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Impacts of the STEM Education Movement on Technology Education Ph.D. Graduate Programs

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IMPACTS OF THE STEM EDUCATION MOVEMENT ON TECHNOLOGY EDUCATION PH.D. GRADUATE PROGRAMS

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SIGNATURE PAGE

Keith L. Upchurch prepared this research study under the direction of Dr. John M. Ritz in OTED 636, Problems in Occupational and Technical Studies. It was submitted to the Graduate Program Director as partial fulfillment for the requirements for the degree of Master of Science in Occupational and Technical Studies.

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To all of you, *Thank You…*

Keith Upchurch

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CHAPTER I

INTRODUCTION

Science, Technology, Engineering, and Mathematics (STEM) are the fastest growing careers fields in the 21st century. Research has shown to remain competitive in the global economy an investment in STEM education must be at the forefront. The United States (U.S.) is considered the world leader in scientific innovation. However, the U.S. government has a rising concern about their ability to remain competitive. Compared with other countries, the U.S. has struggled in both science and mathematics assessments (Program for International Student Assessment, 2003).

To prepare for the 21st century, changes need to occur in how our students are prepared for the technological world. The traditional system of a professor lecturing for an entire class period does not work. This leads to students becoming passive learners and do not grasp the understanding of the STEM subject material. This is not an effective teaching strategy for complex mathematics and science subjects (Wieman, 2007). Also, universities need to put more emphasis on doctoral education. Teachers need to upgrade their teaching strategies to better prepare students for the future.

The most controversial piece of educational legislation in the past 20 years is the *No Child Left behind Act* (NCLB, 1991). This law required a “highly qualified teacher” in all classrooms. There are some disparities on what “highly qualified” actually meant. Does it mean for someone to have a Bachelor of Science degree to teach a science class or someone with the necessary knowledge base and pedagogy skills to teach a science class. Brainard (2007) stated teachers lack the necessary teaching strategies or were never taught effective teaching techniques.

STATEMENT OF PROBLEM

The problem of this study will be to determine if technology education Ph.D. granting institutions have blended STEM concepts into their graduate education programs.

RESEARCH QUESTION

To guide this study the following research questions will be established.

- Determine if graduate programs are integrating the teaching of STEM concepts into their Ph.D. programs?
- Determine the teaching strategies utilized to prepare Ph.D. level technology educators to use STEM concepts?
- Determine sample course requirements to learn if universities are integrating STEM concepts into their technology education Ph.D. programs?
- Determine if doctoral granting institutions are collaborating with local school systems to make STEM integration a reality?
- Determine what needs to occur in the future in incorporate STEM concepts into technology teacher education programs?

BACKGROUND AND SIGNIFICANCE

The launching of the Sputnik I into space set a crisis in the U.S. educational system (Bracey, 2007). This led to the birth of the National Science Foundation (NSF) and other federal educational programs that were fully supported by federal funding. These organizations researched, field tested, and implemented new science and mathematics curriculum throughout the public education system. This sparked a national movement to improve the teaching and learning of these core disciplines. In the 1960's, the number of graduates in STEM fields escalated (National Science Foundation, 2007). Today, our nation faces the same challenges within our educational system. There is a growing skepticism that the U.S. educational system is not preparing a sufficient number of students, teachers, and professionals in the areas of STEM education (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2007).

STEM education plays an important role in the global economy. However, U.S. students seem uninterested or non-motivated to enter these fields. Business leaders and educational leaders have an intense concern on how students are performing compared to other countries. The trend is not too positive. For example, among the 40 countries participating in the 2003 Program for International Student Assessment (PISA), the U.S. ranked 28th in mathematics literacy and 24th in science literacy (PISA, 2003).

Some of the problems identified with STEM education are with the quality of the teachers' credentials. Research has shown that most middle school teachers hold a baccalaureate degree but over 50% did not have a major or minor in the subject field they are teaching (Department of Education, 2002). Both elementary and middle school teachers often do not acquire sufficient STEM content knowledge or skills for teaching the content during their pre-service preparation (National Science Foundation, 2007). Research has shown teachers who have a major in their STEM subject area have made a positive impact on their students achievement (Allen, 2003).

STEM education improvements needs to start at the undergraduate level. Researchers have conducted numerous studies in the past 20 years and concluded that the U.S. does not adequately prepare their undergraduates in STEM education (Baldwin, 2007). The future of STEM education starts with the Ph.D. and Ed.D. students. The skills and techniques they learn will motivate future teachers in STEM education. A well prepared community of future teachers is central to the development of a STEM educated force (National Research Council, 2002).

The major reason for conducting this study was to research more efficient ways to integrate STEM concepts into technology education doctoral programs. Some scholars believe more research needs to be conducted on integration of STEM concepts within technology education (Laporte & Sanders, 1995). Also, the profession needs to learn how STEM is being integrated on an international level. The amount of research on this subject is limited. However, North Carolina Agricultural and Technical State University did a qusai-experimental study on curriculum integration to see if integration improves technology education students to solve technological problems. Childress (1996) concluded that there was no significant difference between the control group that received curriculum integration and students that did not in the design of their study project, a wind collector. However, those who received correlated science and mathematics instruction did outperform those who did not during the post-test and interviews. Childress further defined that additional research was needed in this area.

LIMITATIONS

The following limitations will effect the research of this study:

- The research was limited to technology education Ph.D. and Ed.D. granting institutions worldwide.
- The population was limited to 17 institutions that provided doctoral study in technology education.
- All contact with the international granting institutions was conducted via electronic mail.
- The graduate course requirements for technology education will vary from the different institutions' depending on the interests of the faculty and community.
- The population of the 17 college and university technology education programs is structure differently and controlled by university and government policies.

ASSUMPTIONS

The foundation of this research was based on the following assumptions:

- Not all countries or institutions were politically motivated by STEM initiatives.
- Technology education differs in concept, content, quality, and application from university to university.

PROCEDURES

The procedural method for collection data in this study began with identification of the Ph.D. granting institutions. A questionnaire was developed with specific items that will allow each respondent to reveal how their institutions are integrating STEM concepts into technology education doctorate programs. The questionnaire was e-mailed to the participants and used to provide data needed for the study. The researcher used descriptive statistical methods for presenting the research study.

DEFINITION OF TERMS

This section provided for understanding of key terms and phrases that had special meaning in this study. The definitions of terms and phrases were provided according to the context of this study.

- ***Collaborating*** is working together within the STEM framework to ensure students are sharing and gaining knowledge.
- ***Critical thinking skills*** are the reflective judgments about a problem and developing outcomes based on observation or experience.
- ***Integration*** is the process of bringing all academic disciplines into one course.
- ***Mathematics literacy*** is applying the correct math skills in a given situation to develop the answer or the solution to the problem.
- ***Problem solving skills*** are mental processes that someone goes through to develop a solution to a problem. The process starts with understanding the problem to developing certain outcomes or solutions to the problem.
- ***Science literacy*** is the knowledge and understanding of scientific concepts and processes required to make decisions.
- ***Scientific innovation*** is coming up with new approaches to a scientific problem that makes your idea better and more resourceful.

- ***STEM*** is an acronym for Science, Technology, Engineering, and Mathematics. It is a conceptual term that signifies an element of integration between the academic disciplines.
- ***Technological literacy*** refers to the ability to use, manage, understand, and assess technology (ITEA, 2007).

OVERVIEW OF THE CHAPTERS

This research is segmented into five major areas. Chapter I, *Introduction*, introduces the reader to the study which was to determine how other Ph.D. granting universities had integrated STEM concepts into their graduate programs. The purpose of this study was to research ways one can improve STEM integration at the doctoral level. Also discussed was the history of STEM education in the U.S. and why it is important for all students and teachers. Finally, it was discussed how to increase mathematics, science, and technological literacy through modern changes at the university level. These changes will cascade down to the undergraduate and local K-12 school level.

Chapter II, *Review of Literature*, will be organized and segmented according to the research goals. Also, prior research studies on STEM integration and teachers' preparatory programs will be reviewed and examined.

Chapter III, *Methods and Procedures*, will describe the methods and procedures utilized to gather the data. Also, this chapter will provide an explanation of the statistical methods used to interpret the data.

Chapter IV, *Findings,* will provide the results of the descriptive survey. The results will be organized and segmented by the response rate of the survey findings which were grouped in research question order.

Chapter V, *Summary, Conclusions, and Recommendations*, the researcher will summarize the research study and draw conclusions based on the data received. Finally, the research will make recommendations for future studies.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this chapter was to review the current literature on technology education Ph.D. granting institutions blending STEM concepts into their graduate education programs. This chapter contains four sections. The first section will detail the integration of STEM concepts within the educational system. Next, the researcher will depict the different teaching strategies in technology education programs. The third section will describe the different institutions course requirements for preparation for teaching technology education programs. Finally, the fourth section will describe the different collaborating methods used within the technology education program.

INTEGRATION OF STEM CONCEPTS

Researchers have different perceptions of what STEM means. Some believe that STEM is educators teaching the four (4) areas of science, technology, engineering, and mathematics, separately. However, others believe that STEM is a multitude of educators collaborating together to teach the different concepts of STEM education. Laporte and Sanders (1995) believed we need to have an integrative teacher preparatory education program that encompasses all four interdisciplinary subjects. However, Sanders (2009) recently contradicted his earlier conception and believed it is impossible for an educator to be an expert in both pedagogical expertise and content expertise in all four areas of STEM education.

Additional, research has shown that the integration of STEM education increased the learning behavior of children. Hartzler (2000) conducted a meta-analysis of 30 individual studies of traditional classroom instructions and integrative classroom instructions. Hartzler's study revealed students in an integrative classroom consistently outperformed students in a traditional classroom.

Laporte and Sanders (1995) believed that integrating both science and mathematics will bring technology education to the forefront as an essential course requirement in general education. However, both believed integration may have some disadvantages. The major disadvantage will be with the elimination of the technology education program and incorporating the technology education concepts within science and mathematics course of instructions. The Netherlands' are currently integrating both science education and technology education into one course (M. De Vries, personal communication, October 4, 2009). The stronger technology education programs will survive and enhance the science curriculum. However, the less fortunate or fragile technology education programs will be disbanded or taken over by the science education courses.

U.S. integration projects have room for growth. Project 2061 was a national movement to reform science, mathematics, and technology education for the 21st century. This project proposed "a fundamental reformation of science, mathematics, and technology education" (AAAS, 1995, p. 6). Science, mathematics, and technology have all viewed integration as an important aspect in growing our educational system. The standard of literacy for all three programs has included integration as a benchmark.

STEM integration has shown to increase students understanding of the core concepts of STEM education. Educators have different views on what STEM integration encompasses. Some teachers lack the common know-how to integrate the subject material into their curriculum. However, many educators are promoting different teaching strategies to close the gap in STEM education.

Teaching Strategies

The different learning styles or teaching strategies play an important role in the development of both students and preparatory teachers. Dewey and many other educational theorists believed learning styles such as learning by doing, experiential learning, and hands-on learning are important in the development of learning theories (Swhwaller, 1995). Another, learning model that is commonly associated with technology education is the Bloom Taxonomy. This theory suggested that all learning occurs in three domains: cognitive, emotional, and psychomotor (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). All three domains play a significant role when teaching technology education. In the technology education classroom, students learn most of their information in the cognitive domain and the information is reinforced through the students' psychomotor domain with hand-on projects.

Instructional strategies for preparatory teachers are not developed in U.S. universities. Seymour and Hewitt (1997) stated the compounding problem with STEM education is a majority of undergraduate classes occur in large lecture halls where teaching practices are constrained by seating arrangement. Research has shown that initial teaching strategies are developed during a preparatory teacher's undergraduate course work (Hansen, 2005). Zeichner and Gore (1990) refers to this as teacher socialization. It is the process of transforming an individual into "a participating member of the society of teachers" (p. 326). Students develop their strategies based on how they were taught.

Employers value workers who can evaluate complex problems and think critically (Gokhale, 1995). The secretary's Commission on Achieving Necessary Skills (SCANS) detailed a report on how schools prepare students for the workforce (1991). Critical thinking skills were outline as a core foundation that is required by all students for the 21st century workforce.

Halpern (1996) defines critical thinking as the use of cognitive skills to increase a desired outcome. Additionally, Maiorana (1992) stated the purpose of critical thinking is to use questioning techniques to achieve an understanding or solve a problem. Research is considered a form of thinking critically. The scientific method involves asking questions, researching information, developing questions, testing, analyzing, and communicating the outcomes.

Inquiry base learning is a teaching strategy that uses the investigative method to enhance learning. This strategy is often called an experimental, discovery, testing, or problem solving method. Daiber (1988) stated this method focuses on the process of investigation and to explain or research unusual phenomena. Inquiry base learning encourages students to develop their critical thinking skills. Schwaller (1995) stated this method effectively encouraged students to develop critical thinking skills. Also, he stated some of the advantages of this method are students learning at the highest level of evaluation in the cognitive domain. Also, students learn to work independently and in groups.

The debate process is a form of inquiry base learning. Debate process in science and technology classes can help students' explore and develop their critical thinking skills. Vo and Morris (2006) founded that debates increased the benefits of the traditional lecture by engaging students in the course material. Another researcher, Osborne (2005), stated that this teaching strategy enabled students to demonstrate their ability to read and write critically. Additional, Walker and Warhust (2005) claimed 82% of their students thought debates helped them understand the subject matter more efficiently, while 85% of their students thought debates enabled them to learn something valuable.

College and universities are looking at different ways to develop future teachers. The traditional lecture based teaching styles are not going to prepare future teachers with the necessary skills to be successful in the 21st century.

The National Science Foundation (NSF) has supported a national initiative, the Center for the Integration of Research, Teaching and Learning (CIRTL), designed to address the particular issues associated with preparing future faculty in the STEM fields (Baldwin, 2009). CIRTL aims to collaborate with different research universities to develop models for preparing STEM educators.

Another program that is developing teachers and has received national recognition is the UTEACH program at the University of Texas. This program offers preparatory teachers' an academically challenging curriculum that provides students with early and frequent experiences in the classroom and an in-depth content knowledge in mathematics and sciences. Twenty-five (25) percent of the preparatory teachers are from the science and mathematics fields that have a strong desire to teach STEM education (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2007). Cavanaugh (2007) stated that three-quarters of UTeach graduates are still teaching in the classroom after their first five (5) years compared with an estimated sixty (60) percent of teachers nationwide. Inquiry base instruction is the formula for success for UTEACH teachers. These strategies are heavily emphasized in the program.

The teaching strategies that preparatory teachers develop are the key to a successful teaching career. Inquiry base teaching strategies are how we are going to prepare students for the 21st century STEM career force. Colleges and university are developing methods and strategies to prepare future teachers that have proven to develop critical thinking skills for our students.

COURSE REQUIREMENT

The U.S educational system is mandated by both local and state governments while most other countries have a national educational system. The course requirements for technology education in the U.S. take on many different variants. Some universities programs are based on the old industrial arts model where hands-on and technical competencies are the requirement. However, most universities technology education programs have embraced programs in design and pre-engineering to shape the profession.

The design process is an important aspect in understanding technological literacy. The Standards of Technological Literacy (STL) promotes the importance of design as a tool for both investigating and developing the technological world (ITEA, 2000). Design is woven throughout the many benchmarks of the STL and is identified specifically as four of the 20 overall standards (ITEA, 2000).

Research has shown the importance of the design process in preparing future technology educator. Warner and Morford (2004) stated college and universities play a significant role in preparing future teachers who will interpret and apply these core concepts of technological literacy in the K-12 classroom.

An observational study was conducted for universities and colleges undergraduate pre-service technology education design curriculum. The study categorized design into two aspects of technical and synergistic. Technical aspect included courses in computer aided drafting and other trade related courses. The synergistic aspect included courses in the design process and other courses that integrated the arts with technological literacy. The results of the study concluded that technical aspect courses where the predominate category of design curriculum (Warner & Morford, 2004).

Technology literacy has taken on many forms to infuse in the secondary school systems. Pre-engineering has been recommended as a vehicle to bring about technological literacy into the secondary school system (Lewis, 2005). The NSF has developed different initiatives to incorporate technology literacy with core engineering curriculum. Programs such as Project Lead the Way and Project ProBase are funded projects by the NSF to incorporate engineering into primary and secondary education. Both engineering and technology are similar in many ways. However, Lewis (2005) believes that engineering design places more emphasis on assessing constraints and tradeoffs compared to technology education.

Technology education and engineering education formed an alliance to develop the STL (ITEA, 2000). These benchmarks include engineering principles to advocate technological literacy. School administrators have different perspectives on the role of engineering curriculum within the technology education environment. Business and trade industry are pressing school administrators to reinstate traditional trade focused courses (Welty, 2003). However, Hill (2006) believed these roles vary from establishing a pre-engineering curriculum for high school students or establishing a broader focus of engineering design as a form of creative activity within the general education role.

A research study was conducted to examine if technology teacher educators support the route undergraduate technology education is going with technology literacy. The results indicate that most educators support how technological literacy is evolving through design and engineering as major component of an undergraduate program. However, equal numbers resist the idea of changing the program and preferred an undergraduate program that revolved around a more traditional industrial curriculum organization (Daugherty, 2005).

The four different program requirements for preparatory technology education focus on industrial arts (industrial technologies), technological literacy, design, and engineering in the United States. However, most other countries have national educational systems and have the same technology education course requirements. Even though the preparatory programs in the U.S. are different, many universities base their requirements from the STL.

COLLABORATION METHODS

Collaboration is a term that is used in our everyday lives. Research based universities work collaboratively with industries to design new technologies. Webster (1995) defines collaboration as working together jointly to achieve a goal. *Rising Above the Gathering Storm* (2007) identified both Engineering Research Centers and Science and Technology Centers as two programs that utilize collaboration between different organizations. Education should be no different in establishing collaboration between universities and local school systems to increase STEM education.

Also, collaboration would help develop students going into college. National Science Board (2007) states that almost 30 percent of high school graduating students have to take remedial STEM classes because they are not prepared to take college level courses. The NSB has recommended a vertical alignment of STEM education. Also, they stated three recommendations to increase STEM education (National Science Board, 2007). First, improve the linkage between high school and higher education. Next, create or strengthen STEM education-focused P-16 or P-20 councils in each state. Finally, encourage alignments of STEM education content throughout the P-12 education system.

Collaboration should be a smooth transition from the local school system to higher education. NSB (2007) believes STEM learning is not vertically aligned among grade levels, resulting in an unorganized foundation for STEM education. Finally, the NSB believes that STEM education should be built upon from secondary education to higher education.

Summary

There is a multitude of organizations and government agencies involved in blending the STEM concept into graduate preparatory teaching institutions. However, there is no one organization that is overall in charge of putting STEM education at the forefront.

Additional, the four areas of STEM concepts, teaching strategies, individual universities course requirements, and collaboration between public secondary schools and universities are important to increasing STEM education through technology education pre-service teachers. However, the limited amount of research on this topic makes it difficult for teachers to focus their attention in these areas.

The NSF has been chartered to increase public awareness and increase the teachers' expertise within these STEM fields. However as research has determined, many technology education professionals are reluctant to change.

Chapter III, *Methods and Procedures*, will describe the methods and procedures utilized to gather the data. Also, this chapter will provide an explanation of the statistical methods used to interpret the data.

CHAPTER III

METHODS AND PROCEDURES

The focus of this study was to determine ways technology education Ph.D. granting institutions were implementing STEM concepts into their Ph.D. programs. If STEM concepts were implemented more efficiently, it was believed K-12 teachers could be subsequently prepared and better research and development projects would materialize in improved student learning in STEM subject areas. The instrument used to determine the different strategies was a survey. The survey consisted of questions about teaching strategies and other STEM concepts used by technology education Ph.D. granting institutions. Additional, this chapter will provide an explanation of methods of data collection and a brief description of the statistical analysis.

POPULATION

The population for this study consisted of technology education Ph.D. granting institutions worldwide. A total of 17 technology education Ph.D. institutions were identified during this time frame. Six of the institutions were located outside the United States. These programs were found using the following sources: *Technology Education Graduate Study: State-of-the-Art* (Ritz & Reed, 2008), *International Handbook of Technology Education: Reviewing the Past Twenty Years* (de Vries, & Mottier, 2006), and online searches at individual universities.

The universities that composed the population were the following: Aix-Marseille, British Columbia, Colorado State, Edith Cowan, Georgia, Griffith, Illinois, Indiana State, Iowa State, North Carolina State, Ohio State, Old Dominion, Purdue, Rhodes, Utah State, Virginia Tech, and Delft. For a list of the universities surveyed see Appendix A.

INSTRUMENT DESIGN

The problem of the study was to determine how other universities are implementing STEM concepts into their graduate technology education teacher preparation programs. To guide the investigator towards a solution to this problem, a questionnaire was developed to collect data from the 17 universities department chairs or coordinators of technology education Ph.D. and Ed.D. programs.

The survey combined forced choice responses and open formed questions. Survey Questions 1, 2, 6, 7, and 11 used the five-point Likert scale. The population expressed their degree of agreement or disagreement with the questions through answer selection. Answer choices were "Very High" which had a value of 5, "High" which had a value of 4, "Moderate" which had a value of 3, "Low" which had a value of 2, and "Very Low" which had a value of 1. If the respondents failed to answer the question, the population (n value) was reduced, not to effect the mean. Also, survey Questions 5, 8, 9, and 12 used force choice responses. The respondents selected the answer that best described their program. Similar forced choice responses were summarized and collected accordingly. Survey Questions 3, 4, 10, 13, and 14 all required information in open-form. The respondents had to list their recommendation or changes to the program. Similar responses were summarized and assembled accordingly. Each survey statement and question correlated with the research goals. For an example, of the instrument used, see Appendix B.

METHODS OF DATA COLLECTION

The method of data collection used for this study was electronic mail. The surveys were distributed along with a cover letter (Appendix C) to the 17 technology education Ph.D. granting institutions department chairs or coordinators. The cover letter explained the purpose and the importance of the survey and guaranteed the respondent's confidentiality. Respondent were given 10 days to complete and return the questionnaire.

STATISTICAL ANALYSIS

The researcher used descriptive statistical methods to organize, tabulate, and interpret the collected data. The data compiled from the returned questionnaires used the number of responses, frequency of answers, and means to statistically analyze the data. The frequency and number of responses were calculated and a percentage obtained to determine the results. Additional, the open-ended questions were reviewed and recorded according to similarities.

SUMMARY

Chapter III, *Methods and Procedures*, explains how to collect data to answer the research problem. The researcher described the population used for the study. Also, the researcher defined how the instrument was going to answer the research goals. Next, the researcher explained how the methods of data collection were conducted. Finally, the researcher explored how the data were going to be analyzed.

Chapter IV, *Findings,* will provide the results of the descriptive survey. The results will be organized and segmented by the response rate of the survey findings which were grouped in research question order.

CHAPTER IV

FINDINGS

This chapter presented the findings of the data collected from the questionnaire, a survey instrument specifically designed to measure respondent's opinions on the impacts of STEM education movement on technology education Ph.D. graduate programs. This chapter is separated into sections addressing responses to the survey and the survey questions which were grouped in research question order. Tables were used to support the questionnaire data narrative. The problem of this study was to determine if technology education Ph.D. granting institutions have blended STEM concepts into their graduate education programs.

Response Rate

The survey questionnaires were sent out to 17 respondents using the electronic mail method on May 25, 2010. Based on initial low response rates, follow-up methods using telephone and additional electronic mail were required to increase the response rate output. The period of data collection was from May 25, 2010 to June 25, 2010. Eighty-eight percent of the sample population, or 15 of 17 technology education graduate program coordinators or department chairs, participated in the survey via electronic mail. Although numerous follow-up methods were used, two questionnaires were not received by the June 25, 2010 deadline. Table 1 shows the response rate.

Table 1

Response Rate

Number Sent	Number Collected	Total Response Rate
17	15	88 %

Data Analysis

The findings from the questionnaire consisted of fourteen questions related to the research questions. Due to the 88 percent response rate, data analysis figures were sufficient to represent a larger population of technology education graduate program coordinators or department chairs. The researcher used descriptive statistical methods to organize and tabulate the collected data. The data compiled from the returned questionnaires used number of responses, frequency of answer, and mean to statistically analyze the data.

Research Question 1 was *Determine if graduate programs are integrating the teaching of STEM concepts into their Ph.D. programs?* To answer this question, four survey questions (1, 2, 3, and 4) were designed to analyze the results. Likert scale values assigned to each response ranged from one point for “Very low”, two points for “Low”, three points for “Moderate”, four points for “High”, and five points for “Very high”. These point totals were used to calculate the mean. If the respondents failed to answer the question, the population (n value) was reduced, not to effect the mean.

In Question 1, respondents were asked if the concepts of STEM education are influencing the development of technology education graduate programs. The mean response was calculated at 3.46, which indicates seven of thirteen (54%) perceived to a high degree that concepts of STEM education are influencing technology education programs. While six of thirteen (46%) determined themselves in categories below the mean. The Likert scale frequency of responses and percentage of answers for Question 1 were presented in Table 2.

In Question 2, the respondents were asked to rate their current programs of incorporating STEM concepts and activities. The mean response was calculated as 3.02, which indicated moderate for this category. Six of thirteen (46%) respondents determined their programs above the mean in categories of high to very high. Four of thirteen (31%) respondents rated their programs below the mean in categories of low or very low. Additional only three of thirteen respondents (23%) determined their programs equal to the mean. The Likert scale frequency of responses and percentage of answers for Question 2 were presented in Table 2.

Table 2

Concept of STEM Education

	Did not respond	Very Low	Low	Moderate	High	Very high	M
	f (%)	*f* (%)	*f* (%)	*f* (%)	*f* (%)	*f* (%)	
Q #1	0(0.00)	3(20)	1(16)	2(13)	1(08)	6(46)	3.46
Q #2	0(0.00)	2(15)	2(15)	3(23)	2(15)	4(31)	*3.02*

Note. *f* = frequency of response; % = percentage; total number of respondents, n = 13; *M* = mean (rounded two decimal value)

In Question 3, the respondents were asked their professional opinion regarding the integration of STEM concepts into their technology education doctoral programs. Similarities in respondent answers were summarized and clustered accordingly to the respondent's opinions. Four of thirteen comments (31%) supported STEM integration. For example they responded that, "the importance on integration is vital to the success of STEM education". Another comment stated, it "enables students to be prepared to address research and curriculum development in the emerging areas".

Additional, four of thirteen respondents (31 %) stated that STEM education is not mature enough at the doctoral level. Two of four of these respondents stated "STEM integration has no impact on my doctoral program". Another common opinion is that STEM integration will only occurs in research themes. Four of thirteen respondents (31%) stated "STEM integration only occurs if the research thesis supports integration". For example, if a doctoral candidate research thesis focuses on the integration of STEM, their research will focus on STEM integration. This is the only time that integration is discussed at the doctoral level.

Finally, one of thirteen (8%) respondents focused primary on the integrative approach to STEM education. They stated "the importance of integrative STEM education is on investigation and applications of new approaches". The responses to Question 3 were presented as clustered summaries of the respondent comments in Table 3.

Table 3

Open-Form Responses Regarding Integration of STEM

Q#3 Clustered Responses

- Integration of STEM is vital. (n=4)
- STEM is not developed at the doctoral level. (n=4)
- Research themes of the other disciples of STEM will support the integration of STEM. (n=4).
- Our program focuses on the investigation and application for new integrative approaches to STEM education uniquely sets us apart from other STEM programs. (n-1)

Note. Respondent's comments, n=15

In Question 4, respondents were asked what changes they would recommend to increase the awareness level of STEM integration. Similarities in respondent comments were summarized and clustered into categories that represented their recommendations. Three of thirteen respondents (23%) provided recommendation to increase advertisement of STEM integration. For example, they responded that, "advertise through research listing or distance learning methods would increase the awareness level of STEM integration".

Additional, four of thirteen respondents (31 %) recommended increasing the awareness level through adding classroom discussion on STEM integration in all college classes. Another respondent stated, "each graduate course should include STEM integration or change the textbooks to include STEM integration". Four of thirteen respondents (31%) recommended to developed collaborative research teams. One respondent stated, "having students work together in a collaborative team will raise the level of awareness for STEM integration". Another respondent stated "stronger efforts among the different colleges to collaborate will increase the awareness of integration. Finally, two of thirteen (15%) respondents recommended no change to increasing the awareness level of STEM integration. The responses to Question 4 were presented as clustered summaries of the respondent comments in Table 4.

Table 4

Open-Form Responses Regarding Recommendation for Integration

Q#4 Clustered Responses
• Communicate and advertise through different electronic methods. (n=3)
• Discussion of STEM integration in all college classes. (n=4)
• Develop collaborative Research Teams (n=4)
• No Change. (n=2).

Note. Respondents comments, n=13

Research Question 2 was *Determine the teaching strategies utilized to prepare Ph.D. level technology educators to use STEM concepts?* To answer this question, four survey questions (5, 6, 7, and 8) were designed to analyze the results. Likert scale values assigned to each response ranged from one point for "Very low", two points for "Low", three points for "Moderate", four points for "High", and five points for "Very high". These point totals were used to calculate the mean. If the respondents failed to answer the question, the population (n value) was reduced, not to effect the mean.

In Question 5, respondents were asked to select the response that defines the amount of time devoted toward new curriculum and instructional strategies. Data indicated that only three of thirteen (23%) respondents have incorporated new curriculum and instructional approaches more than 30% of the time. Additional, data indicated that six of thirteen (46%) respondents have incorporated new curriculum and instructional approaches less than 20% of the time. The data reported in Table 5 shows the percentages of time that the respondents spend on integrating new curriculum and instructional approaches.

Table 5

Incorporating New Instructional Approaches

	Did not respond	Less than 10%	10% to 20%	20% to 30%	30% to 40%	More than 40%
	f (%)	*f* (%)	*f* (%)	*f* (%)	*f* (%)	*f* (%)
Q #5	0(0.00)	4(31)	2(15)	4(31)	1(8)	2(15)

Note. *f* = frequency of response; % = percentage (rounded two decimal values); total number of respondents, n = 13.

In Question 6, respondents were asked if the integrative approach was the best way to improving young students development in STEM education. The mean response was calculated at 4, which was high for this category. Ten of thirteen (77%) respondents answered at or above the mean and rated in categories of high or very high. However, three of thirteen (23%) respondents determined themselves in categories below the mean. The Likert scale frequency of responses and percentage of answers for Question 6 were presented in Table 6.

In Question 7, the respondents were asked if doctoral students were gaining the necessary skills and teaching strategies to effectively integrate STEM into future work in technology education teacher preparatory program. The mean response for the respondents was calculated as 3.73, which indicates a high degree of fidelity. Six of eleven (55%) respondents perceived to a high and very high degree that doctoral students are gaining the necessary skills. Three of thirteen (23%) respondents either did not respond or rate very low, citing doctoral candidates should not be developing teaching strategies. The Likert scale frequency of responses and percentage of answers for Question 7 were presented in Table 6.

Table 6

Improving STEM Education

	Did not respond	Very Low	Low	Moderate	High	Very high	M
	f (%)	*f* (%)	*f* (%)	*f* (%)	*f* (%)	*f* (%)	
Q #6	0(0.00)	1(8)	1(8)	1(8)	4(31)	6(46)	4
Q #7	2(18)	1(9)	0(0)	4(36)	2(18)	4(36)	3.73

Note. *f* = frequency of response; % = percentage; total number of respondents, (Q#6 n = 13& Q#7 n=11); *M* = mean (rounded two decimal value)

In Question 8, the respondents were asked to select the responses that accurately describe the teaching strategies that their program employs. Percentages were based on the number of times each item was selected by all respondents. Project based learning was selected eight of thirty (26%) of the time. Both problem based learning and inquiring based learning were selected seven of thirteen (23%) of the time. However, four of thirty (13%) indicated that none of the teaching strategies were employed in their graduate program. The response percentages and frequencies were presented in Table 7.

Table 7

Teaching Strategies

	Did not respond	None of the Above	Lecture Based	Project Based Learning	Inquiring Based Leaning	Problem Based Learning
	f (%)	*f* (%)	*f* (%)	*f* (%)	*f* (%)	*f* (%)
Q #8	0(0.00)	4(13)	4(13)	8(27)	7(23)	7(23)

Note. *f* = frequency of response; % = percentage; total number of responses, n = 30

Research Question 3 was *Determine sample course requirements to learn if universities are integrating STEM concepts into their technology education Ph.D. and Ed. D. programs?* To answer the question, two survey questions (9 and 10) were designed to answer the research question.

In Question 9, respondents were asked to determine the amount of time their doctoral programs addressed STEM and number of courses related to STEM. Data indicated that only eight of thirteen (60%) respondents spend less than 20% of their doctoral program on STEM. Six of eight (75%) of those respondents have developed coursework in STEM. Respondents stated, “STEM coursework is included in other courses”.

Additional, data indicated that four of thirteen (30%) respondents spend more than 30% of their doctoral program on STEM. Three of four (75%) of those respondents have developed three or more STEM related courses. One respondent (8%) did not respond because their doctoral program is research based and STEM is only included if the research thesis support it. The data reported in Table 8 shows the percentages of time doctoral programs address STEM.

Table 8

Doctoral Programs designed for STEM

	Did not respond	Less than 10%	10% to 20%	20% to 30%	30% to 40%	More than 40%
	f (%)	*f* (%)	*f* (%)	*f* (%)	*f* (%)	*f* (%)
Q #9	1(8)	5(38)	3(23)	0(0.00)	1(8)	3(23)

Note. *f* = frequency of response; % = percentage; total number of respondents, n = 12

In Question 10, respondents were asked to list the number and title of doctoral program courses specifically designed to integrate the different STEM concepts. Five of thirteen (38%) respondents have courses specific designed for integration of STEM into their doctoral programs. This was anywhere from one to three courses specifically designed for STEM integration. Three of thirteen (23%) respondents do not have a course specifically designed for STEM integration. However, STEM integration is included when the research thesis supports these concepts. Finally, five of 13 (38%) respondents do not have any courses designed for STEM integration. One respondent (8%) has an entire doctoral program specifically designed on STEM integration. Table 9 lists the individual courses.

Table 9

Open-Form Responses Regarding STEM Courses

Doctoral Program	***f%***	**Courses**
Courses within the current major of the doctoral program	38	• EDD Workforce Education (engineering and technology focus) • PhD Workforce Education (engineering and technology focus) • Foundations for Teaching Technology • Leadership in Technology Education • Scientific and Technical Visualization • Introduction to Technology • Technical Systems
Research Thesis	23	• No specific program courses
Complete Doctoral Program	8	• Program Development in Technology Education • Different Issues and Trends in STEM Education • Advanced Study of Thinking, Learning, and Math/Science Education • Advanced Study of Teaching and Teacher Education in STEM Education • History of Curriculum in Math/ Science/Technology Education • Survey of Research Methodologies in STEM Education • STEM Education Foundation • STEM Education Pedagogy • Trends and Issues in STEM Education • STEM Education Research • STEM Education Seminar • Biotechnology Literacy by Design • Field Studies in STEM Education • Readings in Technology Education
No Program	38	Not Applicable

Note. Respondents comments, n=13. Research thesis doctoral program only include STEM when the research subject involves STEM methods.

Research Question 4 was *Determine if doctoral granting institutions are collaborating with local school systems to make STEM integration a reality?* To answer the question, three survey questions (11, 12, and 13) were designed to answer the research questions. Likert scale values assigned to each response ranged from one point for “Very low”, two points for “Low”, three points for “Moderate”, four points for “High”, and five points for “Very high”. These point totals were used to calculate the mean. If the respondents failed to answer the question, the population (n value) was reduced, not to effect the mean.

In Question 11, respondents were asked their professional opinion if collaboration with local K-12 school systems would improve their doctoral programs experiments with STEM. The mean results for the respondents was calculated as 3.75, which indicates that a majority seven of twelve (58%) perceived to a high degree that collaboration with local k-12 school systems will improve doctoral students experience with STEM. However, five of twelve (42%) respondents rated collaboration with local K-12 school systems below the mean. The Likert scale frequency of responses and percentage of answers for Question 11 were presented in Table 10.

In Question 12, respondents were asked if they actively collaborated with the local K-12 school system to incorporate STEM integration. Eight of thirteen (62%) respondents are actively collaborating with the local schools. However, three of the eight (38%) respondents perceived collaboration with local K-12 school systems to be below the mean in Question 11.

Table 10

Collaboration with Local School Systems

	Did not respond	Very Low	Low	Moderate	High	Very high	M
	f (%)	*f* (%)	*f* (%)	*f* (%)	*f* (%)	*f* (%)	
Q #11	1(8)	1(8)	0(0)	4(33)	3(25)	4(33)	3.75

Note. *f* = frequency of response; % = percentage; total number of respondents, n = 12; *M* = mean (rounded two decimal value); mode = 4

Five of thirteen (38%) respondents are not engaged with the local school system to incorporate STEM integration. However, two of the five (40%) respondents perceived collaboration with local K-12 school systems above the mean in Question 11. The response percentages and frequencies were presented in Table 11.

Table 11

Actively Collaborating with Local School Systems

	Yes	Above *M* in Q#11	Below *M* in Q#11	No	Above *M* in Q#11	Below *M* in Q#11
	f (%)	*f* (%)	*f* (%)	*f* (%)	*f* (%)	*f* (%)
Q #12	8(62)	5(63)	3(38)	5(38)	2(40)	3(60)

Note. *f* = frequency of response; % = percentage; total number of respondents, n = 13

In Question 13, respondents were asked to give examples of collaboration methods they currently perform in local school systems. Respondents could provide more than one comment, which varied among the nine respondents. Similarities in responses were clustered into separate categories. Another four of fifteen (27%) comments used research to implement STEM integration in the local K-12 school systems. Additional, pre-service teacher training and curriculum development at the local school systems amounted for six of fifteen (40%) of the comments. Another four of fifteen (27%) comments use outreach programs to implement STEM integration at the local K-12 school systems. Finally, one of fifteen (7%) respondents stated, "educating senior school board officials as the key to moving STEM integration into the local K-12 school systems". The consolidated list of the respondents' comments for Question 13 was presented in Table 12.

Table 12

Open-Form Responses Regarding STEM Integration

Q#13 Clustered Responses

- Research project (n=4)
  - Doctoral research or other research projects
  - NSF funded PreK-12 projects
  - Research projects
  - Research projects in STEM Education

- Outreach Programs (n=4)
  - Working with local science and technology museum called Imagination Station
  - Graduate students working with robotic design academy

- Implement STEM education through engineering design (n=1)

- Pre-Service Training (n=4)
  - In-service training for teachers (promote activities in science and technology
  - Pre-service teachers required to teach STEM lessons to elementary grade students
  - Experiment integration with real classes and students
  - Doctoral students work with teachers in local schools

- Curriculum Development (n=2)
  - Gaming and computer curriculum
  - Develop curriculum in STEM Education

- Educate school division on Integrative STEM implementation (n=1)

Note. Respondents comments, n=15

Research Question 5 was *Determine what needs to occur in the future to incorporate STEM concepts into technology education graduate programs?* To answer the question, one survey question (14) was designed to answer the question.

In Question 14, respondents were asked to give their opinion on what needs to occur to effectively incorporate STEM concepts into their graduate programs. Respondents could provide more than one comment, which varied among the thirteen respondents. Similarities in respondent comments were clustered into separate categories. Four of fourteen (28%) comments believed that collaboration with the four pillars of STEM (Science, Technology, Mathematics, and Engineering) is the only way to incorporate STEM into their graduate programs.

Additional, three of fourteen (21%) comments believed that there is misconception on what STEM means and what integration consists of. However, two of fourteen (14%) believed the need to institute the current plans. Another three of fourteen (21%) commented that STEM is not where it needs to be. They believed that radical changes need to develop in course content along with research methods to implement STEM integration in their graduate programs. Finally, two of fourteen (14%) commented that research needs to be involved more efficiently. Both teachers and researchers need to discuss where integration of STEM is and how research plays a part into its development. The consolidated list of the respondents' comments for Question 14 was presented in Table 13.

Table 13

Open-Form Responses Regarding Changes to STEM

Q#14 Clustered Responses

- Collaboration with the other Disciplines of STEM (n=4)
    - Joint projects with Science, Math, and Engineering
    - More collaboration with College of Engineering and College of Education, we will need to see if these current proposals get funded, however there is a new class that will bring these stakeholders together in one new course.
    - Course re-alignment and collaboration with school systems, funding and other organizations
    - The main change is to discuss the different income of each epistemology

- Radical Changes (n=3)
    - Change the content
    - Research methods
    - Nature of thesis supervision

- Institute current plans (n=2)
    - Implementation of current plans
    - Move from integration to transformation

- Definition of STEM (n=3)
    - All components of STEM need to define STEM the same way.
    - Everyone should be on the same page before anything will every happen with STEM integration.
    - What are the contents of STEM and does Integrate mean.
- Research Programs (n=2)
    - Greater involvement in STEM related research programs
    - Educational efforts among involved teacher and researcher

Note. Respondents comments, n=14

Summary

In this chapter, the researcher reported the findings regarding the opinions and perceptions of fifteen technology education Ph.D. granting institutions' department chairs or coordinators. Subsections of Chapter IV included population response rates, as well as item responses narratives and tabulated data, which categorized questions by Research Question order. The survey instrument data, which was collected via electronic mail method, was interpreted and presented using descriptive statistics. The data were analyzed to determine if granting institutions have blended STEM concepts into their graduate education programs.

In Chapter V, Summary, Conclusions, and Recommendations, the researcher will present a synopsis of the data using the aggregate data findings. In addition, conclusions will be drawn based on reported data to answer the five research questions, which guided this study. This will be followed by a review of recommendations and proposals for future studies and research.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMEDATIONS

This study emerged from a need to understand how other Ph.D. graduating institution where incorporating STEM into their technology education programs. The purpose of this chapter was to summarize the research study and draw conclusions based on the data received. Finally, the researcher will make recommendations for future considerations of this research problem.

Summary

The problem of the study was to determine if technology education Ph.D. granting institutions have blended STEM concepts into their graduate education programs. The following research questions were established to guide the researcher towards possible solutions to this problem.

- Determine if graduate programs are integrating the teaching of STEM concepts into their Ph.D. programs?
- Determine the teaching strategies utilized to prepare Ph.D. level technology educators to use STEM concepts?
- Determine sample course requirements to learn if universities are integrating STEM concepts into their technology education Ph.D. and Ed.D. programs?
- Determine if doctoral granting institutions are collaborating with local school systems to make STEM integration a reality?

- Determine what needs to occur in the future in incorporate STEM concepts into technology teacher education programs?

The major goal of this research study was to determine more effective ways to integrate STEM concepts into technology education doctoral programs. To accomplish the goal, the researcher collected data that described how other Ph.D. granting institutions were blending STEM concepts into their doctoral programs.

The results of the research data were limited by certain factors and conditions. The following limitations effected the research of this study:

- The research was limited to technology education Ph.D. and Ed.D. granting institutions worldwide.
- The population was limited to 17 institutions that provided doctoral study in technology education.
- All contact with the granting institutions were conducted via electronic mail.
- The graduate course requirements for technology education will vary from different institutions depending on the interests of the faculty and community.
- The population of the 17 college and university technology education programs were structure differently and controlled by university and government policy.

The population for this study consisted of technology education Ph.D. and Ed.D. granting institutions worldwide. A total of 17 technology education doctoral institutions were identified during this time frame. Six of the institutions were located outside the United States.

The instrument used for data collection was a survey. The researcher developed a 14 question survey to determine how other Ph.D. and Ed.D. granting institutions were blending STEM concepts into their graduate programs. The surveys were distributed on May 25, 2010 using the electronic mail method along with a cover letter to the seventeen doctoral technology education granting institutions' department chairs or coordinators. The cover letter explained the purpose and importance of the survey and guaranteed the respondents confidentiality. Based on initial low response rates, follow-up methods using telephone and additions electronic mail were required to increase the low response rate. The period of the data collection ended June 25, 2010.

The data analysis was compiled from the survey. Fifteen of seventeen (88%) respondents participated in the research study. Thirteen respondents participated in the survey, two respondent stated that the questionnaire was not designed to their graduate program, and two respondents failed to participated in the allot time frame. The researcher used descriptive statistical methods to organize, calculate, and interpreted the data using number of responses, percentage of answer, and the mean.

Conclusions

The problem of this study was to determine if technology education Ph.D. granting institutions have blended STEM concepts into their graduate education programs. The findings collected from the survey were analyzed and addressed by answering each research question.

Research Question 1, *Determine if graduate programs are integrating the teaching of STEM concepts into their Ph.D. programs?* The researcher discovered that a majority of technology education program coordinators assessed the integration of STEM concepts in technology education Ph.D. programs as moderate to high. This indicated that graduate technology education programs are integrating STEM into their programs.

However despite these participation levels in incorporating STEM concepts into their graduate technology education programs, most coordinators have differences of opinions on where to integrate these concepts into the graduate programs. For example, four of thirteen (31%) respondents support incorporating STEM concepts through the research thesis, whereas four of thirteen (31%) respondents support integrating STEM through curriculum development and classroom discussion. This indicates that graduate programs are in disagreement on where to focus STEM integration at the graduate level.

Research Question 2, *Determine the teaching strategies utilized to prepare Ph.D. level technology educators to use STEM concepts?* The researcher discovered almost half of the population (46%) is devoting a small percentage (less than 20%) of their time to teaching different instructional strategies for addressing STEM. The majority of graduate programs (73%) are using some form of critical thinking teaching strategy to prepare Ph.D. students. This indicates that technology education pre-service teachers will have the necessary skills to improve K-12 development in STEM education.

Although a small percentage of respondents (23%) believed doctoral students should not be developing teaching strategies, nearly ten of thirteen (77%) respondents agreed the integrative approach was the best way to improving learners in STEM.

Research Question 3*, Determine sample course requirements to learn if universities are integrating STEM concepts into their technology education Ph.D. and Ed.D. programs?* The research discovered the majority (60%) of respondents spend less than 20% of their doctoral program on STEM. This indicates that STEM is only included in their doctoral program if the doctoral candidates is conducting research in a STEM specific area. However, 30% of the respondents do include STEM concepts into their programs. These courses consisted of three or more STEM related courses. Clearly, this indicates that the philosophies of the different universities and the location of the technology education program influence what courses are taught in STEM and what types of research is conducted in STEM. For example, EDD Workforce Education is engineering and technology focused course taught in the College of Engineering and Technology whereas STEM Education Foundation is pedagogy focused course taught in the School of Education. Clearly, both courses teach STEM concepts however the degree of whether it is pedagogy focused or engineering focused is dependent on where the course is taught.

Research Question 4*, Determine if doctoral granting institutions are collaborating with local school systems to make STEM integration a reality?* The researcher discovered that 62% of the respondents are actively collaborating with the local K-12 schools. Moreover, 46% of the respondents do not believe that collaborating with local school helps developed doctoral students. This indicates that the population believes collaborating with local schools is helpful for the students. Additional, 61% of the respondents indicated that research and pre-service training are the majority of the collaborations going on in the local schools. This indicates that both students in K-12 and doctoral students gain specific knowledge in these collaboration efforts.

Research Question 5, *Determine what needs to occur in the future to incorporate STEM concepts into technology education graduate programs?* The researcher determined the respondents all have different opinions on what needs to occur with incorporating STEM into the technology education graduate programs. However, all agree that collaboration will lead to success. For example, researchers from the different disciplines of STEM need to align themselves to conduct joint projects. This would remove some of the confusion that already exists with what STEM consist of and help refine some of the research strategies already developed. Also, K-12 teachers need to be involved in research studies and aligning themselves with the other disciplines of STEM education. All the recommendations of the respondents were based on blending the STEM efforts with other disciplines.

Recommendations

This study was performed to determine what other institutions were accomplishing in their doctoral graduate programs related to STEM. The data indicated that most universities had a different approach on how they perceived the integrative approach to STEM education. Based on the results and conclusions of this study, the following recommendations were made:

- Collaborative efforts between the different STEM fields need to occur to develop the integrative approach. Joint research efforts need to be conducted in STEM fields instead of stove piping the different STEM fields. These efforts will ensure when someone is referring to STEM, everyone will be able to know what they mean.
- Universities that only conduct STEM through research studies need to realign their programs to include STEM concepts and teaching strategies because these future doctoral students will be teaching pre-service technology education teachers. A well prepared community of future teachers is central to the development of STEM educated force (National Research Council, 2002).
- All classes K-20 needs to include STEM integration in both discussion and coursework. This will enable STEM to be standardized in both the educational classroom and governmental policies.
- Further research study is needed on where technology education resides at the collegiate level. Is the school of education or school of engineering the correct answer? The correct answer is the one that will benefit the K-12 students of the future.

- Further research study needs to be undertaken to determine if science, technology, mathematics, and engineering Ph.D. granting institutions have integrated STEM concepts into their graduate programs.

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APPENDIX A

List of Universities

Table 14

List of Universities

University	Location	Doctoral Program	
		Ph.D.	Ed.D.
Aix-Marseille	France	X	
British Columbia	Canada	X	X
Colorado State	United States	X	
Delft	The Netherlands	X	
Edith Cowan	Australia	X	X
Georgia	United States	X	X
Griffith	Australia	X	X
Illinois	United States	X	
Iowa State	United States	X	
Johannesburg	South Africa	X	
North Carolina State	United States		X
Ohio State	United States	X	
Old Dominion	United States	X	
Purdue	United States	X	
Stockholm	Sweden	X	
Utah State	United States	X	X
Virginia Tech	United States	X	X

Note. Universities, n=17

APPENDIX B

Survey Questions

Impacts of the STEM Education Movement on Technology Education Ph.D. Graduate Programs

Purpose: The purpose of this research is to determine the impacts of the STEM education movements on technology education Ph.D. graduate programs. This survey is designed to identify the different ways other technology education Ph.D. granting institutions have integrated STEM concepts into their graduate programs. Participation is voluntary and the information you provide will be kept confidential.

Directions: Please darken the circle that indicates your selection or write-in your answer as appropriate. Each questionnaire item includes an area to provide further comments.

1. Is the concept of STEM Education (Science, technology, engineering, and mathematics) influencing the development of your technology education graduate programs?
   - o Very High
   - o High
   - o Moderate
   - o Low
   - o Very Low

2. How would you rate your program's current work with incorporating STEM concepts and activities?
   - o Very High
   - o High
   - o Moderate
   - o Low
   - o Very Low

3. What is your professional opinion regarding the integration of STEM education concepts into your doctoral program?
   Responses:
   ____
   ____
   ____
   ____
   ____
   ____

4. What changes do you recommend to increase the awareness level of STEM integration in your preparatory and graduate education program?
   Responses:
   ____
   ____
   ____
   ____
   ____
   ____

5. Are you incorporating new curriculum and instructional approaches so your students learn about STEM strategies?
   - Less than 10%
   - 10% to 20%
   - 20% to 30%
   - 30% to 40%
   - More than 40%

6. Do you believe one of the better ways to improve young students development in STEM education is to use an integrative approach to the subjects'.
   - Very High
   - High
   - Moderate
   - Low
   - Very Low

7. Are doctoral students gaining the necessary teaching strategies and skills to effectively integrate these into their future work in technology education teacher preparation program?
    - Very High
    - High
    - Moderate
    - Low
    - Very Low

8. Select the responses that most accurately describes your teaching strategies that your program curriculum employs to teach STEM:

    - Problem Base Learning
    - Inquiry Base Learning
    - Project Base Learning
    - Lectured Based
    - None of the Above

9. What percentage of your doctoral program is designed specifically to address STEM?
    - Less than 10%
    - 10% to 20%
    - 20% to 30%
    - 30% to 40%
    - More than 40%

    How many courses does this include? _______

10. List the number and title of doctoral program courses that are specifically designed to integrate the different STEM education concepts?
    Responses:
    ____
    ____
    ____
    ____
    ____
    ____

11. What is your professional opinion regarding the collaboration with local K-12 school systems to improve your doctoral programs experiments with STEM?
    - Very High
    - High
    - Moderate
    - Low
    - Very Low

12. Does your program actively collaborate with the local school system to incorporate STEM integration?
    - Yes
    - No

13. If yes, what are some examples where your students have worked with K-12 school systems for implementing STEM integration?
    Responses:
    ____
    ____
    ____
    ____
    ____
    ____

14. What changes needs to occur to effectively incorporate the STEM concepts into your technology education graduate programs?
    Responses:
    ____
    ____
    ____
    ____
    ____
    ____

APPENDIX C

Sample Cover Letter

May 16, 2010

<<Title>> <<Firstname>> <<Lastname>>

<<Address1>>

<<Address2>>

<<City>>, <<State>> <<Zip>>

Dear <<Greeting Line>>

You are asked to participate in a research study to determine the impacts of the STEM education movement on technology education based Ph.D. graduate programs. The advancement of the technology education teacher preparatory programs may be dependent on how well the technology education Ph.D. community can effectively integrate STEM education concepts into their programs. This survey is designed to capsulate the different ways other institutions have or may plan to integrate STEM concepts into their graduate programs.

Enclosed you will find a questionnaire that includes both open-form and closed-form questions. Your participation is crucial to the success of this study, so I urge you to participate and complete the attach survey. A high response rate is imperative to accurately identify what other Ph.D. graduate programs are using to increase STEM integration. However, participation in this study is strictly voluntary and all responses will be treated in confidence..

After collecting and processing all the necessary data, all electronic mail and other correspondence will be deleted. The collected data will be reported as aggregated information, so institutions will not be identified without further permission from you. Completing this questionnaire should require about 10 minutes of your time. Your participation in this survey indicates that you've been informed of the purpose of the study and your role, and allow the researcher to use your responses in this study. Please accept our personal thank you for taking the time to answer and return the questionnaire.

Once again, all survey data will be held in strict confidence by the researchers. Please return the questionnaire via electronic mail to kupch001@odu.edu by <<Date>>. Thank you in advance for your cooperation and support of this research study.

Sincerely,

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