STEM implementation in your school?



The purpose of this survey is to determine the extent you feel the following statements represent barriers to Integrative STEM Education implementation in your school. Select the response that best represents your view regarding identified barriers. Throughout the survey you will indicate your level of agreement. You also have the option of writing additional comments regarding identified barriers. For the purpose of this research, consider the following definitions as you complete this survey: STAKEHOLDERS are defined as parents, business/industry, and government leaders. EDUCATORS are defined as teachers or administrators.

The following statements pertain to ***resource barriers*** in your school.

***24. Lack of needed resources (funding, equipment, supplies, etc.) causes issues for implementing integrative STEM education.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

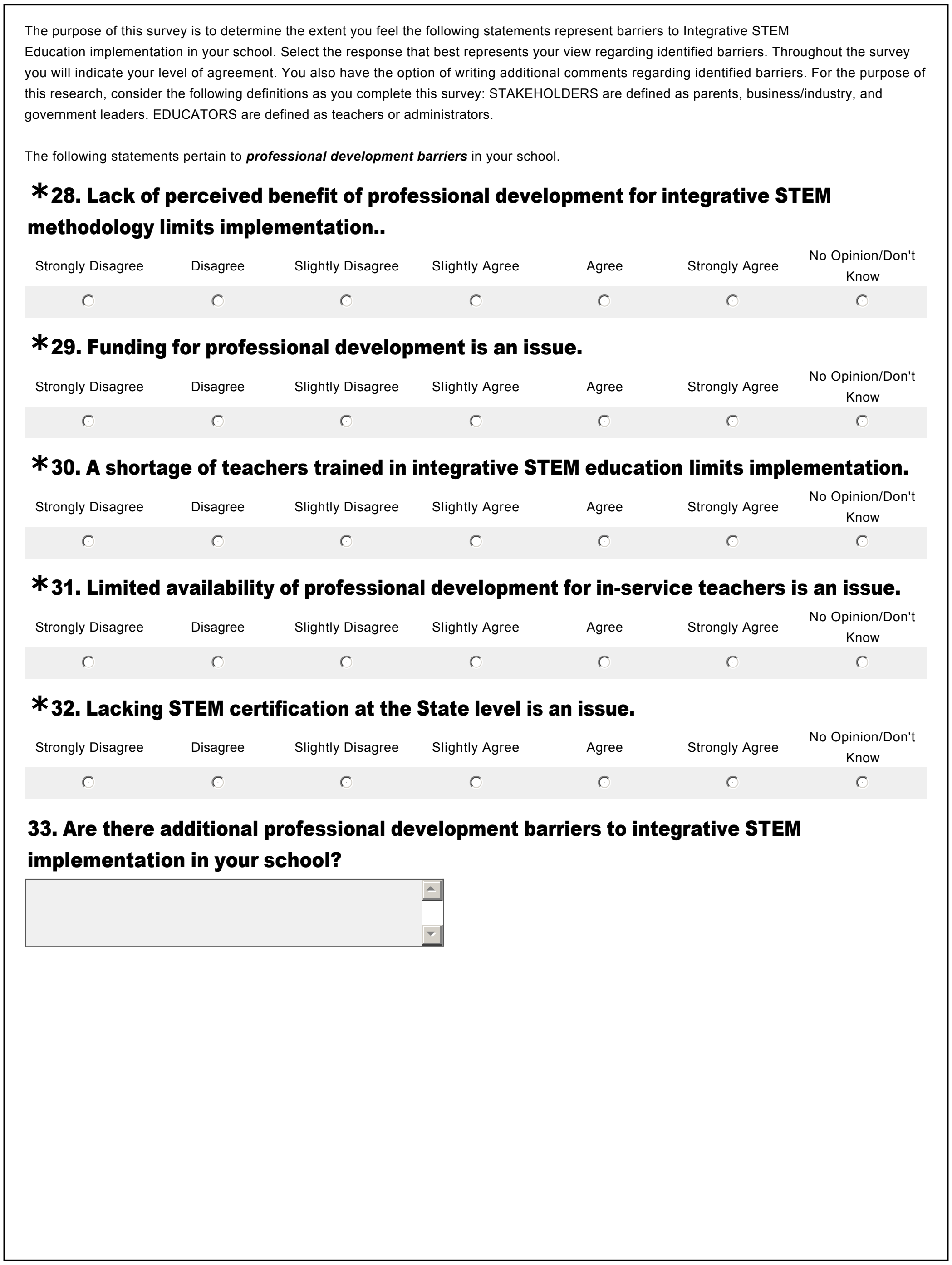
***25. Reliance on textbooks and other outdated classroom resources hinder integrative STEM implementation.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***26. Inadequate facilities limit STEM implementation.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

27. Are there additional resource barriers to integrative STEM implementation in your school?



The purpose of this survey is to determine the extent you feel the following statements represent barriers to Integrative STEM Education implementation in your school. Select the response that best represents your view regarding identified barriers. Throughout the survey you will indicate your level of agreement. You also have the option of writing additional comments regarding identified barriers. For the purpose of this research, consider the following definitions as you complete this survey: STAKEHOLDERS are defined as parents, business/industry, and government leaders. EDUCATORS are defined as teachers or administrators.

The following statements pertain to ***professional development barriers*** in your school.

***28. Lack of perceived benefit of professional development for integrative STEM methodology limits implementation..**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***29. Funding for professional development is an issue.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***30. A shortage of teachers trained in integrative STEM education limits implementation.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

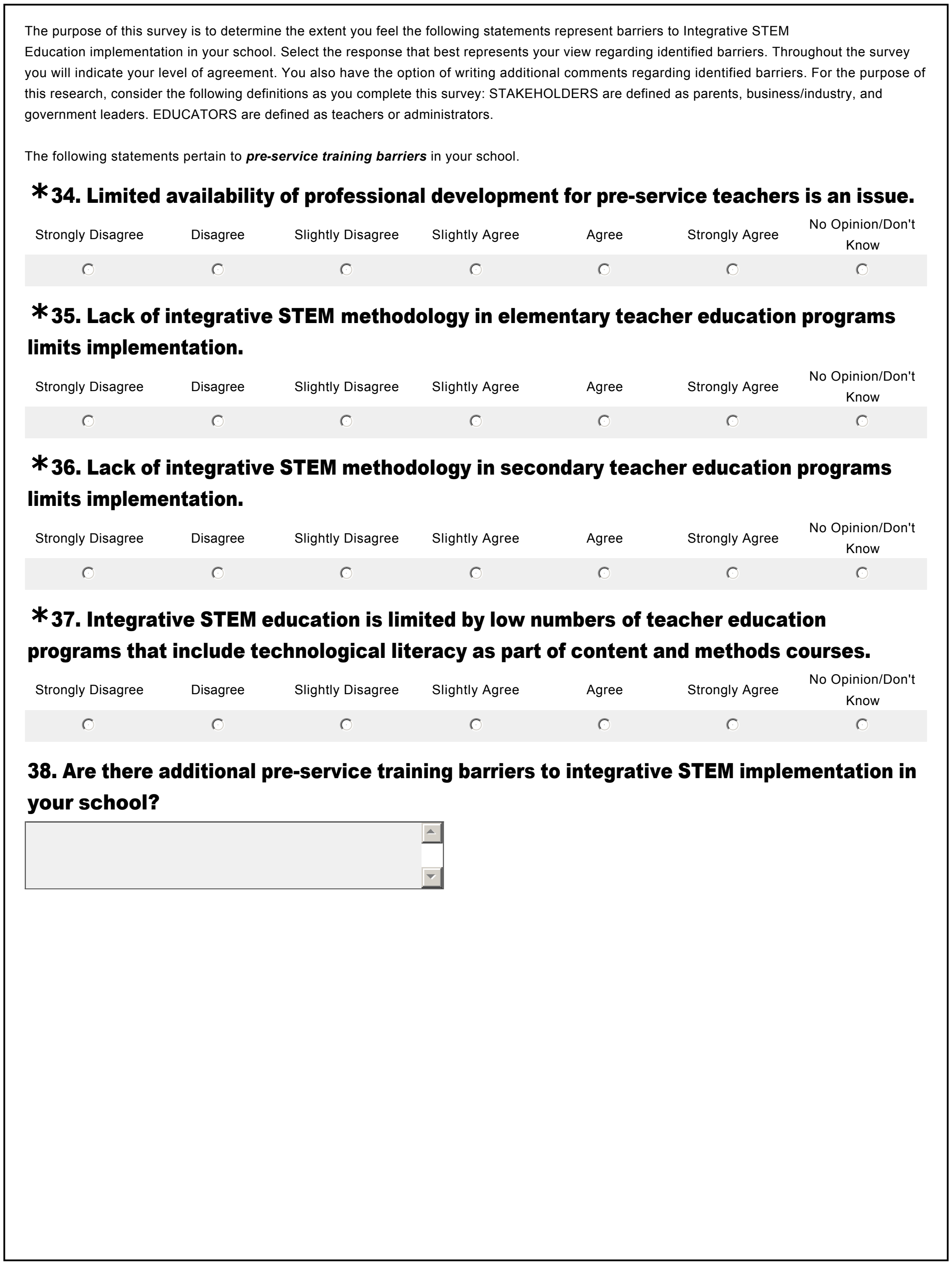
***31. Limited availability of professional development for in-service teachers is an issue.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***32. Lacking STEM certification at the State level is an issue.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

33. Are there additional professional development barriers to integrative STEM implementation in your school?



The purpose of this survey is to determine the extent you feel the following statements represent barriers to Integrative STEM Education implementation in your school. Select the response that best represents your view regarding identified barriers. Throughout the survey you will indicate your level of agreement. You also have the option of writing additional comments regarding identified barriers. For the purpose of this research, consider the following definitions as you complete this survey: STAKEHOLDERS are defined as parents, business/industry, and government leaders. EDUCATORS are defined as teachers or administrators.

The following statements pertain to ***pre-service training barriers*** in your school.

***34. Limited availability of professional development for pre-service teachers is an issue.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***35. Lack of integrative STEM methodology in elementary teacher education programs limits implementation.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

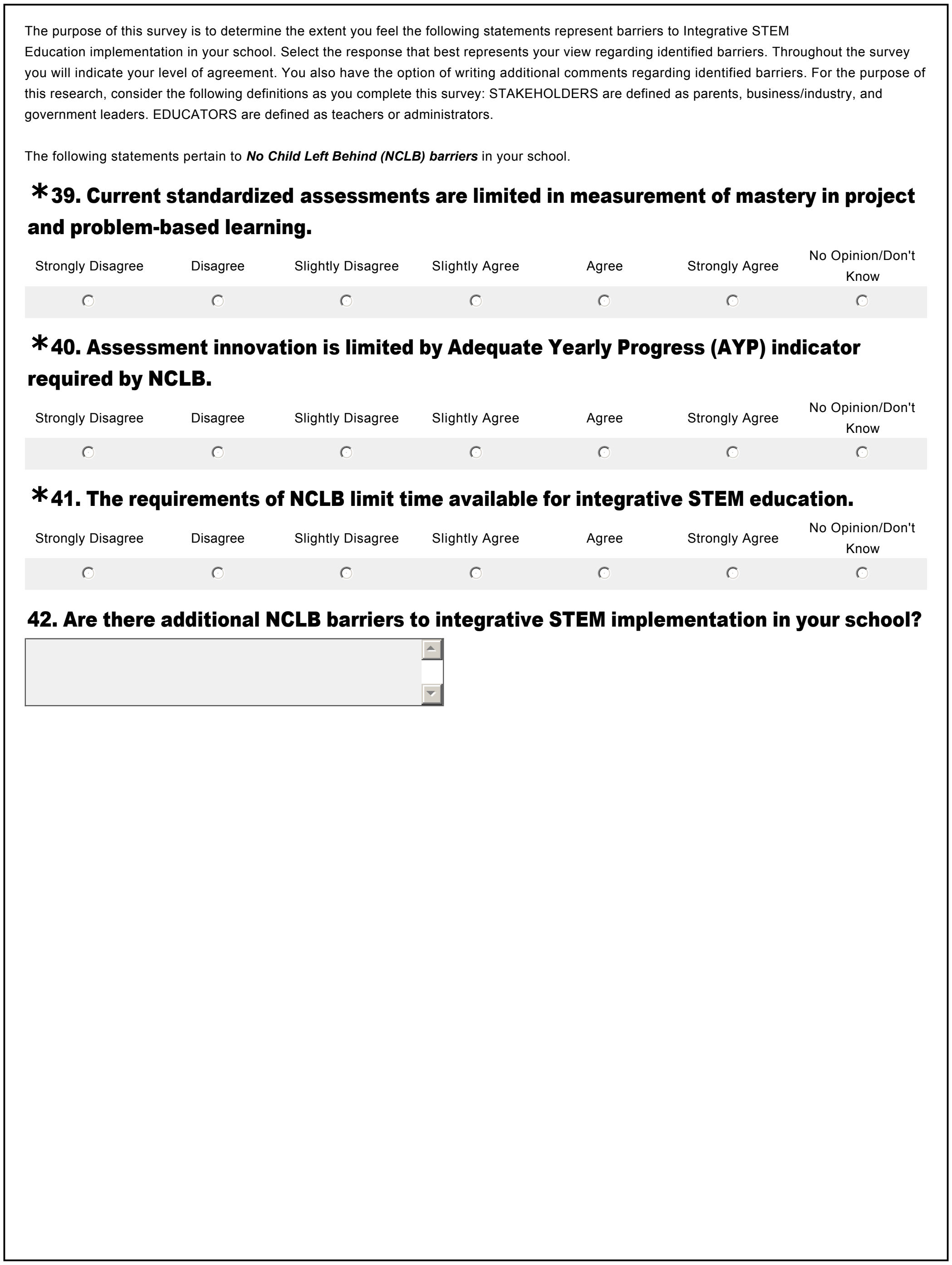
***36. Lack of integrative STEM methodology in secondary teacher education programs limits implementation.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***37. Integrative STEM education is limited by low numbers of teacher education programs that include technological literacy as part of content and methods courses.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

38. Are there additional pre-service training barriers to integrative STEM implementation in your school?



The purpose of this survey is to determine the extent you feel the following statements represent barriers to Integrative STEM Education implementation in your school. Select the response that best represents your view regarding identified barriers. Throughout the survey you will indicate your level of agreement. You also have the option of writing additional comments regarding identified barriers. For the purpose of this research, consider the following definitions as you complete this survey: STAKEHOLDERS are defined as parents, business/industry, and government leaders. EDUCATORS are defined as teachers or administrators.

The following statements pertain to ***No Child Left Behind (NCLB) barriers*** in your school.

***39. Current standardized assessments are limited in measurement of mastery in project and problem-based learning.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

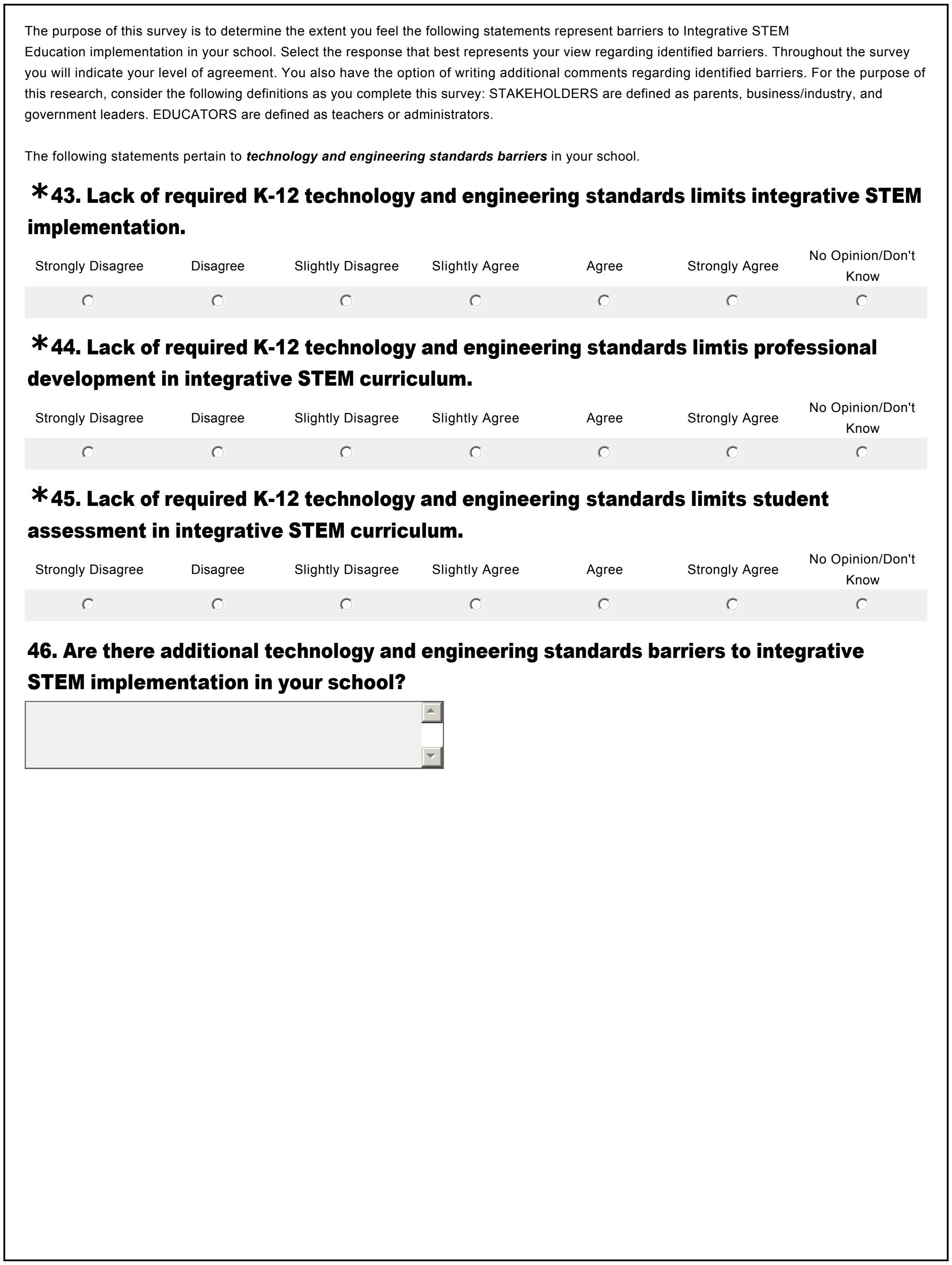
***40. Assessment innovation is limited by Adequate Yearly Progress (AYP) indicator required by NCLB.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***41. The requirements of NCLB limit time available for integrative STEM education.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

42. Are there additional NCLB barriers to integrative STEM implementation in your school?



The purpose of this survey is to determine the extent you feel the following statements represent barriers to Integrative STEM Education implementation in your school. Select the response that best represents your view regarding identified barriers. Throughout the survey you will indicate your level of agreement. You also have the option of writing additional comments regarding identified barriers. For the purpose of this research, consider the following definitions as you complete this survey: STAKEHOLDERS are defined as parents, business/industry, and government leaders. EDUCATORS are defined as teachers or administrators.

The following statements pertain to ***technology and engineering standards barriers*** in your school.

***43. Lack of required K-12 technology and engineering standards limits integrative STEM implementation.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

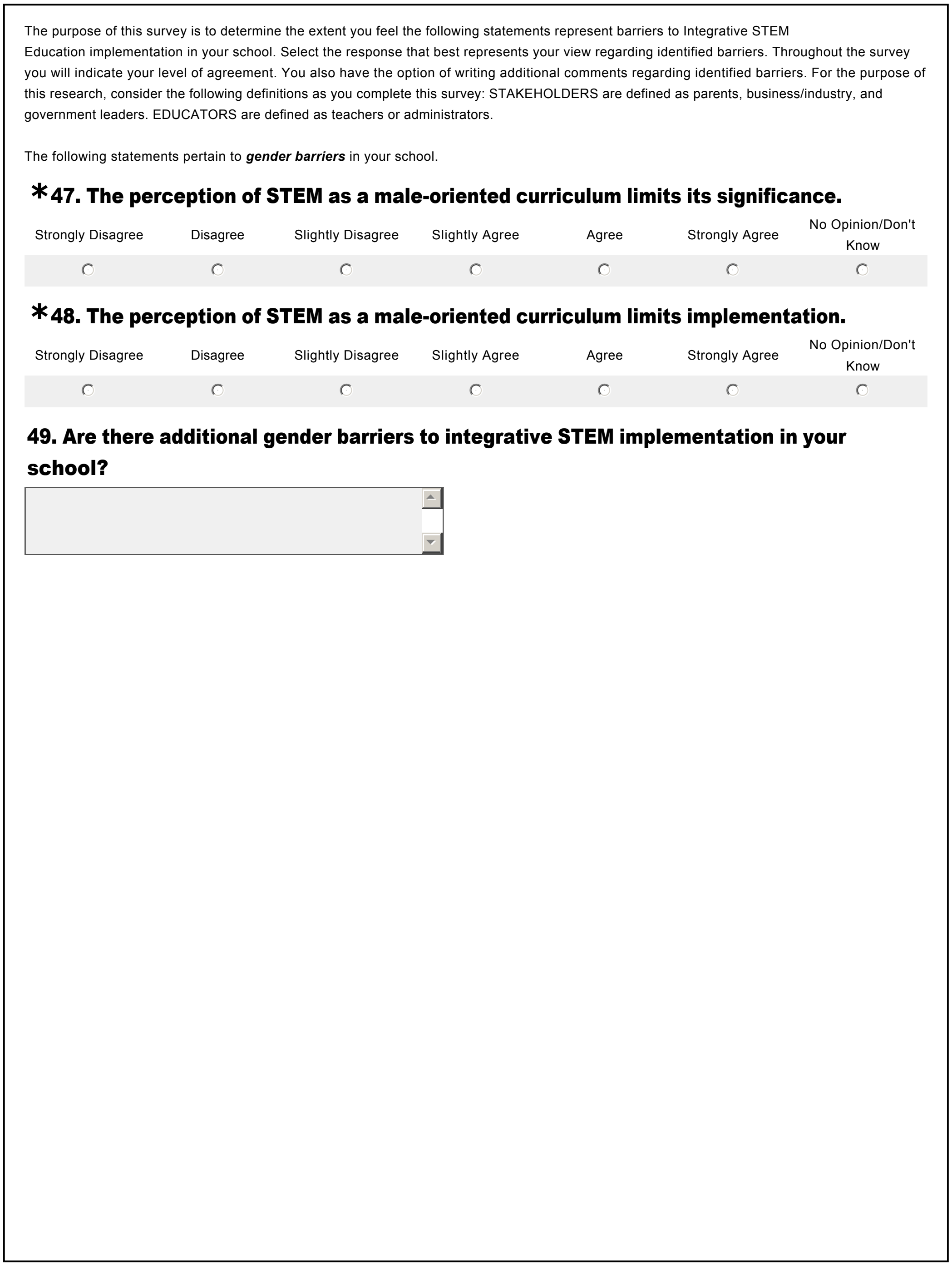
***44. Lack of required K-12 technology and engineering standards limtis professional development in integrative STEM curriculum.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***45. Lack of required K-12 technology and engineering standards limits student assessment in integrative STEM curriculum.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

46. Are there additional technology and engineering standards barriers to integrative STEM implementation in your school?



The purpose of this survey is to determine the extent you feel the following statements represent barriers to Integrative STEM Education implementation in your school. Select the response that best represents your view regarding identified barriers. Throughout the survey you will indicate your level of agreement. You also have the option of writing additional comments regarding identified barriers. For the purpose of this research, consider the following definitions as you complete this survey: STAKEHOLDERS are defined as parents, business/industry, and government leaders. EDUCATORS are defined as teachers or administrators.

The following statements pertain to ***gender barriers*** in your school.

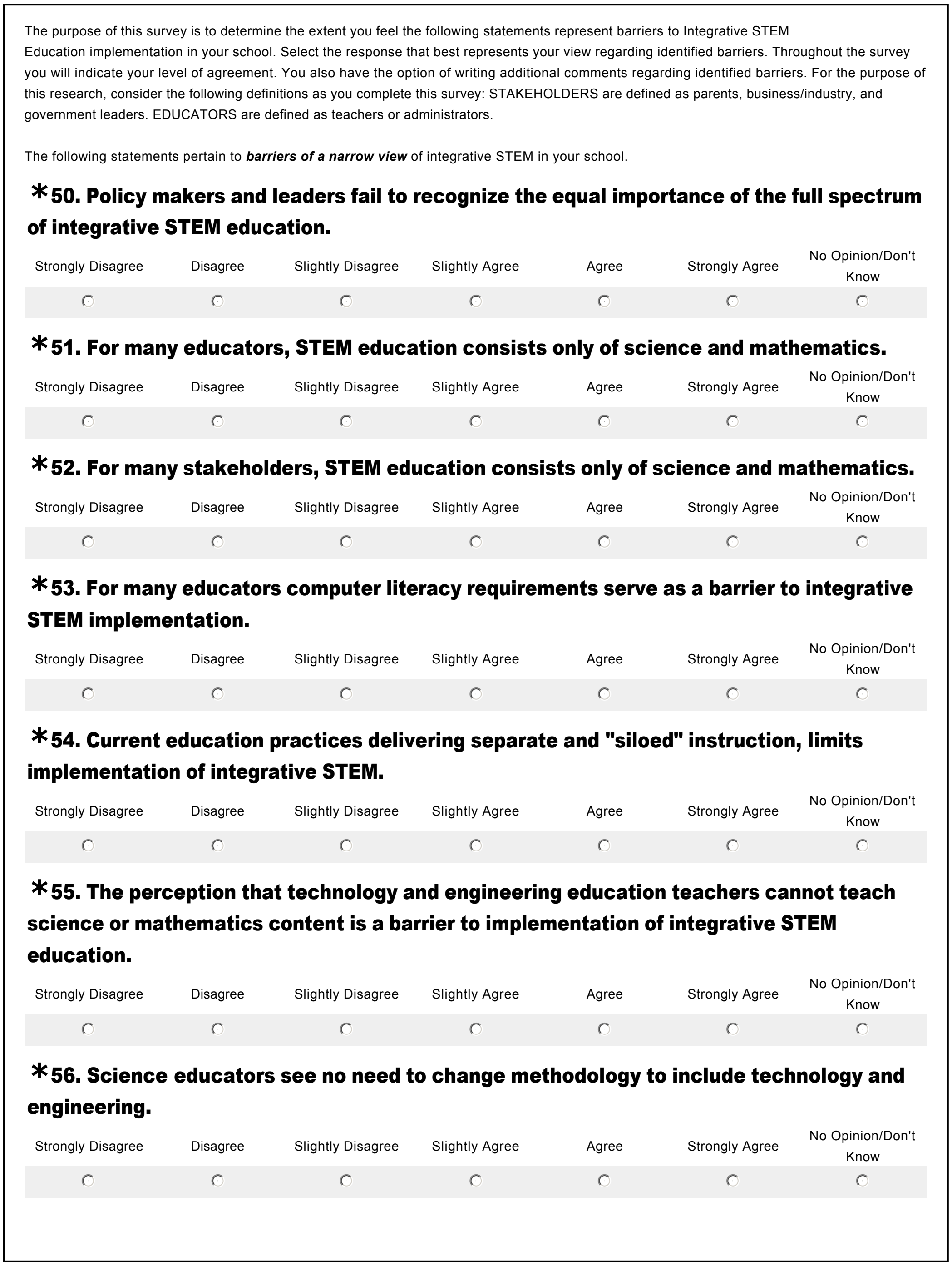
***47. The perception of STEM as a male-oriented curriculum limits its significance.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***48. The perception of STEM as a male-oriented curriculum limits implementation.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

49. Are there additional gender barriers to integrative STEM implementation in your school?



The purpose of this survey is to determine the extent you feel the following statements represent barriers to Integrative STEM Education implementation in your school. Select the response that best represents your view regarding identified barriers. Throughout the survey you will indicate your level of agreement. You also have the option of writing additional comments regarding identified barriers. For the purpose of this research, consider the following definitions as you complete this survey: STAKEHOLDERS are defined as parents, business/industry, and government leaders. EDUCATORS are defined as teachers or administrators.

The following statements pertain to ***barriers of a narrow view*** of integrative STEM in your school.

***50. Policy makers and leaders fail to recognize the equal importance of the full spectrum of integrative STEM education.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***51. For many educators, STEM education consists only of science and mathematics.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***52. For many stakeholders, STEM education consists only of science and mathematics.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***53. For many educators computer literacy requirements serve as a barrier to integrative STEM implementation.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***54. Current education practices delivering separate and "siloed" instruction, limits implementation of integrative STEM.**

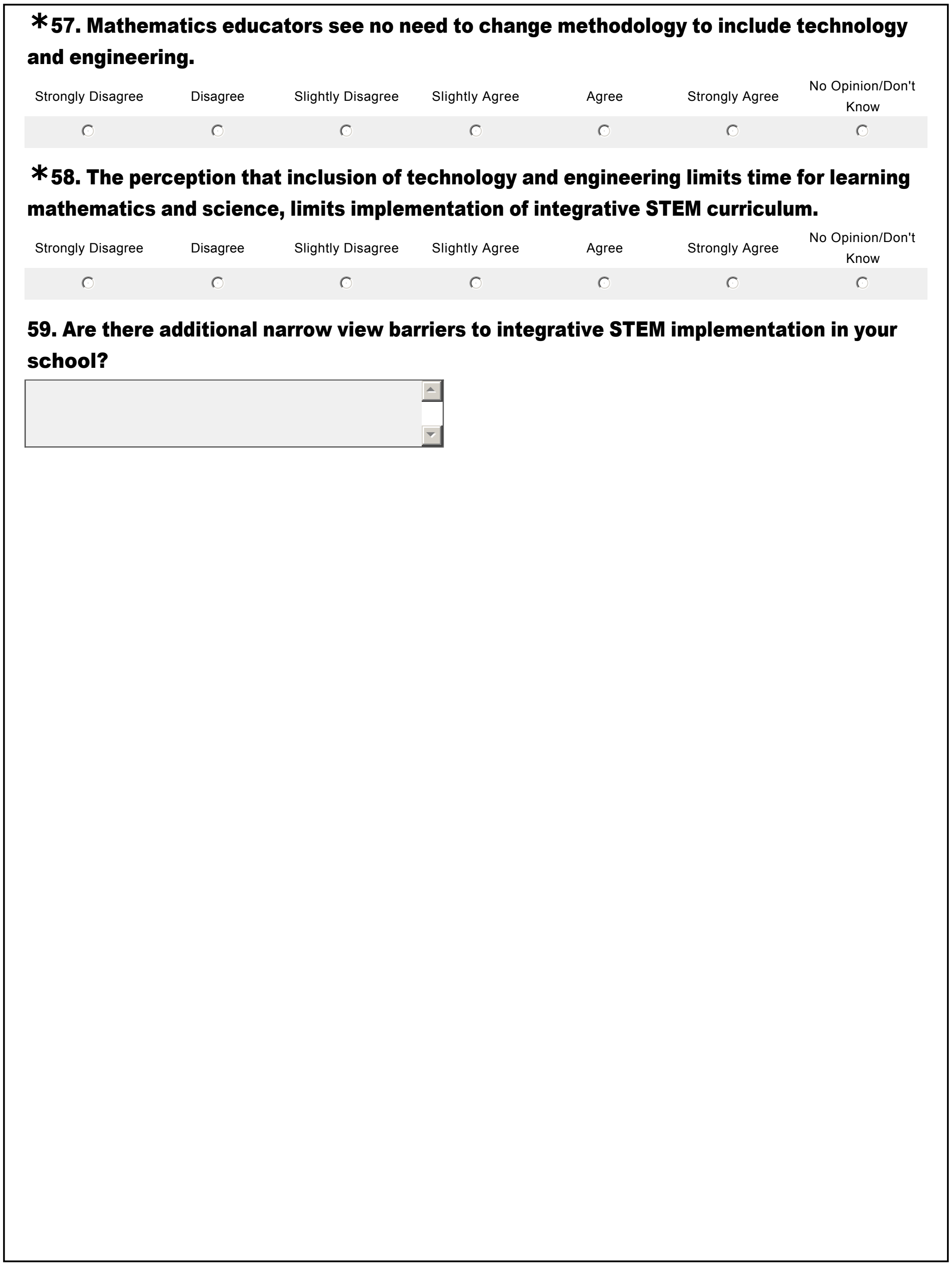
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***55. The perception that technology and engineering education teachers cannot teach science or mathematics content is a barrier to implementation of integrative STEM education.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***56. Science educators see no need to change methodology to include technology and engineering.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○



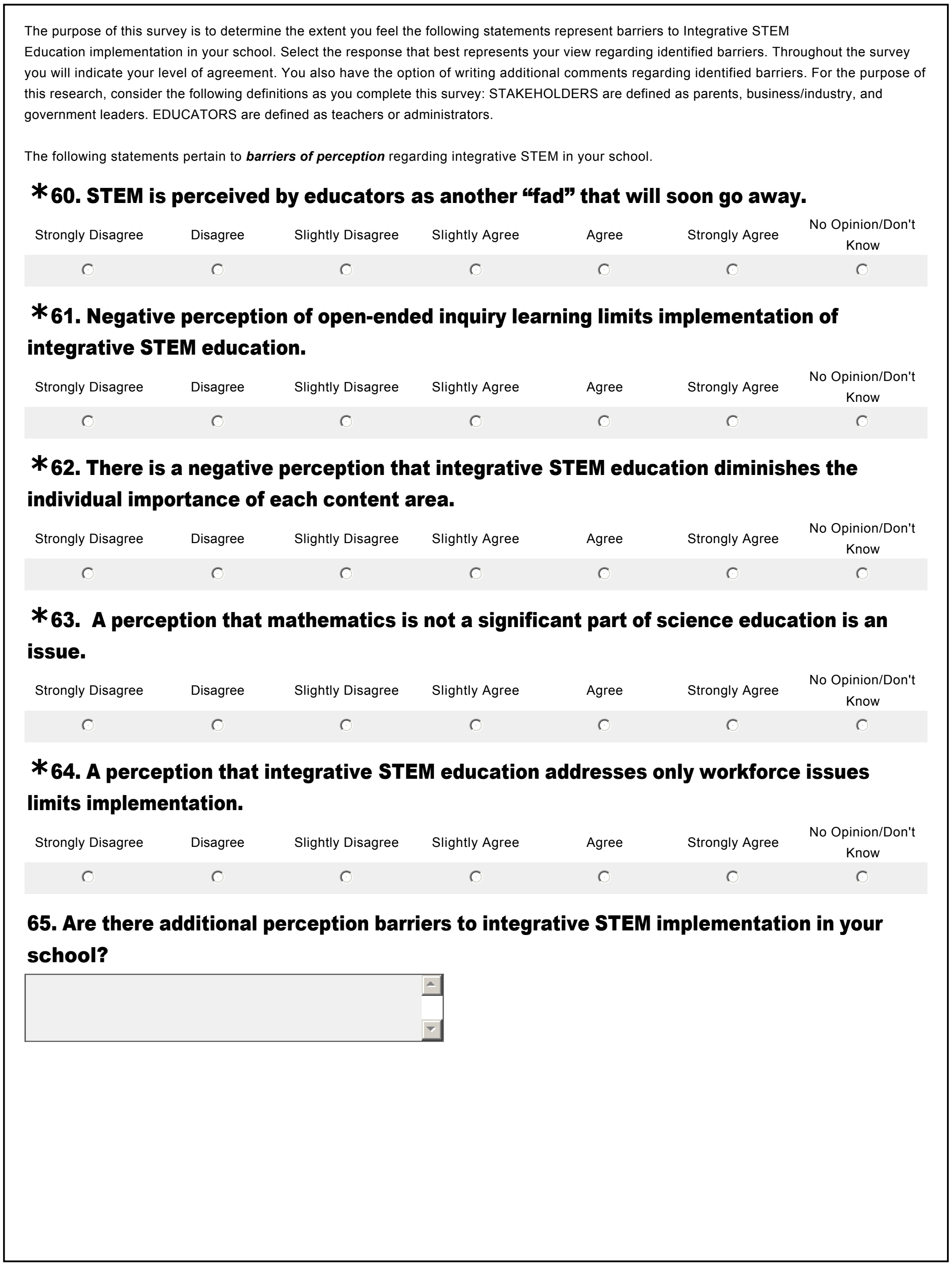
***57. Mathematics educators see no need to change methodology to include technology and engineering.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***58. The perception that inclusion of technology and engineering limits time for learning mathematics and science, limits implementation of integrative STEM curriculum.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

59. Are there additional narrow view barriers to integrative STEM implementation in your school?



The purpose of this survey is to determine the extent you feel the following statements represent barriers to Integrative STEM Education implementation in your school. Select the response that best represents your view regarding identified barriers. Throughout the survey you will indicate your level of agreement. You also have the option of writing additional comments regarding identified barriers. For the purpose of this research, consider the following definitions as you complete this survey: STAKEHOLDERS are defined as parents, business/industry, and government leaders. EDUCATORS are defined as teachers or administrators.

The following statements pertain to ***barriers of perception*** regarding integrative STEM in your school.

***60. STEM is perceived by educators as another “fad” that will soon go away.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***61. Negative perception of open-ended inquiry learning limits implementation of integrative STEM education.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***62. There is a negative perception that integrative STEM education diminishes the individual importance of each content area.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

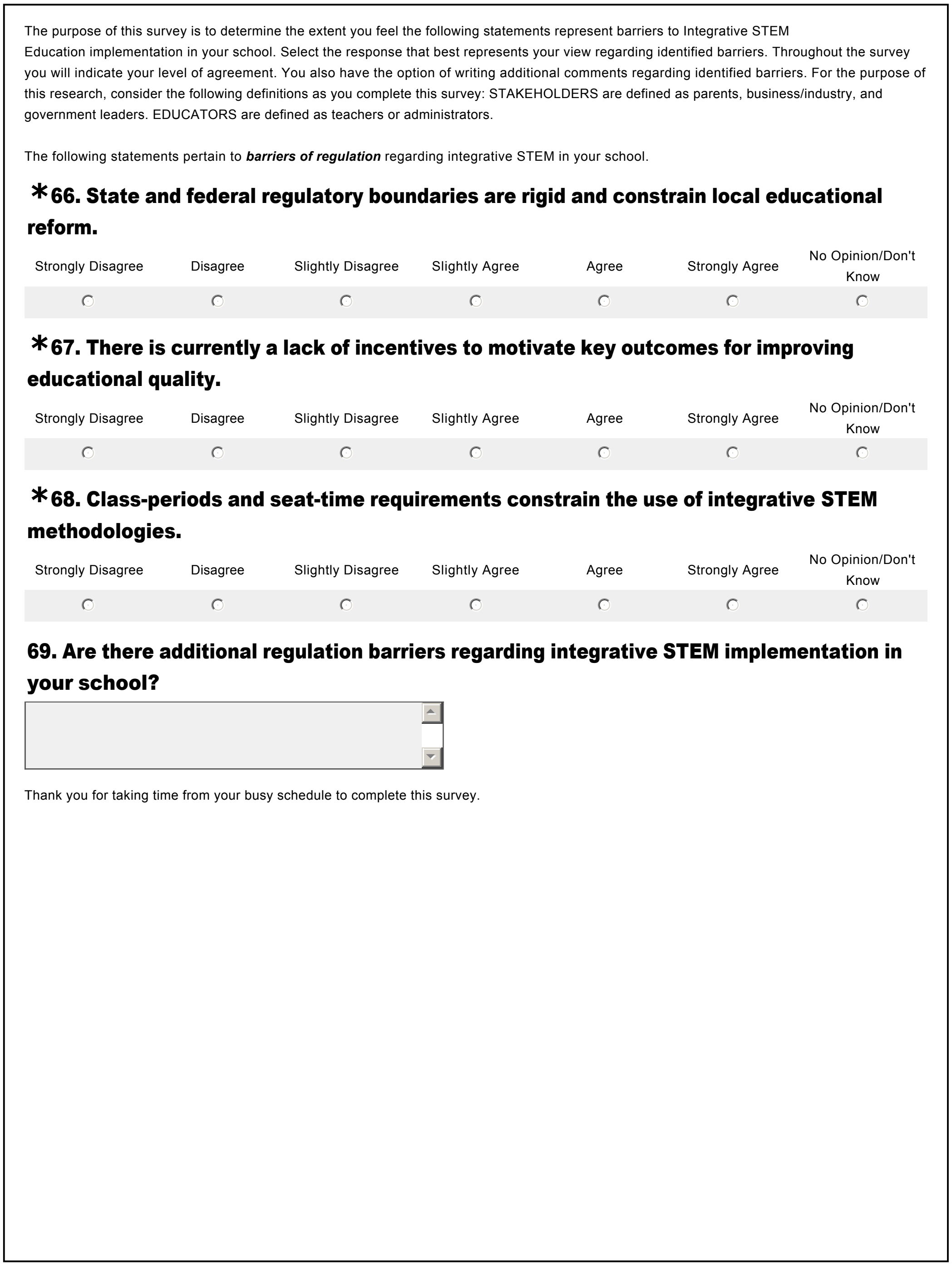
***63. A perception that mathematics is not a significant part of science education is an issue.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***64. A perception that integrative STEM education addresses only workforce issues limits implementation.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

65. Are there additional perception barriers to integrative STEM implementation in your school?



The purpose of this survey is to determine the extent you feel the following statements represent barriers to Integrative STEM Education implementation in your school. Select the response that best represents your view regarding identified barriers. Throughout the survey you will indicate your level of agreement. You also have the option of writing additional comments regarding identified barriers. For the purpose of this research, consider the following definitions as you complete this survey: STAKEHOLDERS are defined as parents, business/industry, and government leaders. EDUCATORS are defined as teachers or administrators.

The following statements pertain to ***barriers of regulation*** regarding integrative STEM in your school.

***66. State and federal regulatory boundaries are rigid and constrain local educational reform.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***67. There is currently a lack of incentives to motivate key outcomes for improving educational quality.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

***68. Class-periods and seat-time requirements constrain the use of integrative STEM methodologies.**

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	No Opinion/Don't Know
○	○	○	○	○	○	○

69. Are there additional regulation barriers regarding integrative STEM implementation in your school?

Thank you for taking time from your busy schedule to complete this survey.

APPENDIX E. IDENTIFIED BARRIERS FOR ISEG EVALUATION

1. Teachers are uncomfortable with delivering engineering content and concepts. (Miaoulis)
2. Administrators are uncomfortable with delivering engineering content and concepts. (Miaoulis)
3. Teachers and administrators have difficulty implementing technological content and concepts. (Miaoulis)
4. Administrators have difficulty implementing technological content and concepts. (Miaoulis)
5. Isolation and/or access to professional development regarding STEM methodology is a problem. (Gjøvik)
6. The skills and knowledge to implement all areas of STEM in the classroom are challenging. (Gjøvik)
7. It is difficult to develop interdisciplinary content. (Gjøvik)
8. Without participation in STEM workshops, it is difficult to understand the goals of STEM methodology. (Gjøvik)
9. Without receiving training, STEM methodologies and concepts are difficult to implement for teachers. (Gjøvik)
10. Buy-in of public and educators in preparing students for careers in engineering is an issue. (Sandlin)
11. Buy-in of teachers in preparing students for careers in engineering is an issue. (Sandlin)
12. Buy-in of administrators in preparing students for careers in engineering is an issue. (Sandlin)
13. STEM education and methodology is not commonly understood by leaders in education. (Ashida and Hunter)
14. STEM education and methodology is not commonly understood by leaders in business and industry. (Ashida and Hunter)
15. STEM education and methodology is not commonly understood by the general public. (Ashida and Hunter)
16. The accepted values and benefits associated with STEM are not well known in education. (Ashida and Hunter)
17. The accepted values and benefits associated with STEM are not well known in business and industry (Ashida and Hunter)
18. The accepted values and benefits associated with STEM are not well known by the general public. (Ashida and Hunter)
19. Transition to STEM literacy is hindered by stakeholders not contributing across a broad spectrum of interests, expertise, and capacities. (Ashida and Hunter)
20. STEM initiatives are negatively affected if local industry is not involved. (Gjøvik)
21. STEM initiatives are negatively affected if local scientists are not involved. (Gjøvik)
22. STEM initiatives are negatively affected if local engineers are not involved. (Gjøvik)
23. STEM initiatives are negatively affected if parents are not involved. (Gjøvik)
24. Non-supportive teachers hinder implementation of STEM methodology. (Gjøvik)
25. Non-supportive administrators hinder implementation of STEM methodology. (Gjøvik)
26. Teachers are not empowered to change teaching methods to include STEM methodology. (Gjøvik)

27. There is a lack of emphasis on teaching applied mathematics and science concepts in K-12. (Gjøvik)
28. Without collaboration (team-teaching, professional learning communities) implementation is limited. (Gjøvik)
29. Teachers see no need to change methodology in order to incorporate STEM. (Gjøvik)
30. Administrators see no need to change methodology in order to incorporate STEM. (Gjøvik)
31. The perception that STEM does little to improve students' abilities in mathematics and science is limiting. (Gjøvik)
32. Teachers perceiving little benefit from STEM in the classroom is a barrier. (Gjøvik)
33. Administrators perceiving little benefit from STEM in the classroom is a barrier. (Gjøvik)
34. Perception of lack of benefit from STEM professional development limits implementation. (Gjøvik)
35. The perception that STEM methodology does little to improve student outcomes is an issue. (Gjøvik)
36. Unwillingness to implement after school, summer and/or contests has hindered STEM. (Gjøvik)
37. The long-term stability of STEM has been compromised because education is not entrepreneurial in nature. (Ashida and Hunter)
38. Lack of needed resources cause issues for STEM implementation. (Miaoulis)
39. Out of date technology is an issue. (Ashida and Hunter)
40. Reliance on textbooks and other outdated classroom resources hinder STEM implementation. (Ashida and Hunter)
41. STEM implementation is limited by lack of capital investment. (Ashida and Hunter)
42. Schools lack funding to properly implement STEM. (Derivative of Miaoulis)
43. Inadequate facilities limit STEM implementation. (Derivative of Miaoulis)
44. Inadequate equipment limits STEM implementation. (Derivative of Miaoulis)
45. Lack of financial support by Administration hinders implementation. (Gjøvik)
46. Administrators inhibit STEM implementation. (Gjøvik)
47. Funding for professional development is an issue. (Sandlin, Miaoulis)
48. A shortage of STEM certified teachers limits implementation. (Ashida and Hunter)
49. Limited availability of professional development for pre and in-service teachers is an issue. (Ashida and Hunter)
50. Lacking STEM certification at the State level is an issue. (Ashida and Hunter)
51. A lack of mathematics content/methodology in elementary teacher education programs limits STEM. (Sandlin)
52. A lack of science content/methodology in elementary teacher education programs limits STEM. (Sandlin)
53. Lack of professional development in co-curricular competitive programs and contests is an issue. (Gjøvik)
54. Females desiring entrance into careers in science is an issue. (Derivative of Sandlin)
55. Females desiring entrance into careers in technology is an issue. (Derivative Sandlin)
56. Females desiring entrance into careers in engineering is an issue. (Sandlin)
57. Females desiring entrance into careers in mathematics is an issue. (Sandlin)
58. Student exposure to advances in science. (derivative of Sandlin)
59. Student exposure to advances in technology. (Sandlin)

60. Student exposure to advances in engineering. (derivative of Sandlin)
61. Student exposure to advances in mathematics. (derivative of Sandlin)
62. Current assessments do not measure mastery in project and problem-based learning. (Ashida and Hunter)
63. Assessment innovation is limited by Adequate Yearly Progress (AYP) indicator required by NCLB (Ashida and Hunter)
64. The requirements of NCLB limit implementation of new methodologies and/or content. (Gjøvik)
65. Perception of little or no time available to implement STEM due to requirements of NCLB. (Miaoulis)
66. There is no time in the curriculum for additional courses in technology and engineering. (Lantz)
67. Teachers are limited in time to network and collaborate regarding STEM implementation. (Gjøvik)
68. Lack of K-12 pre-engineering standards limit curriculum development in STEM. (Miaoulis)
69. Lack of K-12 pre-engineering standards limit professional development in STEM. (Miaoulis)
70. Lack of K-12 pre-engineering standards limit student assessment in STEM. (Miaoulis)
71. Policy makers and leaders fail to recognize the full spectrum of STEM methodology. (Miaoulis)
72. For teachers, STEM education consists only of science. (Lantz)
73. For teachers, STEM education consists only of mathematics. (Lantz)
74. For administrators, STEM education consists only of science. (Lantz)
75. For administrators, STEM education consists only of mathematics. (Lantz)
76. For many teachers, additional computers, peripherals and software fulfill technology literacy requirements. (Lantz)
77. For many administrators, additional computers, peripherals and software fulfill technology literacy requirements. Lantz)
78. Technology education and engineering are different and troublesome (Lantz)
79. Current education practices delivering “siloed” instruction limit students’ understanding of multiple literacies. (Ashida and Hunter)
80. The perception that technology teachers cannot teach science or mathematics content limits implementation. (Lantz)
81. The perception that engineers cannot teach science and mathematics content limits implementation. (Lantz)
82. There is a perception of STEM as another educational “fad” that will soon go away. (Lantz)
83. There is a negative perception that all inquiry is open-ended (Lantz)
84. There is a negative perception that hands-on learning and inquiry are the same thing. (Lantz)
85. There is a negative perception that STEM education does not include laboratory work or the scientific method. (Lantz)
86. The perception STEM educated students will be forced to choose technical fields because they do not have a liberal arts foundation is an issue. (Lantz)
87. Perception that mathematics education is not part of science education is an issue (Lantz)
88. Perception that STEM education addresses only workforce issues limits implementation. (Lantz)

89. Colleges and universities not accepting STEM credits from high school courses is an issue. (Lantz)
90. K-20 system is not structured to support STEM, leading to lack of joint program development between 13-20 and K-12. (Ashida and Hunter)
91. State and federal regulatory boundaries are rigid and constrain local educational reform. (Ashida and Hunter)
92. Current system of incentives do not motivate key outcomes such as student performance or teaching quality. (Ashida and Hunter)
93. Class-periods and seat-time requirements constrain STEM methodologies. (Ashida and Hunter)
94. Teacher union contracts impede STEM reforms. (Ashida and Hunter)

APPENDIX F. LIKERT RESPONSE BY CONSTRUCT/ITEM FREQUENCY TABLES

Table F1

Barriers Regarding Efficacy Frequency Table

Item	*N*	StD	D	SlD	SlA	A	StA	NO	MR
8. Teachers are uncomfortable with implementing technology content and concepts.	149	8	24	28	37	42	10	4	0
9. Teachers are uncomfortable with their ability to deliver engineering content and concepts.	148	5	16	15	37	49	26	5	0
10. Access to professional development regarding integrative STEM education is limited.	153	3	24	24	32	35	35	0	0
11. Without training in integrative STEM methodology it is difficult to understand the goals and concepts.	153	2	12	14	19	53	53	0	0

Table F2

Barriers of Integrative STEM Buy-In Frequency Table

Item	*N*	StD	D	SlD	SlA	A	StA	NO	MR
13. Buy-in of stakeholders regarding preparing students for careers in engineering is an issue.	138	4	23	25	27	36	23	11	4
14. Buy-in of teachers regarding preparing students for careers in engineering is an issue.	142	5	26	28	27	35	21	7	4
15. Implementation of integrative STEM education is negatively affected by lack of stakeholder involvement.	139	5	23	16	32	40	23	10	4
16. Non-supportive teachers hinder implementation of integrative STEM education.	144	5	12	11	19	58	39	5	4
17. Without collaboration of educators and stakeholders, implementation is limited.	146	2	6	5	10	77	46	3	4
18. The perception that integrative STEM education does little to improve student outcomes is a barrier.	139	8	30	24	26	29	22	10	4

Table F3

Barriers of Adoption Frequency Table

Item	*N*	StD	D	SlD	SlA	A	StA	NO	MR
20. Integrative STEM education is not commonly understood by stakeholders.	142	2	11	13	42	48	26	7	4
21. Teachers don't feel empowered to change teaching methods to include integrative STEM.	146	4	21	21	26	47	27	3	4
22. Lack of support by administrators hinders implementation.	143	10	18	20	24	27	44	6	4

Note. StD = *Strongly Disagree* (1), D = *Disagree* (2), SlD = *Slightly Disagree* (3), SlA = *Slightly Agree* (4), A = *Agree* (5), StA = *Strongly Agree* (6), NO = *No Opinion/Don't Know* (Null), MR = Missing Response (Null)

Table F4

Resource Barriers Frequency Table

Item	*N*	StD	D	SlD	SlA	A	StA	NO	MR
24. Lack of needed resources (funding, equipment, supplies, etc.) causes issues for implementing integrative STEM education.	148	4	7	10	16	35	76	1	4
25. Reliance on textbooks and other outdated classroom resources hinder integrative STEM implementation.	147	7	17	12	18	52	41	2	4
26. Inadequate facilities limit STEM implementation.	148	4	14	20	20	34	56	1	4

Table F5

Professional Development Barriers Frequency Table

Item	*N*	StD	D	SlD	SlA	A	StA	NO	MR
28. Lack of perceived benefit of professional development for integrative STEM methodology limits implementation.	139	5	12	14	36	52	20	9	5
29. Funding for professional development is an issue.	142	8	4	13	19	56	42	6	5
30. A shortage of teachers trained in integrative STEM education limits implementation.	147	3	3	7	19	59	56	1	5
31. Limited availability of professional development for in-service teachers is an issue.	146	5	14	11	25	50	41	2	5
32. Lacking STEM certification at the State level is an issue.	124	7	23	8	23	40	23	24	5

Table F6

Pre-Service Training Barriers Frequency Table

Item	*N*	StD	D	SlD	SlA	A	StA	NO	MR
34. Limited availability of professional development for pre-service teachers is an issue.	122	5	11	11	20	45	30	25	6
35. Lack of integrative STEM methodology in elementary teacher education programs limits implementation.	111	3	6	10	12	47	33	36	6
36. Lack of integrative STEM methodology in secondary teacher education programs limits implementation.	119	5	2	4	25	53	30	28	6
37. Integrative STEM education is limited by low numbers of teacher education programs that include technological literacy as part of content and methods courses.	119	4	3	9	14	45	44	28	6

Note. StD = *Strongly Disagree* (1), D = *Disagree* (2), SlD = *Slightly Disagree* (3), SlA = *Slightly Agree* (4), A = *Agree* (5), StA = *Strongly Agree* (6), NO = *No Opinion/Don't Know* (Null), MR = Missing Response (Null)

Table F7

No Child Left Behind (NCLB) Barriers Frequency Table

Item	*N*	StD	D	SlD	SlA	A	StA	NO	MR
39. Current standardized assessments are limited in measurement of mastery in project and problem-based learning.	137	2	5	7	19	49	55	7	9
40. Assessment innovation is limited by Adequate Yearly Progress (AYP) indicator required by NCLB.	122	1	4	6	20	42	49	22	9
41. The requirements of NCLB limit time available for integrative STEM education.	124	2	7	3	23	34	55	20	9

Table F8

Technology and Engineering Standards Barriers Frequency Table

Item	*N*	StD	D	SlD	SlA	A	StA	NO	MR
43. Lack of required K-12 technology and engineering standards limits integrative STEM implementation.	139	8	16	12	26	43	34	5	9
44. Lack of required K-12 technology and engineering standards limits professional development in integrative STEM curriculum.	139	8	15	12	32	38	34	5	9
45. Lack of required K-12 technology and engineering standards limits student assessment in integrative STEM curriculum.	138	4	16	9	32	40	37	6	9

Table F9

Barriers of Male-Oriented Content Frequency Table

Item	*N*	StD	D	SlD	SlA	A	StA	NO	MR
47. The perception of STEM as a male-oriented curriculum limits its significance.	137	14	39	23	28	23	10	7	9
48. The perception of STEM as a male-oriented curriculum limits implementation.	137	15	42	25	22	23	10	7	9

Note. StD = *Strongly Disagree* (1), D = *Disagree* (2), SlD = *Slightly Disagree* (3), SlA = *Slightly Agree* (4), A = *Agree* (5), StA = *Strongly Agree* (6), NO = *No Opinion/Don't Know* (Null), MR = Missing Response (Null)

Table F10

Barriers of a Narrow View Frequency Table

Item	*N*	StD	D	SlD	SlA	A	StA	NO	MR
50. Policy makers and leaders fail to recognize the equal importance of the full spectrum of integrative STEM education.	129	4	5	7	29	40	44	14	10
51. For many educators, STEM education consists only of science and mathematics.	136	5	9	6	18	51	47	7	10
52. For many stakeholders, STEM education consists only of science and mathematics.	126	3	9	5	19	43	47	17	10
53. For many educators computer literacy requirements serve as a barrier to integrative STEM implementation.	138	9	20	17	25	50	17	5	10
54. Current education practices delivering separate and "siloed" instruction, limits implementation of integrative STEM.	128	7	4	4	24	46	43	15	10
55. The perception that technology and engineering education teachers cannot teach science or mathematics content is a barrier to implementation of integrative STEM education.	129	7	9	13	25	49	26	14	10
56. Science educators see no need to change methodology to include technology and engineering.	130	10	23	19	24	35	19	13	10
57. Mathematics educators see no need to change methodology to include technology and engineering.	125	8	18	23	13	40	23	18	10
58. The perception that inclusion of technology and engineering limits time for learning mathematics and science, limits implementation of integrative STEM curriculum.	129	6	8	21	22	38	34	14	10

Table F11

Barriers of Perception Frequency Table

Item	*N*	StD	D	SlD	SlA	A	StA	NO	MR
60. STEM is perceived by educators as another "fad"" that will soon go away.	127	11	20	17	31	33	15	15	11
61. Negative perception of open-ended inquiry learning limits implementation of integrative STEM education.	132	9	15	20	33	41	14	10	11
62. There is a negative perception that integrative STEM education diminishes the individual importance of each content area.	121	9	22	27	30	22	11	21	11
63. A perception that mathematics is not a significant part of science education is an issue.	136	14	38	32	16	24	12	6	11
64. A perception that integrative STEM education addresses only workforce issues limits implementation.	125	8	24	23	26	35	9	17	11

Note. StD = *Strongly Disagree* (1), D = *Disagree* (2), SlD = *Slightly Disagree* (3), SlA = *Slightly Agree* (4), A = *Agree* (5), StA = *Strongly Agree* (6), NO = *No Opinion/Don't Know* (Null), MR = Missing Response (Null)

Table F12

Barriers of Regulation Frequency Table

Item	*N*	StD	D	SlD	SlA	A	StA	NO	MR
66. State and federal regulatory boundaries are rigid and constrain local educational reform.	118	4	11	16	17	34	36	24	11
67. There is currently a lack of incentives to motivate key outcomes for improving educational quality.	127	4	11	11	16	47	38	15	11
68. Class-periods and seat-time requirements constrain the use of integrative STEM methodologies.	137	5	18	11	23	36	44	5	11

Note. StD = *Strongly Disagree* (1), D = *Disagree* (2), SlD = *Slightly Disagree* (3), SlA = *Slightly Agree* (4), A = *Agree* (5), StA = *Strongly Agree* (6), NO = *No Opinion/Don't Know* (Null), MR = Missing Response (Null)

APPENDIX G. ITEM-BY-ITEM PRINCIPAL COMPONENT ANALYSIS EXTRACTION VALUES

Item	Communality
8. Teachers are uncomfortable with implementing technology content and concepts.	.738
9. Teachers are uncomfortable with their ability to deliver engineering content and concepts.	.750
10. Access to professional development regarding integrative STEM education is limited.	.652
11. Without training in integrative STEM methodology it is difficult to understand the goals and concepts.	.465
13. Buy-in of stakeholders regarding preparing students for careers in engineering is an issue.	.703
14. Buy-in of teachers regarding preparing students for careers in engineering is an issue.	.668
15. Implementation of integrative STEM education is negatively affected by lack of stakeholder involvement.	.655
16. Non-supportive teachers hinder implementation of integrative STEM education.	.551
17. Without collaboration of educators and stakeholders, implementation is limited.	.599
18. The perception that integrative STEM education does little to improve student outcomes is a barrier.	.500
20. Integrative STEM education is not commonly understood by stakeholders.	.570
21. Teachers don’t feel empowered to change teaching methods to include integrative STEM.	.649
22. Lack of support by administrators hinders implementation.	.610
24. Lack of needed resources (funding, equipment, supplies, etc.) causes issues for implementing integrative STEM education.	.680
25. Reliance on textbooks and other outdated classroom resources hinder integrative STEM implementation.	.637
26. Inadequate facilities limit STEM implementation.	.725
28. Lack of perceived benefit of professional development for integrative STEM methodology limits implementation.	.593
29. Funding for professional development is an issue.	.644
30. A shortage of teachers trained in integrative STEM education limits implementation.	.804
31. Limited availability of professional development for in-service teachers is an issue.	.813
32. Lacking STEM certification at the State level is an issue.	.577
34. Limited availability of professional development for pre-service teachers is an issue.	.673
35. Lack of integrative STEM methodology in elementary teacher education programs limits implementation.	.730
36. Lack of integrative STEM methodology in secondary teacher education programs limits implementation.	.755
37. Integrative STEM education is limited by low numbers of teacher education programs that include technological literacy as part of content and methods courses.	.691
39. Current standardized assessments are limited in measurement of mastery in project and problem-based learning.	.750
40. Assessment innovation is limited by Adequate Yearly Progress (AYP) indicator required by NCLB.	.744
41. The requirements of NCLB limit time available for integrative STEM education.	.722
43. Lack of required K-12 technology and engineering standards limits integrative STEM implementation.	.894

Item	Communality
44. Lack of required K-12 technology and engineering standards limits professional development in integrative STEM curriculum.	.888
45. Lack of required K-12 technology and engineering standards limits student assessment in integrative STEM curriculum.	.891
47. The perception of STEM as a male-oriented curriculum limits its significance.	.894
48. The perception of STEM as a male-oriented curriculum limits implementation.	.881
50. Policy makers and leaders fail to recognize the equal importance of the full spectrum of integrative STEM education.	.678
51. For many educators, STEM education consists only of science and mathematics.	.753
52. For many stakeholders, STEM education consists only of science and mathematics.	.794
53. For many educators computer literacy requirements serve as a barrier to integrative STEM implementation.	.483
54. Current education practices delivering separate and "siloed" instruction, limits implementation of integrative STEM.	.717
55. The perception that technology and engineering education teachers cannot teach science or mathematics content is a barrier to implementation of integrative STEM education.	.658
56. Science educators see no need to change methodology to include technology and engineering.	.856
57. Mathematics educators see no need to change methodology to include technology and engineering.	.836
58. The perception that inclusion of technology and engineering limits time for learning mathematics and science, limits implementation of integrative STEM curriculum.	.726
60. STEM is perceived by educators as another “fad” that will soon go away.	.684
61. Negative perception of open-ended inquiry learning limits implementation of integrative STEM education.	.700
62. There is a negative perception that integrative STEM education diminishes the individual importance of each content area.	.690
63. A perception that mathematics is not a significant part of science education is an issue.	.673
64. A perception that integrative STEM education addresses only workforce issues limits implementation.	.694
66. State and federal regulatory boundaries are rigid and constrain local educational reform.	.732
67. There is currently a lack of incentives to motivate key outcomes for improving educational quality.	.599
68. Class-periods and seat-time requirements constrain the use of integrative STEM methodologies.	.596

APPENDIX H. NO IMPLEMENTATION ITEM RANKINGS, FACTORS, AND MEANS

Items	Rank	Factor	Mean[a]
24. Lack of needed resources (funding, equipment, supplies, etc.) causes issues for implementing integrative STEM education.	1	8	5.4
40. Assessment innovation is limited by Adequate Yearly Progress (AYP) indicator required by NCLB.	2	5	5.2
41. The requirements of NCLB limit time available for integrative STEM education.	2	5	5.2
30. A shortage of teachers trained in integrative STEM education limits implementation.	3	1	5.1
35. Lack of integrative STEM methodology in elementary teacher education programs limits implementation.	3	1	5.1
36. Lack of integrative STEM methodology in secondary teacher education programs limits implementation.	3	1	5.1
37. Integrative STEM education is limited by low numbers of teacher education programs that include technological literacy as part of content and methods courses.	3	1	5.1
39. Current standardized assessments are limited in measurement of mastery in project and problem-based learning.	3	5	5.1
52. For many stakeholders, STEM education consists only of science and mathematics.	3	9, 10	5.1
50. Policy makers and leaders fail to recognize the equal importance of the full spectrum of integrative STEM education.	4	10	5.0
51. For many educators, STEM education consists only of science and mathematics.	4	9	5.0
17. Without collaboration of educators and stakeholders, implementation is limited.	5	3	4.8
20. Integrative STEM education is not commonly understood by stakeholders.	5	*	4.8
26. Inadequate facilities limit STEM implementation.	5	8	4.8
45. Lack of required K-12 technology and engineering standards limits student assessment in integrative STEM curriculum.	5	2	4.8
66. State and federal regulatory boundaries are rigid and constrain local educational reform.	5	3	4.8
68. Class-periods and seat-time requirements constrain the use of integrative STEM methodologies.	5	3	4.8
16. Non-supportive teachers hinder implementation of integrative STEM education.	6	3	4.7
21. Teachers don't feel empowered to change teaching methods to include integrative STEM.	6	7	4.7
31. Limited availability of professional development for in-service teachers is an issue.	6	1	4.7
43. Lack of required K-12 technology and engineering standards limits integrative STEM implementation.	6	2	4.7
54. Current education practices delivering separate and "siloed" instruction, limits implementation of integrative STEM.	6	9	4.7
15. Implementation of integrative STEM education is negatively affected by lack of stakeholder involvement.	7	10	4.6
22. Lack of support by administrators hinders implementation.	7	10	4.6
28. Lack of perceived benefit of professional development for integrative STEM methodology limits implementation.	7	*	4.6
29. Funding for professional development is an issue.	7	1	4.6
34. Limited availability of professional development for pre-service teachers is an issue.	7	1	4.6

Items	Rank	Factor	Mean[a]
44. Lack of required K-12 technology and engineering standards limits professional development in integrative STEM curriculum.	7	2	4.6
58. The perception that inclusion of technology and engineering limits time for learning mathematics and science, limits implementation of integrative STEM curriculum.	7	11	4.6
67. There is currently a lack of incentives to motivate key outcomes for improving educational quality.	7	3	4.6
9. Teachers are uncomfortable with their ability to deliver engineering content and concepts.	8	7	4.5
10. Access to professional development regarding integrative STEM education is limited.	8	*	4.5
11. Without training in integrative STEM methodology it is difficult to understand the goals and concepts.	8	*	4.5
25. Reliance on textbooks and other outdated classroom resources hinder integrative STEM implementation.	9	8	4.4
32. Lacking STEM certification at the State level is an issue.	9	*	4.4
13. Buy-in of stakeholders regarding preparing students for careers in engineering is an issue.	10	10	4.3
55. The perception that technology and engineering education teachers cannot teach science or mathematics content is a barrier to implementation of integrative STEM education.	10	9	4.3
57. Mathematics educators see no need to change methodology to include technology and engineering.	11	11	4.2
8. Teachers are uncomfortable with implementing technology content and concepts.	12	7	4.1
53. For many educators computer literacy requirements serve as a barrier to integrative STEM implementation.	12	*	4.1
56. Science educators see no need to change methodology to include technology and engineering.	13	11	4.0
61. Negative perception of open-ended inquiry learning limits implementation of integrative STEM education.	13	4	4.0
14. Buy-in of teachers regarding preparing students for careers in engineering is an issue.	14	10	3.9
18. The perception that integrative STEM education does little to improve student outcomes is a barrier.	14	*	3.9
60. STEM is perceived by educators as another "fad" that will soon go away.	14	4	3.9
47. The perception of STEM as a male-oriented curriculum limits its significance.	15	6	3.6
62. There is a negative perception that integrative STEM education diminishes the individual importance of each content area.	15	4	3.6
64. A perception that integrative STEM education addresses only workforce issues limits implementation.	15	4	3.6
48. The perception of STEM as a male-oriented curriculum limits implementation.	16	6	3.5
63. A perception that mathematics is not a significant part of science education is an issue.	17	4	3.0

Note: * = Item did not load into a Factor grouping

[a] Mean rounded to nearest decimal point, N = 45

APPENDIX I. PREPARATION ITEM RANKINGS, FACTORS, AND MEANS

Items	Rank	Factor	Mean[a]
67. There is currently a lack of incentives to motivate key outcomes for improving educational quality.	1	3	5.5
30. A shortage of teachers trained in integrative STEM education limits implementation.	2	1	5.3
17. Without collaboration of educators and stakeholders, implementation is limited.	3	3	5.2
37. Integrative STEM education is limited by low numbers of teacher education programs that include technological literacy as part of content and methods courses.	3	1	5.2
68. Class-periods and seat-time requirements constrain the use of integrative STEM methodologies.	3	3	5.2
24. Lack of needed resources (funding, equipment, supplies, etc.) causes issues for implementing integrative STEM education.	4	8	5.1
29. Funding for professional development is an issue.	4	1	5.1
11. Without training in integrative STEM methodology it is difficult to understand the goals and concepts.	5	*	5.0
25. Reliance on textbooks and other outdated classroom resources hinder integrative STEM implementation.	5	8	5.0
35. Lack of integrative STEM methodology in elementary teacher education programs limits implementation.	5	1	5.0
40. Assessment innovation is limited by Adequate Yearly Progress (AYP) indicator required by NCLB.	5	5	5.0
51. For many educators, STEM education consists only of science and mathematics.	5	9	5.0
66. State and federal regulatory boundaries are rigid and constrain local educational reform.	5	3	5.0
31. Limited availability of professional development for in-service teachers is an issue.	6	1	4.9
34. Limited availability of professional development for pre-service teachers is an issue.	6	1	4.9
52. For many stakeholders, STEM education consists only of science and mathematics.	6	9, 10	4.9
55. The perception that technology and engineering education teachers cannot teach science or mathematics content is a barrier to implementation of integrative STEM education.	6	9	4.9
28. Lack of perceived benefit of professional development for integrative STEM methodology limits implementation.	7	*	4.8
36. Lack of integrative STEM methodology in secondary teacher education programs limits implementation.	7	1	4.8
41. The requirements of NCLB limit time available for integrative STEM education.	7	5	4.8
50. Policy makers and leaders fail to recognize the equal importance of the full spectrum of integrative STEM education.	7	10	4.8
54. Current education practices delivering separate and "siloed" instruction, limits implementation of integrative STEM.	7	9	4.8
20. Integrative STEM education is not commonly understood by stakeholders.	8	*	4.7
26. Inadequate facilities limit STEM implementation.	8	8	4.7
39. Current standardized assessments are limited in measurement of mastery in project and problem-based learning.	8	5	4.7
10. Access to professional development regarding integrative STEM education is limited.	9	*	4.6

Items	Rank	Factor	Mean^a
21. Teachers don’t feel empowered to change teaching methods to include integrative STEM.	9	7	4.6
9. Teachers are uncomfortable with their ability to deliver engineering content and concepts.	10	7	4.5
58. The perception that inclusion of technology and engineering limits time for learning mathematics and science, limits implementation of integrative STEM curriculum.	10	11	4.5
15. Implementation of integrative STEM education is negatively affected by lack of stakeholder involvement.	11	10	4.4
57. Mathematics educators see no need to change methodology to include technology and engineering.	11	11	4.4
16. Non-supportive teachers hinder implementation of integrative STEM education.	12	3	4.3
22. Lack of support by administrators hinders implementation.	13	10	4.2
32. Lacking STEM certification at the State level is an issue.	13	*	4.2
44. Lack of required K-12 technology and engineering standards limits professional development in integrative STEM curriculum.	13	2	4.2
56. Science educators see no need to change methodology to include technology and engineering.	13	11	4.2
60. STEM is perceived by educators as another “fad” that will soon go away.	13	4	4.2
61. Negative perception of open-ended inquiry learning limits implementation of integrative STEM education.	13	4	4.2
13. Buy-in of stakeholders regarding preparing students for careers in engineering is an issue.	14	10	4.1
43. Lack of required K-12 technology and engineering standards limits integrative STEM implementation.	14	2	4.1
45. Lack of required K-12 technology and engineering standards limits student assessment in integrative STEM curriculum.	14	2	4.1
18. The perception that integrative STEM education does little to improve student outcomes is a barrier.	15	*	4.0
53. For many educators computer literacy requirements serve as a barrier to integrative STEM implementation.	15	*	4.0
8. Teachers are uncomfortable with implementing technology content and concepts.	16	7	3.9
14. Buy-in of teachers regarding preparing students for careers in engineering is an issue.	17	10	3.7
64. A perception that integrative STEM education addresses only workforce issues limits implementation.	17	4	3.7
47. The perception of STEM as a male-oriented curriculum limits its significance.	18	6	3.5
48. The perception of STEM as a male-oriented curriculum limits implementation.	18	6	3.5
63. A perception that mathematics is not a significant part of science education is an issue.	18	4	3.5
62. There is a negative perception that integrative STEM education diminishes the individual importance of each content area.	19	4	3.4

Note: * = Item did not load into a Factor grouping

^{a} Mean rounded to nearest decimal point, N = 21

APPENDIX J. PARTIAL IMPLEMENTATION ITEM RANKINGS, FACTORS, AND MEANS

Items	Rank	Factor	Mean[a]
17. Without collaboration of educators and stakeholders, implementation is limited.	1	3	5.1
30. A shortage of teachers trained in integrative STEM education limits implementation.	2	1	5.0
39. Current standardized assessments are limited in measurement of mastery in project and problem-based learning.	2	5	5.0
40. Assessment innovation is limited by Adequate Yearly Progress (AYP) indicator required by NCLB.	2	5	5.0
54. Current education practices delivering separate and “siloed” instruction, limits implementation of integrative STEM.	2	9	5.0
11. Without training in integrative STEM methodology it is difficult to understand the goals and concepts.	3	*	4.9
24. Lack of needed resources (funding, equipment, supplies, etc.) causes issues for implementing integrative STEM education.	3	8	4.9
37. Integrative STEM education is limited by low numbers of teacher education programs that include technological literacy as part of content and methods courses.	3	1	4.9
41. The requirements of NCLB limit time available for integrative STEM education.	3	5	4.9
50. Policy makers and leaders fail to recognize the equal importance of the full spectrum of integrative STEM education.	4	10	4.8
51. For many educators, STEM education consists only of science and mathematics.	4	9	4.8
52. For many stakeholders, STEM education consists only of science and mathematics.	4	9, 10	4.8
16. Non-supportive teachers hinder implementation of integrative STEM education.	5	3	4.7
36. Lack of integrative STEM methodology in secondary teacher education programs limits implementation.	5	1	4.7
26. Inadequate facilities limit STEM implementation.	6	8	4.6
29. Funding for professional development is an issue.	6	1	4.6
35. Lack of integrative STEM methodology in elementary teacher education programs limits implementation.	6	1	4.6
67. There is currently a lack of incentives to motivate key outcomes for improving educational quality.	7	3	4.5
25. Reliance on textbooks and other outdated classroom resources hinder integrative STEM implementation.	8	8	4.4
34. Limited availability of professional development for pre-service teachers is an issue.	8	1	4.4
45. Lack of required K-12 technology and engineering standards limits student assessment in integrative STEM curriculum.	8	2	4.4
55. The perception that technology and engineering education teachers cannot teach science or mathematics content is a barrier to implementation of integrative STEM education.	8	9	4.4
58. The perception that inclusion of technology and engineering limits time for learning mathematics and science, limits implementation of integrative STEM curriculum.	8	11	4.4
9. Teachers are uncomfortable with their ability to deliver engineering content and concepts.	9	7	4.3

Items	Rank	Factor	Mean[a]
31. Limited availability of professional development for in-service teachers is an issue.	9	1	4.3
43. Lack of required K-12 technology and engineering standards limits integrative STEM implementation.	9	2	4.3
44. Lack of required K-12 technology and engineering standards limits professional development in integrative STEM curriculum.	9	2	4.3
66. State and federal regulatory boundaries are rigid and constrain local educational reform.	9	3	4.3
68. Class-periods and seat-time requirements constrain the use of integrative STEM methodologies.	9	3	4.3
20. Integrative STEM education is not commonly understood by stakeholders.	10	*	4.2
14. Buy-in of teachers regarding preparing students for careers in engineering is an issue.	11	10	4.1
21. Teachers don't feel empowered to change teaching methods to include integrative STEM.	11	7	4.1
22. Lack of support by administrators hinders implementation.	11	10	4.1
28. Lack of perceived benefit of professional development for integrative STEM methodology limits implementation.	11	*	4.1
53. For many educators computer literacy requirements serve as a barrier to integrative STEM implementation.	11	*	4.1
15. Implementation of integrative STEM education is negatively affected by lack of stakeholder involvement.	12	10	4.0
57. Mathematics educators see no need to change methodology to include technology and engineering.	12	11	4.0
10. Access to professional development regarding integrative STEM education is limited.	13	*	3.9
13. Buy-in of stakeholders regarding preparing students for careers in engineering is an issue.	13	10	3.9
32. Lacking STEM certification at the State level is an issue.	13	*	3.9
61. Negative perception of open-ended inquiry learning limits implementation of integrative STEM education.	13	4	3.9
64. A perception that integrative STEM education addresses only workforce issues limits implementation.	13	4	3.9
18. The perception that integrative STEM education does little to improve student outcomes is a barrier.	14	*	3.8
56. Science educators see no need to change methodology to include technology and engineering.	14	11	3.8
8. Teachers are uncomfortable with implementing technology content and concepts.	15	7	3.7
60. STEM is perceived by educators as another "fad" that will soon go away.	16	4	3.6
62. There is a negative perception that integrative STEM education diminishes the individual importance of each content area.	17	4	3.5
63. A perception that mathematics is not a significant part of science education is an issue.	18	4	3.4
47. The perception of STEM as a male-oriented curriculum limits its significance.	19	6	3.2
48. The perception of STEM as a male-oriented curriculum limits implementation.	20	6	3.0

Note: * = Item did not load into a Factor grouping

[a] Mean rounded to nearest decimal point, N = 59

APPENDIX K. FULL IMPLEMENTATION ITEM RANKINGS, FACTORS, AND MEANS

Items	Rank	Factor	Mean[a]
17. Without collaboration of educators and stakeholders, implementation is limited.	1	3	5.1
39. Current standardized assessments are limited in measurement of mastery in project and problem-based learning.	2	5	5.0
40. Assessment innovation is limited by Adequate Yearly Progress (AYP) indicator required by NCLB.	3	5	4.7
11. Without training in integrative STEM methodology it is difficult to understand the goals and concepts.	3	*	4.7
41. The requirements of NCLB limit time available for integrative STEM education.	3	5	4.7
30. A shortage of teachers trained in integrative STEM education limits implementation.	3	1	4.7
16. Non-supportive teachers hinder implementation of integrative STEM education.	4	3	4.6
35. Lack of integrative STEM methodology in elementary teacher education programs limits implementation.	4	1	4.6
24. Lack of needed resources (funding, equipment, supplies, etc.) causes issues for implementing integrative STEM education.	5	8	4.4
31. Limited availability of professional development for in-service teachers is an issue.	5	1	4.4
29. Funding for professional development is an issue.	5	1	4.4
25. Reliance on textbooks and other outdated classroom resources hinder integrative STEM implementation.	6	8	4.3
52. For many stakeholders, STEM education consists only of science and mathematics.	6	9, 10	4.3
37. Integrative STEM education is limited by low numbers of teacher education programs that include technological literacy as part of content and methods courses.	7	1	4.2
36. Lack of integrative STEM methodology in secondary teacher education programs limits implementation.	7	*	4.2
54. Current education practices delivering separate and "siloed" instruction, limits implementation of integrative STEM.	8	9	4.1
51. For many educators, STEM education consists only of science and mathematics.	8	9	4.1
50. Policy makers and leaders fail to recognize the equal importance of the full spectrum of integrative STEM education.	8	10	4.1
67. There is currently a lack of incentives to motivate key outcomes for improving educational quality.	9	3	4.0
34. Limited availability of professional development for pre-service teachers is an issue.	9	1	4.0
67. There is currently a lack of incentives to motivate key outcomes for improving educational quality.	9	3	4.0
20. Integrative STEM education is not commonly understood by stakeholders.	10	*	3.9
26. Inadequate facilities limit STEM implementation.	10	8	3.9
28. Lack of perceived benefit of professional development for integrative STEM methodology limits implementation.	10	*	3.9
66. State and federal regulatory boundaries are rigid and constrain local educational reform.	10	3	3.9
45. Lack of required K-12 technology and engineering standards limits student assessment in integrative STEM curriculum.	11	2	3.8

Items	Rank	Factor	Mean^{a}
55. The perception that technology and engineering education teachers cannot teach science or mathematics content is a barrier to implementation of integrative STEM education.	11	9	3.8
58. The perception that inclusion of technology and engineering limits time for learning mathematics and science, limits implementation of integrative STEM curriculum.	12	11	3.7
10. Access to professional development regarding integrative STEM education is limited.	13	*	3.6
22. Lack of support by administrators hinders implementation.	13	10	3.6
32. Lacking STEM certification at the State level is an issue.	13		3.6
43. Lack of required K-12 technology and engineering standards limits integrative STEM implementation.	13	2	3.6
44. Lack of required K-12 technology and engineering standards limits professional development in integrative STEM curriculum.	13	2	3.6
61. Negative perception of open-ended inquiry learning limits implementation of integrative STEM education.	13	4	3.6
62. There is a negative perception that integrative STEM education diminishes the individual importance of each content area.	13	4	3.6
60. STEM is perceived by educators as another “fad” that will soon go away.	14	4	3.5
14. Buy-in of teachers regarding preparing students for careers in engineering is an issue.	15	10	3.4
57. Mathematics educators see no need to change methodology to include technology and engineering.	15	11	3.4
9. Teachers are uncomfortable with their ability to deliver engineering content and concepts.	16	7	3.3
53. For many educators computer literacy requirements serve as a barrier to integrative STEM implementation.	16	*	3.3
56. Science educators see no need to change methodology to include technology and engineering.	16	11	3.3
18. The perception that integrative STEM education does little to improve student outcomes is a barrier.	17	*	3.2
63. A perception that mathematics is not a significant part of science education is an issue.	17	4	3.2
8. Teachers are uncomfortable with implementing technology content and concepts.	18	7	3.1
13. Buy-in of stakeholders regarding preparing students for careers in engineering is an issue.	18	10	3.1
64. A perception that integrative STEM education addresses only workforce issues limits implementation.	19	4	3.0
68. Class-periods and seat-time requirements constrain the use of integrative STEM methodologies.	19	3	3.0
15. Implementation of integrative STEM education is negatively affected by lack of stakeholder involvement.	20	10	2.9
47. The perception of STEM as a male-oriented curriculum limits its significance.	20	6	2.9
21. Teachers don’t feel empowered to change teaching methods to include integrative STEM.	21	7	2.8
48. The perception of STEM as a male-oriented curriculum limits implementation.	21	6	2.8

Note: * = Item did not load into a Factor grouping

[a] Mean rounded to nearest decimal point, N = 18