Key Factors Affecting the Implementation of Biotechnology Instruction in Secondary School Level Technology Education Classrooms

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(ABSTRACT)

The growing impact of biotechnology globally and nationally over the past few decades has prompted the need for elevating general biotechnological literacy levels in all populations. This need is currently being addressed through the field of technology education (TE). Although included in the Standards for Technological Literacy (ITEA, 2000), the actual delivery of biotechnology instruction in TE classrooms has not realized broad implementation. Previous studies have recognized this issue and called for systematic research to identify key factors affecting the implementation of biotechnology instruction in secondary school level TE classrooms.

The purpose of this study is to identify the key factors affecting the implementation of biotechnology instruction in secondary level TE classrooms and establish predictive values for the identified factors. This study, which employs a research design grounded in both Rogers' Diffusion Theory (2003) and Eccles Expectancy-Value Theory (2005), was conducted to address this implementation issue. This study involved the administration of a composite on-line instrument to collect demographic, attitudinal, motivational, and open-ended data related to the phenomena under investigation. Data collected from the on-line composite survey were analyzed through statistical (descriptive, independent *t*-tests, correlations, hierarchical multiple regressions) and thematic analysis.

A total of 395 secondary school TE teachers across the five selected states (Virginia, New York, Connecticut, New Jersey, and Pennsylvania) participated in this study.

Analyses of the data led to the following conclusions. Insufficient implementation and preparation toward teaching biotechnology presented in this study are consistent with the low level of implementation of biotechnology instruction in TE classrooms revealed through prior studies. In addition, TE teachers' motivation (expectancy, value, and cost), their preparation (pre-service courses and/or in-service PD), and infrastructure are all significant predictors for the implementation of biotechnology instruction. Thus, it is necessary for the TE teachers to have a variety of opportunities and support for developing their self-belief toward teaching biotechnology and experiencing the usefulness and importance of teaching biotechnology. The findings and conclusions drawn from the data analysis provide implications to the TE teachers and pre-service teacher preparation institutes.

DEDICATION

To my father, *Ohyun Kwon,* who instilled the value of faith and perseverance in me. Rest in Peace, father.

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"*Those who sowed in tears have reaped their joy*". The successful completion of my dissertation is a joyful reaping in my life. It would not have been possible without the cooperation and support of many people. I would like to sincerely share this joyful accomplishment with each of those individuals for their grateful support and encouragement over the past fifteen years that led to my entering the field of technology education and completing this dissertation.

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CHAPTER ONE: INTRODUCTION

From the latest advances in genetic engineering to the foods and fuels that sustain and improve the quality of our everyday lives, biotechnology is an integral part of fields such as food, energy, environment, and health. Biotechnology has been a part of human history for thousands of years and is perceived as an indicator of prosperity and development.

Etymologically, biotechnology means “the study of tools from living things”, combining the Greek words “bio” (living organism or life), “techno” (art, skill, system or tool), and “logos” (speech, study of) (Wells, 1999a, 2007, 2008; Wells & Kwon, 2008, p. 316). Today, the most widely accepted operational definition of biotechnology at the secondary education level is,

> any technique that uses living organism (or parts of organism) to make or modify products, improve plants or animals, or to develop micro-organisms for specific uses. (Office of Technology Assessment (OTA), 1984, 1988, 1991; Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), 1992, 1993; Wells, 1992, 1994, 1995; 1999a, 1999b, 2007, 2008; International Technology Education Association (ITEA), 1996, 2000; Wells & Kwon, 2008)

Modern biotechnology is central to human innovation and our future. Generally, promoters of biotechnology have focused on increasing public awareness related to the benefits and impacts of biotechnology through the educational process (Project 2061 Panel report, 1989; Wells, 1992, 1994). The educational community at large and specific fields of education such as technology education (Savage & Sterry, 1990; Wells, 1992, 1994; ITEA, 2000), science education (Leslie & Schibeci, 2003; Steele & Aubusson, 2004), and agriculture education (Wilson, Kirby, & Flower, 2000) are very aware of the importance and need for teaching biotechnology content at the secondary level.

As part of the growing effort to assist students in becoming technologically literate, biotechnology is now included as a content area of technology education (Savage & Sterry, 1990; Wells, 1992, 1994; ITEA, 1996, 2000, 2002). Specifically, technology education recognizes biotechnology as a major content organizer that should be taught as part of any technology education program. Initial efforts to integrate biotechnology into technology education suggested it should be treated as a fourth and equal content organizer alongside transportation, production, and communication, as presented in *A Conceptual Framework for Technology Education* (Savage & Sterry, 1990). For nearly two decades, technology education organizations have worked to establish a background for biotechnology education in technology education programs (Wells, 1992, 1994; ITEA, 1996, 2000), but compared to most content organizers for technology education, biotechnology remains a relatively new content organizer (Russell, 2003; Wells & Kwon, 2008).

Although widely recognized as a content organizer in the field of technology education and included in the Standards for Technological Literacy (ITEA, 2000), the actual teaching of biotechnology has not yet been broadly implemented in the nation's technology education classes

(Brown, Kemp, & Hall, 1998; Sanders, 2001; Russell, 2003). Although several studies have emphasized the need for teacher professional development to be associated with biotechnology instruction at both the pre-service and in-service levels, the reasons why it is not being taught to a greater extent in technology education classes remain unclear (Brown et al., 1998; Dunham, Wells, & White, 2002; Scott, Washer, & Wright, 2006). However, Brown et al. (1998) did indicate that outside factors such as school setting, and the availability of appropriate laboratories and related administrative support were probably at least partially responsible. Wells and Kwon (2008) pointed out that teachers' misconceptions regarding the field and their consequent lack of confidence in the material likely resulted from insufficient professional development of the type necessary for teaching biotechnology content.

In response to the heightened awareness of its growing significance in society, biotechnology has been an accepted content area in technology education for nearly two decades. Yet, in spite of continuous efforts to incorporate biotechnology in technology education programs, it has not yet been broadly implemented in technology education classrooms. As was alluded to in the prior studies outlined above, reasons for this may be attributed to insufficient opportunities for the professional development of technology teachers, inadequate school and administrative support systems, and teachers' many misconceptions related to biotechnology. However, to data no empirical evidence has been presented to verify or refute the influence of these variables.

Need for the Study

In spite of the many background studies supporting the inclusion of biotechnology in technology education (Savage & Sterry, 1990; Wells, 1992, 1994; ITEA, 1996, 2000, 2002), there has been little empirical research conducted in technology education to identify those key factors preventing the large scale adoption of biotechnology instruction in technology education classes. Although the technology education community has long recognized the significance and value of biotechnology and included biotechnology content for technology education, the implementation of biotechnology instruction in classrooms has failed to match this recognition.

Several previous studies have suggested possible barriers that hinder the implementation of biotechnology instruction (Brown et al., 1998; Daugherty, 2005; Rogers, 1996; Scott et al., 2006). For example, Rogers (1996) and Daugherty (2005) highlighted the shortage of biotechnology content in technology teachers' pre-service preparation. Although these studies were conducted almost a decade apart, their findings regarding the inclusion of biotechnology instruction in technology teacher education were very similar, suggesting little progress has been made. Brown et al. (1998) agreed, suggesting that additional professional development and better support systems should be provided for technology teachers to increase the implementation of biotechnology instruction as part of an effort to address the problem of the poor implementation of biotechnology instruction in Kentucky. However, all these studies focused primarily on diagnosing the current status of biotechnology instruction in technology education and concluded that there was a need for further studies to identify the factors that affect the implementation of biotechnology instruction.

Research to assess the reasons and extent to which biotechnology instruction has been included in technology education will provide useful data with which to address these issues. The lack of research regarding the precise nature of the barriers impeding the widespread implementation of biotechnology instruction in secondary technology education thus provides the motivation for this study.

Purpose of Study

The purpose of this study is to identify the key factors affecting the implementation of biotechnology instruction in secondary level Technology Education program and establish predictive values for the identified factors. This research is intended to provide a rationale for pre-service and in-service professional development in terms of biotechnology instruction.

Research Questions

This study is directed by the following research question and sub-questions:

1. What predictive values do the identified key factors that affect the implementation of

biotechnology instruction in secondary school level technology education classrooms?

The data were collected through focusing on the following set of sub-questions.

1. How do motivational constructs of technology education teachers affect the implementation of biotechnology instruction in their secondary school level technology education classrooms?
2. How does the preparation (pre-service and in-service professional development) of technology education teachers affect their decision to implement biotechnology instruction in their secondary school level technology education classrooms?
3. How does the infrastructure (local, state, and national level) supporting technology education programs affect technology education teachers' implementation of biotechnology instruction in their secondary school level technology education classrooms?

Delimitations

Participants in this study were drawn from secondary school level technology education teachers practicing in five eastern seaboard states. As prior studies (Rogers, 1996; Sanders, 2001) pointed out, the implementation of biotechnology instruction in secondary technology education classrooms has been generally poor. Also, the distribution of the technology education teachers in many states is skewed regarding the implementation of biotechnology instruction. In order to obtain a reasonable sample, a convenience sample of five eastern seaboard states that have had *Technology Education Biotechnology Curriculum* (TEBC) professional development were selected to participate in this study.

Limitations

The study sample was recruited from the listservs that the state *Career Technical Education/Technology Education* supervisor or *Technology Education Teachers Association* president/board member managed. Therefore, the sample may not be representative of all the technology education teachers in the United States.

Definitions

Biotechnology

Any technique that uses living organisms (or parts of organisms) to make or modify products, improve plants or animals, or to develop micro-organisms for specific uses (OTA, 1984, 1988, 1991; FCCSET, 1992, 1993; Wells, 1992, 1994, 1995; 1999a, 199b, 2007, 2008; ITEA, 2000; Stotter, 2004; Wells & Kwon, 2008).

Biotechnology Instruction

The delivery of biotechnology content as a major content of the Technology Education program at the secondary level (Dunham et al., 2002).

Cost

“What the individual has to give up to do a task” (Wigfield, Tonks, and Eccles, 2004, p. 172). In particular, it can be conceptualized regarding “the loss of time and energy for other activities” (Eccles, 2005, p. 113).

Expectancy

“Individual’s expected probability for success on a specific task” (Wigfield, Tonks, and Eccles, 2004, p. 167)

Infrastructure

The school support components, including the physical environment provided for education purposes such as the school facilities and capital (Crampton, Thompson, & Vesely, 2004). In this study, school infrastructure indicates a comprehensive component supporting the implementation of biotechnology instruction.

Innovation

“An idea, practice, or object that is perceived as new by an individual or other unit of adoption” (Rogers, 2003, p. 12). The innovation in this study is the implementation of biotechnology instruction for technology education programs at the secondary level.

Innovation-decision process

"The process through which an individual (or other decision-making unit) passes from gaining initial knowledge of an innovation, to forming an attitude toward the innovation, to making a decision to adopt or reject" (Rogers, 2003, p. 168).

Professional development

"A continuous process of lifelong learning and growth that begins early in life, continues through the undergraduate, pre-service experience, and extends through the in-service years" (ITEA, 2003, p. 140).

Technological literacy

"The ability to use, manage, assess, and understand technology" (ITEA, 2000, p. 9)

Technology education

"A school subject specifically designed to help students develop technological literacy" (ITEA, 2003, p. 142)

Technology education teacher

A teacher currently teaching technology education courses at the secondary school level.

Value

"A set of stable, general beliefs about what is desirable and a class of motives that affect behavior by influencing the attractiveness of different possible goals and thus the motivation to attain the goals" (Wigfield et al., 2004, p. 168)

CHAPTER TWO: LITERATURE REVIEW

The development of an appropriate research design for this study requires a through understanding of the breadth of key factors that have the potential to influence the implementation of biotechnology. Therefore, presented in this chapter is a review of the literature associated with the key factors highlighted in the research questions guiding this study. Each key factor is discussed independently in the following three sections: Biotechnology in Technology Education, Factors Affecting the Implementation of Biotechnology Instruction, and Relevant Research Methods.

Section one addresses the definition of biotechnology, its evolution and the challenges involved in integrating biotechnology instruction into technology education, and the incorporation of biotechnology into other subjects such as science education and agricultural education. Section two investigates the myriad factors that may affect the classroom implementation of curricula in general, followed by a closer look at those particular factors that could affect the implementation of biotechnology instruction in technology education classroom specifically. The final section in this review of the literature highlights those research methodologies that have been found to be best suited to studying this type of phenomena.

Biotechnology in Technology Education

Biotechnology

Biotechnology is a major potential source of valuable research in support of improving the human condition. It has been a pervasive influence driving advances in health and agriculture throughout human history and the technology currently being developed will be strongly associated with the future development of our global society. As a result of its pervasiveness, the term biotechnology is often used as a broad concept by many industries, or even in inappropriate contexts presented through the media (Wells, 1995). Etymologically, biotechnology means "the study of tools from living things", which is a combination of the Greek words of "*bio*" (living organism or life), "*techno*" (art, skill, system or tool), and "*logos*" (speech or study of) (Wells, 199a, 2007, 2008; Wells & Kwon, 2008, p. 316). Confusion surrounding the definition of biotechnology was addressed by the Office of Technology Assessment (OTA, 1988) and found to be the result of wide variations in definitions used by the many biotechnology industries. Reports by the OTA in both 1988 and 1991 emphasized the rationale and need for a careful definition of biotechnology, reaching a consensus on the following definition:

> … any technique that uses living organisms (or parts of organisms) to make or modify products, improve plants or animals, or to develop micro-organisms for specific uses (OTA, 1988, 1991).

National acceptance of this definition was demonstrated in the report entitled

Biotechnology for the 21st Century (1992, 1993) prepared by the Committee on Life Sciences and Health (CLSH) of the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET). Furthermore, Wells (1992) provided a strong rationale for adopting this definition of biotechnology as one appropriate for the content that should be addressed by the technology education field at the secondary school level, and one recognized and accepted by other disciplines.

Having achieved consensus at the national level, and with a rationale established for its adoption by the field of technology education, the definition was adopted by *Technology for All Americans: A Rationale and Structure for the Study of Technology* (ITEA, 1996) and *Standards for Technological Literacy*: *Content for the Study of Technology* (ITEA, 2000). It is equally important to note that this definition was not only adopted by the Technology Education profession, but also by science educators (e.g. in the biological sciences) and agriculture educators (ITEA, 2000; Stotter, 2004; Wells, 1992, 1994, 1995; Wells & Kwon, 2008).

Growth of Biotechnology Literacy

The application and development of biotechnology is not at all new. Humankind has purposefully utilized living organisms (or parts of organisms) for thousands of years, though for most of that time without any real understanding of the science involved (Wells, 1992, 1994). The manufacture of fermented foods such as beer, bread, and cheese with no true understanding of the underlying science is considered *traditional or classic* biotechnology (OTA, 1988; Project 2061 Panel Report, 1989; Wells, 1992, 1994) because it is based solely on experience and/or tradition. The discovery of the chemical structure of deoxyribonucleic acid (DNA) by Watson and Crick in the early 1950s provided scientists with the beginnings of a molecular understanding of cellular processes, which Wells (1992, 1994) described as *modern* biotechnology. Today, modern biotechnology techniques are utilized extensively by industries and have affected human life in both positive and negative ways. The increasing growth and awareness of modern biotechnology has provided society with the tools needed to deal with some enormous problems confronting humankind. The impact of biotechnology continues to be progressive and increasingly pervasive in every aspect of our daily life. These trends will require better informed citizens with specific education, skills, and attitudes regarding the development and use of biotechnology (Wells, 1992, 1994). To address this growing need, professionals in both science and technology have recognized that biotechnology education is necessary for all students to achieve an acceptable level of general technological literacy (Project 2061 Panel Report, 1989; ITEA, 2000). The precursor to good biotechnology education is the identification of content, followed by the development of suitable curricula that can then be used to guide the design of instruction for the secondary school level.

Biotechnology Content in Technology Education

Contemporary technology education evolved from the curricula of manual arts, manual training, and industrial arts. Curricula developed in the decades preceding the beginning of the twentieth century emphasized tool skills, particularly drawing, woodworking, and metal working (Wright, 1995). In the 1880s and 1890s a consensus was reached that manual training should be integrated into both public education systems and society as a whole (Stotter, 2004). In an effort to present content based on Technology Education, Warner's 1947 publication, *A Curriculum to Reflect Technology*, suggested that the major subject areas should be power, transportation, manufacture, construction, communication, and personnel management. Two decades later, Towers, Lux, and Ray (1966) developed the Industrial Arts Curriculum Project (IACP) at The Ohio State University. IACP categorized human knowledge into four domains, namely formal, descriptive, prescriptive, and praxiological, and organized the subject matter around manufacturing and construction. At the same time DeVore (1966) suggested that technology content areas be organized around production, transportation, and communication.

In 1981 a curriculum effort launched by the committee of the American Industrial Arts Association produced a document known as the *Jackson's Mill Industrial Arts Curriculum Theory* which affected the direction of future curriculum development in the profession (Snyder & Hales, 1981). This was a significant effort to draw content for Industrial Arts based on human adaptive behavior and human technical endeavors which exist to extend human potential. It describes the subsystems of the human technical endeavor as follows:

> Each of these subsystems represents a discrete human endeavor which can be studied in isolation. For example, throughout history people have manufactured goods, constructed structures, communicated ideas, and transported goods and people. (p. 23)

This new perspective on content organizers for industrial arts (IA) was based on systems knowledge, and organized around communication, construction, manufacturing, and transportation (Snyder & Hales, 1981). Though there was a significant effort to change content for technology education, the emerging technological field of biotechnology was not yet included as a major content organizer for the Technology Education curriculum. In the 1980s a group of key individuals in the IA field advocated changing the name of the profession to Technology Education to better reflect the technological world. As a result, the American Industrial Arts Association (AIAA) made the decision in 1985 to change their name to the International Technology Education Association (ITEA). In the new era of Technology Education, curricular efforts endeavored to include the broadest possible scope of modern technology (ITEA, 1996, 2000, 2006; Savage & Sterry, 1990; Wells, 1992, 1994).

In their document *A Conceptual Framework for Technology Education*, Savage and Sterry (1991) provided a theoretical framework for technology education by incorporating the concept of technological systems, which for the first time suggested the inclusion of biotechnology content into the technology education curricula. Though using the contrived term "bio-related technology," biotechnology had emerged as a content organizer for technology education alongside communication, production, and transportation. The new framework was based on the concept of technology being a human endeavor first presented in the Jackson' Mill Industrial Arts Curriculum Theory (Snyder & Hale, 1981).

Wells (1992) established a taxonometric structure for the study of biotechnology in response to the lack of an identified curriculum structure that could include biotechnology at the secondary school level. Using a Delphi panel comprised of experts from across disciplines and agencies involved in biotechnology, he identified eight main biotechnology knowledge areas and eighty-four subdivisions for biotechnology at the secondary school level. This 1992 study was the seminal research that determined the specific biotechnology content that would be included in Technology Education. Based on this taxonomy, Wells (1994) developed the Technology Education Biotechnology Curriculum (Biosens, 2000) organized around eight biotechnology knowledge areas and their forty content sub-categories (Table 1).

Table 1

TEBC Biotechnology Knowledge Areas and Content Sub-Categories (Biosens, 2000)

Foundations of Biotechnology	**Genetic Engineering**
Defining Biotechnology	Probing Techniques
Historical Background	Genetic Engineering Applications
Relevant Terms	Genetic Code
Career Information	Molecular Biological Techniques
Social Impact	Analysis of DNA
Environment	**Biochemistry**
Bioremediation	Enzymology
Biological Controls	Control and Regulation
Biotreatment Systems	Proteins
Biorestoration	Methods of Analysis
Environmental Satefy	Carbohydrates
Agriculture	**Medicine**
Tissue culturing	Molecular Medicine
Plant/Animal Applications	Immunology
Agrichemicals	Genetic Therapeutics
Aquaculture	Health Care
Plant Science	Social Impact
Bioprocessing	**Bioethics**
Fermentation	Principles of Ethics
Bio-products	Impacts of Biotechnology
Microbial Applications	Potentials of Genetics
Separation/Purification	Patenting of Life
Processing Design	Forensics

The most recent and significant support for the inclusion of biotechnology content into Technology Education was in *Technology for all Americans,* published by ITEA (1996). To identify a rationale and structure for the study of technology, the *Technology for All Americans* project was reviewed by hundreds of practitioners of technology, science, engineering, mathematics, and other areas at all levels. It presented biological systems alongside informational and physical systems, identifying them as the context for technological literacy. Emphasizing the power and promise of technology, the report described the importance of biotechnological developments thus:

> There is truth in all of these views, for technology is created, managed, and used by societies and individuals, according to their goals and values. For example, biotechnological developments can eradicate a plague or cause one. (ITEA, 1996, p. 3)

Based on this earlier work, in 2000 ITEA released the *Standards for Technological Literacy: Content for the Study of Technology (STL)*. The new STL (ITEA, 2000) identified content standards for the study of technology and established benchmarks for technological literacy. The STL used five categories of standards to structure the study of technology, namely "The Nature of Technology, Technology and Society, Design, Abilities for a Technological World, and The Designed World" (p. 14). Although the content directly related to biotechnology is included within Standard 15: Agricultural and Related Biotechnologies, it is clearly embedded across all five categories of the standards. The benchmarks for Standard 15 are presented by grade levels (K-2, 3-5, 6-8, and 9-12) and provide general indicators for broad biotechnology enduring concepts (Wells, 2007, 2008; Wells & Kwon, 2008), as shown in Table 2.

Table 2

Enduring Biotechnology Concepts in Standard 15 of the STL

Grade Level	Biotechnology Enduring Concepts
Grades K-2	- Living things depend on air
	- Ecosystems are collections of organisms
Grades 3-5	- Artificial ecosystems are human-made environments
	- Bio-fuels can be made from recycled wastes
Grades 6-8	- Living things are manipulated to make/improve products
	- Biological principals are used to create products/processes
Grades 9-12	- Applications in most fields (agriculture, food, medicine, energy, etc.)
	- Design wastes management systems using microorganisms
	- Environmental/Societal impacts of artificial ecosystems.

Throughout the evolution of technology education, content organizers have changed in response to technological innovations. Such a response is seen in the recognition by those shaping the field of technology education of biotechnology as a content area that should be taught in the technology education program. Initial efforts to include biotechnology in the field of technology education suggested it be a fourth and equal content organizer along side transportation, production, and communication (Savage & Sterry, 1990; Wells, 1992). And since that time technology education profession has continued its efforts to include biotechnology as a content area of technology education (Wells, 1994; ITEA, 1996, 2000, 2002). The key publications that include biotechnology as a content organizer are presented in Table 3.

Table 3

Key Publications That Include Biotechnology in Technology Education

Key Publication	Content Organizers
A Conceptual Framework for Technology Education (Savage & Sterry, 1990)	Communication, Production, Transportation, Bio-related
Establishment of a Taxonometric Structure for the Study of Biotechnology as a Secondary School Component of Technology Education (Wells, 1992)	Communication, Production, Transportation, Biotechnology
Technology for All Americans (ITEA, 1996)	Biological Systems, Informational Systems, Physical Systems
Standards for Technological Literacy (ITEA, 2000)	The Nature of Technology, Technology and Society, Design, Abilities for a Technological World, The Designed World

Biotechnology Instruction in Technology Education Classes

The steady efforts by Savage and Sterry (1990), Wells (1992), and the ITEA (1996, 2000, 2006) have provided a coherent theoretical basis for the inclusion of biotechnology content into technology education. Having on this theoretical foundation, this section investigates the literature associated with biotechnology instruction for technology education programs at the secondary school level.

The first reported effort to identify the status of biotechnology instruction in technology education was undertaken by Brown (1995), who conducted a descriptive study of technology education programs in secondary schools in the United States. Brown (1995) employed a stratified sample of 100 teachers from those who taught biotechnology in each state and investigated the program name, instruction approach, and teachers' demographic information. Brown (1995) concluded that although biotechnology was included as a content organizer for technology education, instruction in biotechnology was still a novelty in technology education programs. Three years later, Kentucky teachers' perceptions concerning biotechnology content and its instruction were surveyed by Brown, Kemp, and Hall (1998), who reported that relatively little progress had been made toward implementation of biotechnology instruction at the secondary level in the state and there was a need for teacher training with respect to biotechnology instruction at both the in-service and pre-service levels and teachers suffered from a lack of relevant systems for supporting biotechnology instruction. The researchers also noted that the teachers who participated in the study perceived biotechnology to be an interdisciplinary topic that included science, technology, and agricultural science.

As Brown et al. (1998) reported, and other research supports (Dunham et al., 2002; Haynie & Greenburg, 2001; Wells, Pinder, & Smith, 1992), biotechnology instruction is indeed inherently interdisciplinary and requires a suitable support system that allows for this. Even though biotechnology instruction is taught in technology education classes, it is often perceived to require close collaborations with teachers from other disciplines. Wells, Pinder, and Smith (1992) described a variety of projects that could be used to teach biotechnical concepts and applications, emphasizing an approach based on design activities for teaching biotechnology through technology education programs. Furthermore, ten years later, Dunham, Wells,, and White (2002) presented more detailed explanations for the implementation of biotechnology instruction through procedural descriptions of biotechnology activities, offering clear examples for teaching biotechnology in secondary technology education classes and emphasizing the integrative components necessary for implementing biotechnology instruction. Haynie and Greenburg (2001) took the stance for recommending that technology teachers use an integrative approach and collaborate with teachers from other disciplines to implement biotechnology instruction.

Several studies have indicated a growing need for better implementation of biotechnology instruction (Brown et al., 1998; Daugherty, 2005; Haynie & Greenburg, 2001; Russell, 2003; Sanders, 2001; Scott et al., 2006). In addition, the emergence of new technology education standards, accreditation requirements for technology teachers, and technological advancements have served to highlight the need to enhance technology teachers' professional development regarding biotechnology instruction. Recognizing this, Daugherty (2005) investigated the degree of technology teacher educators' support for the guidelines in *Standards for Technological Literacy* (STL) (ITEA, 2000) and *Advancing Excellence in Technological Literacy* (AETL) (ITEA, 2003) to identify whether or not there was a need to modify existing undergraduate technology teacher education. The survey results concerning the twenty STL standards showed that core concepts related to agriculture and related biotechnologies received the lowest mean scores, indicating the low perceived status of agriculture and related biotechnologies in technology teacher education compared to other technologies. Daugherty's (2005) results concerning support for change indicated that the survey participants felt there was a strong need for major changes in technology teacher education, which they considered should be more willing to adopt new technologies and stood in urgent need of new standards. Concurrent with these results, Scott et al. (2006) examined the biotechnology competencies for first-year/initially certified technology education teachers, suggesting that to facilitate the implementation of biotechnology instruction in technology education, technology teachers should be adequately prepared to deliver biotechnology content along with the corresponding competencies. Unfortunately, most of the technology teacher education programs examined by researchers failed to include any biotechnology content (Daugherty, 2005; Rogers, 1996; Russell, 2003; Scott et al., 2006).

The lack of suitable infrastructure is another factor that has been shown to hamper the implementation of biotechnology instruction (Brown et al., 1998; Haynie & Greenburg, 2001). Brown et al. (1998) suggested that school environment issues such as the provision of laboratory equipment and support for the development of instructional materials were critical elements for incorporating biotechnology content into secondary school classes. In the same context, Haynie and Greenburg (2001) indicated that there were several reasons for insufficient attention to biotechnology instruction, highlighting the lack of technology teachers' knowledge and skills regarding biotechnology, insufficient school equipment and supplies, and the scarcity of curriculum resources and vendors in this area.

Despite the ongoing effort to provide better support for biotechnology instruction within technology education, the initial findings of researchers (Brown, 1995; Brown et al., 1998) seeking to identify the implementation level of biotechnology instruction for technology education indicated that biotechnology instruction was not routinely included in technology education programs. This situation has not improved, and the implementation of biotechnology instruction in technology teacher education remains relatively rare (Rogers, 1996; Russell, 2003; Scott et al., 2006). Previous studies have speculated on the reasons for this, suggesting possible barriers preventing the implementation of biotechnology instruction (Rogers, 1996; Brown et al., 1998; Daugherty, 2005; Scott et al., 2006) and advocating the need for professional development and infrastructure to support biotechnology instruction in technology education programs. However, there have been no reports of studies that have focused primarily on identifying the factors that have led to this low implementation level of biotechnology instruction in technology education.

Biotechnology Instruction in Other Subjects

The widespread recognition of the importance of secondary level biotechnology instruction has prompted many countries around the world to incorporate biotechnology content into their school curricula (Saez, Nino, & Carretero, 2008; Wells & Kwon, 2008) and biotechnology education is an integral part of a number of science curriculum frameworks (Corner, 2000; Dawson, 2007; Solomon, 2001; Steele & Aubusson, 2004). Professional science educators have endeavored to incorporate biotechnology content which impacts our society in many ways into their classrooms. In particular, topics related to genetic engineering and its social impacts are prominent in current research on science education (Dawson, 2007; Gray & Bryce, 2006; Saez et al., 2008). However, Leslie and Schibeci (2006) indicate that at present the implementation of biotechnology instruction in science education is inadequate and that there is a consequent need to encourage teachers to adopt biotechnology in the science curriculum.

According to their survey of 88 science teachers, key barriers to the teaching of biotechnology included the teachers' limited knowledge of content and a lack of resources such as information, laboratory materials, and computer access. Dawson (2007) also highlighted the insufficient and inappropriate implementation of biotechnology instruction in science classrooms. Steele and Aubusson (2004) investigated what the teachers themselves thought were the main obstacles to teaching biotechnology in science education and concluded that biotechnology instruction could be made more interesting to students in secondary schools by including more practical work.

Agricultural education is another major subject area that includes a significant biotechnology component. The increased significance of biotechnology in the agricultural industry has impelled agricultural education to adopt biotechnology content into their classrooms. Wilson et al. (2002) asked agricultural educators about their perceptions regarding a “Biotechnology and Agriscience Research” course. Their results revealed barriers such as a lack of both the teachers’ perceived knowledge and the actual knowledge that they needed to teach biotechnology, insufficient coverage in the teachers’ in-service training, and a shortage of funding and equipment.

There is a common recognition of the growing need to incorporate biotechnology into science and agricultural education, as well as technology education. Both science education and agricultural education have endeavored in recent years to incorporate biotechnology content into their classrooms, but the actual implementation of biotechnology instruction remains insufficient. Several studies (Dawson, 2007; Leslie & Schibeci, 2006; Steele & Aubusson, 2002) have investigated the implementation of biotechnology instruction in the classroom and reported deficiencies in teachers' knowledge, professional development, and the administrative support needed to teach biotechnology (Wilson et al., 2002).

Factors Affecting the Implementation of Biotechnology Instruction

The above review of prior literature highlighted the importance and need to teach biotechnology not only as part of technology education but also in science education and agricultural education. While the literature reviewed in the previous section presented the current status of biotechnology instruction, this section provides the necessary framework to investigate the underlying classroom implementation issues using Rogers' (2003) diffusion of innovations theory and expectancy-value theory. This study seeks to identify key factors affecting the implementation of biotechnology instruction in secondary level technology education program, and also to establish predictive values for the identified factors. As such, Rogers' diffusion of innovation theory and expectancy-value theory will provide a sound framework to examine the implementation of biotechnology classroom instruction as an innovation, and to reveal key factors affecting that innovation.

Rogers's Diffusion of Innovations Theory

The theoretical basis for the diffusion of an innovation has been studied for over 30 years, with one of the most popular theories being that developed by Everett Rogers (2003). His adoption/diffusion theory has now been applied in a variety of disciplines, including political science, public health, communication, technology, and education, to examine change (Ellsworth, 2000). Many educational researchers have argued that using diffusion of innovations as a framework is a particularly effective way to examine the adoption of technology by schools and teachers (Sahin, 2006; Sahin & Thompson, 2006; Schroll, 2007; Yates, 2001).

Rogers defined diffusion as "the process in which an innovation is communicated through certain channels over time among the members of a social system" (2003, p. 5). He depicted diffusion as the process by which an innovation is adopted in our social system and considered that it is made up of four main elements: the innovation itself, the communication channels used to disseminate it, time, and the social system in which it occurs. Rogers went on to describe diffusion as "a special type of communication in which the messages are about a new idea" (2003, p. 6) and outlined two major concepts of newness indicating some degree of uncertainty in the diffusion and uncertainty implying a lack of predictability, structure, and information. Rogers (2003) also suggested that individual innovativeness could explain why some teachers adopt technology at a faster rate than others, dividing potential adopters of an innovation into categories of innovators (2.5%), early adopters (13.5%), early majority (34%), late majority (34%), and laggards (16%) using the bell curve presented in Figure 1. In particular, he considered innovators "active information seekers about new ideas" (p. 22)

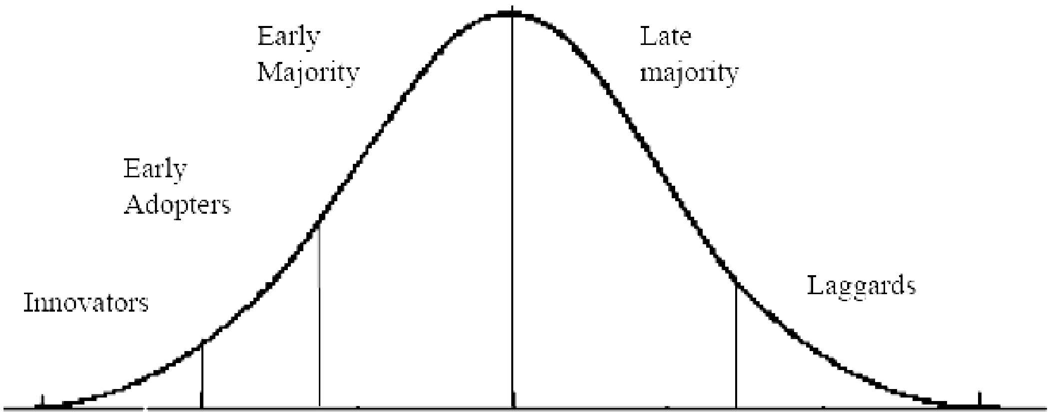

Figure 1. Adopter categorization on the basis of innovativeness (Rogers, 2003)

Rogers described these adopter categories as "the classifications of members of a social system on the basis of innovativeness" (2003, p.22). In each adopter category, individuals have several similar attributes in terms of their innovativeness which he defined as "the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system" (Rogers, 2003, p. 22). This innovativeness concept is very helpful in understanding the desired behavior in an innovation-decision process. Rogers (2003) suggested five basic stages of this decision process, namely knowledge, persuasion, decision, implementation, and confirmation, in terms of the process of diffusion and conceptualized a model of the innovation decision process as presented in Figure 2. The model, as represented in Figure 2, represents a process that occurs over time and consists of a series of different actions, thus emphasizing that the adoption of an innovation is not an instantaneous act (Rogers, 2003). Rogers also defined the innovation-decision process as the process through which an individual (or other decision-making unit) passes from gaining initial knowledge of an innovation, to forming an attitude toward the innovation, to making a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision (Rogers, 2003).

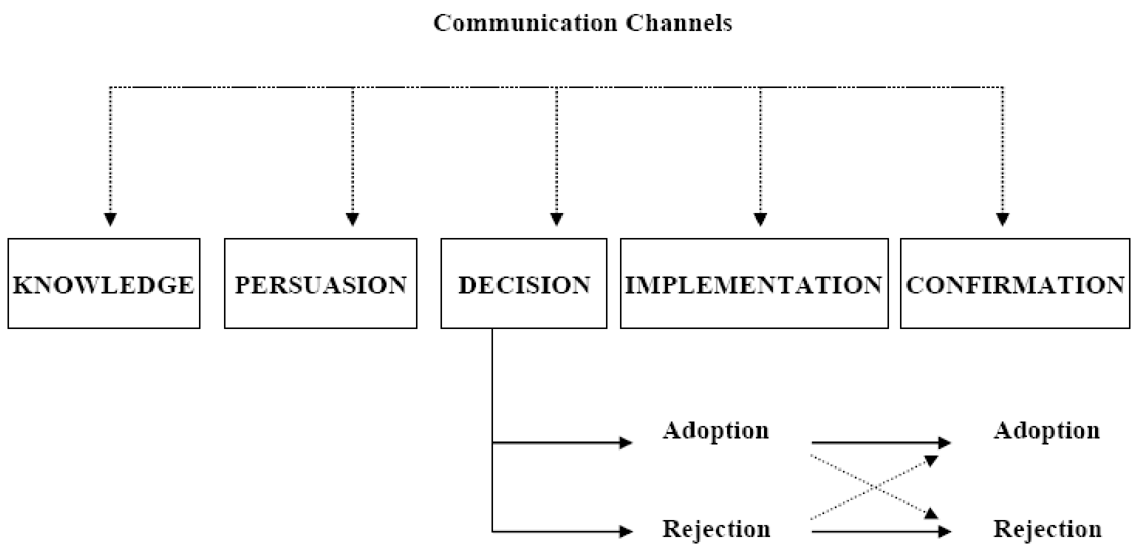

Figure 2. A model of five stages in the innovation-decision process (Rogers, 2003)

Rogers concluded that the factors determining the rate at which adopters moved from one category to a higher one were their awareness, interest, evaluation, trial, and adoption. The idea of perceived attributes is that a potential adopter adopts an innovation based on their perception in five specific areas. These key attributes of an innovation (Table 4) help to explain their different rates of adoption.

Table 4

Perceived Attributes of Innovations in Rogers' Diffusion of Innovation (Rogers, 2003)

Key Attributes	Descriptions
Relative Advantages	"The degree to which an innovation is perceived as better than the idea it supersedes" (p. 15).
Compatibility	"The degree to which an innovation is perceived as being consistent with the existing values, past experiences, and need of potential adopters" (p.15)
Complexity	"The degree to which an innovation is perceived as difficult to understand and use" (p. 16)
Trialability	"The degree to which an innovation may be experimented with on a limited basis" (p. 16)
Observability	"The degree to which the results of an innovation are visible to others" (p. 16)

According to Rogers (2003), although relative advantage may be measured in purely economic terms, other important factors such as social prestige factors, convenience, and satisfaction also play a role. The perceived relative advantage of an innovation will positively affect the rate of adoption. An idea that is both compatible with the values and norms of a social system and simple to understand and use will be rapidly adopted. Good trialability of the innovation also speeds adoption as it reduces the uncertainty for the individual adopter. Synthesizing these perceived attributes of innovations, Rogers reasoned that “individuals as having greater relative advantage, compatibility, trialability, and observability and less complexity will be adopted more rapidly than other innovations” (2003, p. 16).

Rogers’ theory is widely used as a theoretical framework and a meta-theory that relates to the overall concept in the diffusion and adoption of innovations (Sahin, 2006; Sahin & Thompson, 2006; Yates, 2001). A number of studies in the educational field applying Rogers’ adoption/diffusion theory have concentrated on two major concepts, namely the innovation-decision process and the perceived attributes affecting the adoption rate of the innovations (Sahin, 2006). According to Rogers’ theory, the innovation-decision process is based on five distinct stages: knowledge, persuasion, decision, implementation, and confirmation (Rogers, 2003). Potential adopters must learn about the innovation. They must be persuaded to try it by weighing the benefits of the innovation. They must make a decision to adopt the innovation and implement it. Finally, they must confirm if their decision to adopt was appropriate or not. When they decide to adopt an innovation, they take into account five key attributes of the innovation: relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003).

The major concepts of the innovation-decision process and perceived attributes affecting the adoption rate of the innovations described above are used as the framework for this research. These concepts will be used to investigate how teachers are adopting the innovation of biotechnology teaching as part of their technology education programs.

Expectancy-Value Theory

The study of motivation is based on two fundamental questions of “What causes behavior?” and “Why does behavior vary in its intensity?” (Reeve, 2005). These questions have led to theories that explain why people do what they do. Reeve categorized the behavioral expressions of motivation into effort, latency, persistence, choices, probability of response, facial expressions, and bodily gestures, defining the study of motivation as “those processes that give behavior its energy and direction” (2005, p. 6).

The exploration of factors influencing students’ learning has a long history in education and psychology (Green, 2002). However, unlike the many studies into students’ motivation, there has been little research into their teachers’ motivation (Abrami, Poulsen, & Chambers, 2004). The conceptualization of expectancy-value theory has developed from the work of various theorists (Tolman, 1932; Atkinson, 1958; Vroom, 1964). Atkinson (1958) developed the expectancy value model to explain different kinds of behaviors such as striving for success, choice among tasks, and persistence. Building on this work, several theorists have identified the impacts of individual’s expectancy and value beliefs on performance, persistence, and choice through a number of validated works in real world settings (Eccles, 2005; Graham & Taylor, 2002; Wigfield et al., 2004).

Wigfield et al. defined expectancy as an “individual’s expected probability for success on a specific task” (2004, p. 167). An individual’s expectations of success can thus be used to predict their educational, vocational, and other achievement related choices (Eccles, 2005; Wigfield et al., 2004). Graham and Taylor described an individual’s value as “attractiveness or usefulness” (2002, p. 122) regarding a specific activity and Wigfield et al. defined it as “a set of stable, general beliefs about what is desirable… [and]… a class of motives that affect behavior by influencing the attractiveness of different possible goals and thus the motivation to attain the goals” (2004, p. 168). Personal values directly influence performance, activity choice, and participation (Eccles, 2005).

Abrami, Poulsen, and Chambers (2004) used the expectancy-value theory to model the diverse issues that affect a teacher’s decision to implement cooperative learning as an educational innovation. They concluded that an education innovation is more likely to be implemented if teachers have a high value and likelihood of the innovation. In other words, the expectancy and value that teachers have regarding the innovation affect their decision whether or not to implement an educational innovation. The personal values that they measured included benefits to both teachers (congruence with teaching philosophy and career advancement) and students (increased achievement, improved attitude, and enhanced interpersonal skills). They also measured internal factors such as teacher self-efficacy and skill and external factors such as student characteristics, classroom environment, and support. Based on their findings, they suggested how useful and successful education innovation could be implemented as part of relevant professional development. Wozney, Venkatesh, and Abrami (2006) based their study of teachers' decisions to adopt computer technologies in their classroom on the Abrami et al. model and identified three major factors, namely expectancy, value, and cost, that were involved in making the decision.

Kay (2006) used expectancy-value theory as a practical element to examine influential factors in teachers' classroom decision-making processes, especially in relation to their willingness to implement a curriculum in their classroom. She concluded that teachers' expectancy-value beliefs were associated with their willingness to implement a constructivist based curriculum. For example, she believed that teachers who demonstrated lower levels of curriculum implementation had fewer expectations and placed a lower value on the curriculum.

All the studies applying the expectancy-value theory in educational contexts indicated its usefulness as a research framework (Abrami et al., 2004; Hancock, 1996). In particular, these studies (Abrami et al., 2004; Kay, 2006; Wozney et al., 2006) confirmed that a teacher's decision to implement a curriculum was strongly related to “how highly they value it”, “how successful they expect to be”, and “how high they perceive the cost of it”.

The concepts involved in the expectancy-value theory provide a useful framework to identify factors affecting the implementation of biotechnology instruction. In particular, this study investigates technology teachers’ perceived expectation and value regarding the implementation of biotechnology instruction for technology education programs.

Application to the Implementation of Biotechnology Instruction

The applications of two theoretical backgrounds, namely Rogers’ adoption/diffusion theory and expectancy-value theory, in this study of the implementation of biotechnology instruction for technology education are described in this section. In particular, the theories are used to identify key factors affecting the implementation of biotechnology instruction and investigate their predictive value.

Rogers' theory is used as the first background framework to identify the levels of concerns regarding key factors affecting the implementation of biotechnology instruction. One of the most valuable perspectives of the theory is its key attributes for successful innovations that address two questions: “Why do certain innovations spread more quickly than others?” and “Why do others fail?” These questions are particularly relevant to this study, and in this section the application of Rogers’ theory to the implementation of biotechnology instruction is investigated. The five basic stages (knowledge, persuasion, decision, implementation, and confirmation) of the innovation-decision process in Rogers' adoption/diffusion theory provide the overarching framework for investigating biotechnology teaching as an innovation. Within that framework, and specific to this study, the levels of concern relative to the five key attributes (relative advantages, compatibility, complexity, trialability, and observability) of Rogers' adoption/diffusion theory are explored in an effort to identify those factors primarily responsible for affecting the implementation of biotechnology instruction.

Innovation-decision process. The innovation-decision process in this study is "an information-seeking and information-processing activity" (Rogers, 2003, p. 172) concerning the final implementation of biotechnology instruction (the innovation). Furthermore, the implementation of biotechnology instruction for technology education programs can be described by five stages: knowledge, persuasion, decision, implementation, and confirmation.

To implement biotechnology instruction for technology education programs at the secondary level, this process starts with the knowledge stage. In this stage, technology teachers learn about the existence of biotechnology instruction for technology education programs as well as seek information about it. Through several communication channels, technology teachers become aware of the existence of biotechnology and its instruction. The low implementation level of biotechnology instruction may be explained by the relatively few opportunities to learn about biotechnology instruction and seek information about it. This low experience of biotechnology and its instruction at the pre-service and in-service level (Daugherty, 2006; Rogers, 1996; Russell, 2003) negatively affects their innovation decision process to adopt and implement biotechnology instruction because they have not been exposed to knowledge regarding biotechnology and its instruction in technology education programs. Therefore, the provision of additional opportunities for professional development at the pre-service and in-service level may serve as an important mechanism that drives the implementation of biotechnology.

The persuasion stage entails changing an individual's attitude positively toward an innovation, which in this case is biotechnology instruction. This stage is strongly related to the formation of technology teachers' feelings toward biotechnology instruction. Insufficient professional development related to the inclusion of biotechnology content and instruction in the technology education program is likely to impart a negative attitude toward the teaching of biotechnology. However, the formation of a favorable or unfavorable feeling toward biotechnology instruction does not always lead directly or indirectly to a decision to teach biotechnology content for technology education programs.

At the decision stage of the innovation-decision process, technology teachers choose to adopt or reject the biotechnology instruction for technology education. Implementation is the fourth stage of the innovation-decision process and represents the point at which the technology teacher attempts the delivery of biotechnology instruction. In the fifth and final stage, the technology teacher, based on their consideration of the benefits and disadvantages of biotechnology instruction for their technology education programs, confirms or not the commitment for continuing to include biotechnology instruction. They may at this stage decide not to implement (replacement, disenchantment, and discontinuance). Rogers (2003) points out that reducing the uncertainty toward an innovation is important throughout the innovation-decision process if adoption/diffusion is to occur. Logically then, the degree to which technology teachers are uncertain toward the innovation (biotechnology instruction) will be directly related to the affects of the key attributes held by that innovation.

Key attributes for successful innovation. The attributes held by innovations include five characteristics: ***relative advantages, compatibility, complexity, trialability, and observability*** (Rogers, 2003). The effects of key factors toward the implementation of biotechnology instruction can be explained by these five characteristics, and are significant predictors for the rate of adoption of biotechnology instruction. The ***relative advantage*** of biotechnology instruction is paraphrased into a question, “Do technology teachers feel there is a significant or beneficial reason biotechnology instruction makes an impact on meeting the goals of technology education programs?” In other words, technology teachers weigh the benefits and challenges concerning the adoption and implementation of biotechnology instruction for technology education programs from the perspectives of economic terms, convenience, and satisfaction. As well, there is a strong association with technology teachers' perception and infrastructure in relation to the adoption and implementation of biotechnology instruction. Technology teachers' perceptions of factors such as convenience and satisfaction may also influence the decision to adopt and implement biotechnology instruction. The availability of infrastructure such as a supportive administration, school system and environment, and regional organization can be a second significant factor affecting the implementation of biotechnology instruction.

The ***compatibility*** of an innovation is represented by how consistent the innovation is with technology teachers' existing values, past experiences, and needs. Thus, the basic condition for implementing biotechnology instruction is that biotechnology instruction for technology education programs should be compatible with technology teachers' existing values, past experience, and needs. Compatibility is strongly related to teachers' perceptions and professional development. Technology teachers who perceive biotechnology instruction to be a valuable component of a technology education program will be more eager to adopt and implement biotechnology instruction in their classes. Also, teachers' past experience has been formed through a number of professional development opportunities, ranging from pre-service education to in-service sessions. Consequently, technology teachers' professional development can be a significant factor in their decision to adopt and implement biotechnology instruction for technology education programs.

The ***complexity*** for an innovation refers to how difficult the innovation is to understand and use. Complexity can be presented as a question, "Are the challenges with relationship to biotechnology instruction too difficult for technology teachers to adopt and implement biotechnology instruction?" ***Trialability*** is the extent to which the teachers will have the opportunity to practice biotechnology instruction (innovation) in such a way that they do not need to continue if they do not want to. ***Observability*** refers to the opportunities afforded the teacher to watch another teacher who has already adopted and implemented biotechnology instruction in their technology education programs. With respect to trialability and observability, technology teachers' professional development provides a mechanism for practicing and observing the implementation of biotechnology instruction at the secondary school level technology education programs. The key attributes listed above provide the framework for identifying key factors affecting the implementation of biotechnology instruction for technology education programs.

Application of expectancy-value theory. The second main theoretical framework guiding this study is the expectancy-value theory which addresses motivation. A technology teacher' decision to adopt and implement biotechnology instruction in their classrooms depends to a large degree on their perceptions of biotechnology instruction. The present study is designed to answer two questions: 1) “What causes the adoption/implementation of biotechnology instruction for technology education programs at the secondary school setting?” and 1) “Why does it vary in its intensity?” Both questions are fundamentally motivational questions. Specifically, technology teachers’ perceived expectations and values regarding the implementation of biotechnology instruction in technology education programs are investigated in this section.

Wigfield et al. (2004) defined expectancy as an “individual’s expected probability for success on a specific task” (p. 167). A technology education teacher’s expectations of success toward teaching biotechnology can thus be used to predict their choices (in this study, the implementation of biotechnology instruction) (Eccles, 2005; Wigfield et al., 2004). The expectation for successful implementation of biotechnology instruction includes technology teachers’ confidence or ability about perceptions regarding biotechnology and its instruction and is a factor affecting the implementation of biotechnology instruction. Also, Wigfield et al. (2004) defined value as “a set of stable, general beliefs about what is desirable…. a class of motives that affect behavior by influencing the attractiveness of different possible goals and thus the motivation to attain the goals” (p. 168). A technology education teacher’s perceived value regarding the implementation of biotechnology instruction is another factor affecting the implementation of biotechnology instruction. Eccles (2005) suggested that there were four components of subjective task value: attainment value (or the value an activity has), intrinsic value of the task, utility value (or extrinsic value), and cost. As with the expectancy construct, these four components of the value construct can be used to measure technology education teachers' motivation toward teaching biotechnology in this study. The value that biotechnology instruction has in the perspectives of students and teachers can affect the implementation of biotechnology instruction.

Historically, compared to the instruction of the more traditional content areas in technology education, the instruction of biotechnology content is relatively new, with a very short history. Furthermore, the inclusion of biotechnology in technology education classes is perceived as a relatively new idea by individual technology teachers and the profession as a whole (Russell, 2003; Scott et al, 2006). For this study two theoretical backgrounds, namely Rogers' adoption/diffusion theory and expectancy-value theory (Wigfield et al., 2004), provide a theoretical framework with which to identify key factors affecting the implementation of biotechnology instruction and establish predictive values of the identified factors. Two main ideas of Rogers' theory: the innovation-decision process and perceived attributes of the innovation were reviewed in this study. The second theoretical background is expectancy-value theory. The expectancy-value theory provides a viewpoint for identifying key factors that affect the implementation of biotechnology instruction and are compatible with the five attributes of innovations that Rogers' theory suggests.

Research Directions

Designing a relevant research method is important to enable researchers to achieve the goal of their research. Thus, the research design should be considered in conjunction with the research goal or research questions of the study (Creswell, 2003). Therefore, the research goal or research questions and theoretical backgrounds should be reviewed to design this research.

Research Methodologies in Prior Studies

The current study is designed to investigate predictive values for the identified factors (teachers' motivation, professional development, and infrastructure) affecting the implementation of biotechnology instruction in secondary school level technology education classrooms. To investigate these predictive values, research methodologies that have been found to be best suited to studying this type of phenomena should be used. The key phenomenon in this study is the implementation of biotechnology instruction in secondary school level technology education classrooms, which in this case is considered the innovation. Therefore, prior studies investigating teachers' attitudes toward an innovation should be reviewed regarding the research methodology. The way innovations are diffused in educational settings has generally been studied using quantitative methods, as described below.

Quantitative methods have been used in a number of studies that focused on the adoption and diffusion of an educational innovation, particularly to measure the constructs related to the phenomena. Therefore, the choice of instrumentation and its statistical analysis have been crucial issues, with the instrumentation process requiring researchers to establish a robust theoretical background for the phenomena. Wilson et al. (2002) used several self-reported instruments to identify factors related to the decision of agricultural science teachers to adopt the integrated agricultural biotechnology curriculum. The instruments were developed by the authors based on their review of prior studies and the relevant theory. With a focus on the expectancy-value theory, their studies measured teachers' perceptions regarding the importance of teaching biotechnology and their expectations for it by administering these instruments. Abrami et al. (2004) investigated teacher's beliefs and how these affected their decision to implement an innovation using quantitative data collected by the Cooperative Learning Implementation Questionnaire (CLIQ). They emphasized the importance of teacher motivation as a major factor that affects the implementation decisions of teachers regarding educational innovations. Based on their review of the expectancy-value theory, the instrument was developed by the authors, and consisted of three main components: expectancy, value, and cost. Schroll (2007) studied the key factors affecting a teacher's choice to adopt technology and constructivist principles in the classroom learning environment. The theoretical background for this study was provided by Rogers' diffusion of innovation theory (2003). The Classroom Learning Environment Survey (CLES) was administered to 83 elementary teachers to examine their classroom learning environments. The quantitative data obtained depicts the degree to which teachers integrated technology and utilized constructivist principles. Kay (2006) examined the influential factors in teachers' classroom decision –making process with respect to the implementation of an innovative curriculum. Based on an expectancy and value theory, the study investigated teachers' beliefs such as the value, knowledge and learning, and self-efficacy regarding an innovative curriculum using quantitative methods, with a quantitative methodology being adopted by several self-reported instruments to measure teachers' beliefs. In particular, the self-reported instrument developed by Abrami et al. (2004) was used for measuring teachers' motivation.

In prior studies dealing with the phenomena, quantitative methods that developed and administered relevant instruments containing the major constructs that each investigated were frequently used (Abrami et al., 2004; Eccles, 2005; Graham & Taylor, 2002; Wigfield et al., 2004; Wozney et al., 2006). Clearly, quantitative data from the surveys plays a powerful role in efforts to measure the major constructs in both confirmatory and exploratory ways using several statistical techniques.

Measuring Teachers' Attitudes Toward Innovation

Prior studies (Christou, Eliophotou-menon, & Philippou, 2004; Lemani, 2004; Liu & Huang, 2005; Perkins & McKnight, 2005; Wells, 2000) investigating teachers' attitudes toward an innovation described the relevant theoretical background and the instrumentation process. These prior studies commonly emphasized the use of the Concerns-Based Adoption Model (*CBAM*) a systematic instrument with which to measure the teachers' attitude toward an innovation.

The CBAM is a well-established model that is appropriate for investigating teachers' concerns toward an innovation (Hall, George, & Rutherford, 1977). The *SoC* instrument was designed to describe the levels of concern regarding the adoption of an educational innovation and in particular measure teachers' attitudinal positions concerning that educational innovation (Hall et al., 1977). The *SoC* instrument does not measure teachers' concerns at a single stage along an adoption/diffusion continuum, but rather across seven different stages. It contains 35 items that are scored using an eight point Likert scale. The first four stages (awareness, informational, personal, and management) of the instrument address internal concerns while the last three stages (consequence, collaboration, and refocusing) of the instrument deal with external concerns. According to Hall et al. (1977), teachers during the pre-stage and early stages of using the innovation are likely to have internal concerns. In the late phase there tends to be a shift to external concerns that concentrate on students learning and development.

A number of studies have used the Stages of Concerns (SoC), a key tool used to collect relevant data in the Concerns-Based Adoption Model (*CBAM*). For example, Lemani (2004) studied key factors of the Trek-21 professional development that were significant with regard to teacher's practices in terms of the integration of instructional technologies. The study used quantitative statistics in a descriptive and correlation research design, applying a number of instruments to accomplish the research goal. In particular, the Stages of Concerns (*SoC*) questionnaire developed by Hall et al. (1977) was used in the research to measure teachers' concern toward the incorporation of instructional technologies into their classroom practices. Liu & Huang (2005) also examined teachers' concerns toward technology integration using the Stages of Concerns questionnaire. In their study, the innovation was also defined as the integration of instruction technology (IT) into the classroom. Recognizing that teachers involved in the adoption/diffusion of any innovation would not move through the predicted seven stages of concern at the same rate or have the same intensity of concern at the various levels (Hall et al., 1977), they chose the CBAM to measure and explore participating teachers' attitudes toward the IT innovation. Perkins & McKnight (2005) used the SoC to determine if teachers are using *WebQuests* (a Web-inquiry activity) in their classrooms. They measured teachers' concern over implementing an innovation, in this case *WebQuests*. As evidenced by the numerous studies conducted over the past decade (Christou et al., 2004; Lemani, 2004; Liu & Huang, 2005; Perkins & McKnight, 2005; Wells, 2000) the SoC has been used extensively to measure the stage of concern practitioners experience when presented with an instructional innovation.

The final section in the review of literature described the research direction by revisiting research goals and reviewing those research methodologies that have been found to be best suited to studying the type of phenomena that this current study is designed to investigate. Contemporary studies related to the adoption and diffusion of innovations in educational settings (Rogers, 2003) and expectancy-value theory (Wigfield et al., 2004) frequently used quantitative data to achieve their research goals. Regardless of the type of research methodology, prior studies have focused on accomplishing their research goals in accordance with their theoretical backgrounds. In particular, studies focused on teachers' decision regarding an educational innovation (Christou, Eliophotou-menon, & Philippou, 2004; Lemani, 2004; Liu & Huang, 2005; Perkins & McKnight, 2005; Wells, 2000) have used quantitative research designs (e.g. the SoC instrument) to measure the phenomena. Therefore, this current study also adopted a quantitative design with which to investigate the predictive values of the identified factors affecting the implementation of biotechnology instruction in secondary school level technology education classrooms.

Summary of the Literature Review

The review of literature was approached by presenting and discussing three distinct areas determined to be relevant to an investigation of research question and sub-questions. The first section of this chapter reviewed the definition of biotechnology, the evolution of the field and the challenges of teaching biotechnology, both within technology education and in other subjects. The literature review pointed out the importance of teaching biotechnology in secondary school level classrooms and its generally insufficient practice in technology education. Many studies have highlighted the growing need for the implementation of biotechnology instruction in secondary school level technology education classrooms (Brown et al., 1998; Russell, 2003; Sanders, 2001; Scott et al., 2006). These prior studies commonly ascribed the dearth of biotechnology instruction to poor teacher motivation, few professional development opportunities, and a lack of administrative support. The necessary theoretical framework with which to investigate the underlying classroom implementation issues, namely Rogers' (2003) diffusion of innovations theory and expectancy-value theory (Wigfield et al, 2004) was provided in the second section of this chapter. The expectancy-value theory provided a viewpoint for identifying key factors that affect the implementation of biotechnology instruction. Finally, the research methodologies that have been found to be best suited to investigating this type of phenomena were reviewed. Reports of the diffusion of an innovation in educational settings have mainly adopted a quantitative perspective to establish their theoretical framework for the data collection. Prior studies (Christou et al., 2004; Lemani, 2004; Liu & Huang, 2005; Perkins & McKnight, 2005; Wells, 2000) investigating teachers' attitude toward innovation emphasized the relevant theoretical background and the use of a systematic instrument. The Concerns-Based Adoption Model (*CBAM*) is a well-established model that has often been used to investigate teachers' concerns toward an innovation (Hall et al., 1977). A number of studies have also used the Stages of Concerns (*SoC*), a key tool used to collect relevant data in the Concerns-Based Adoption Model (*CBAM*). With this in mind, this study accepts the idea of the *CBAM* and uses the Stages of Concerns (*SoC*) to measure technology education teachers' concerns toward teaching biotechnology.

CHAPTER 3: RESEARCH METHOD

This chapter presents the method used to conduct the research for this study and includes the following sections: research design, participants, instruments, data collection, data analysis, and summary. Quantitative methods were predominantly employed to answer the main research question with the three sub-questions being assessed with a qualitative method (five open ended questions). The research question and sub-questions that this study sought to answer are:

RQ-1. What predictive values do the identified key factors that affect the implementation of biotechnology instruction in secondary school level technology education classrooms?

SQ-1. How do motivational constructs of technology education teachers affect the implementation of biotechnology instruction in their secondary level technology education classrooms?

SQ-2. How does the preparation (pre-service and in-service professional development) of technology education teachers affect their decision to implement biotechnology instruction in their secondary level technology education classrooms?

SQ-3. How does the infrastructure (local, state, and national level) supporting technology education programs affect technology education teachers' implementation of biotechnology instruction in their secondary technology education classrooms?

Research Design

This study investigated the key factors (motivation, professional development, and infrastructure) affecting the implementation of biotechnology instruction in secondary level Technology Education program and established predictive values for the identified factors using a quantitative research methodology. This research approach involved the administration of a composite instrument, the *Technology Teachers' Belief To Teach Biotechnology (TTBTTB)*, to collect demographic, attitudinal, motivational, and open-ended data related to the phenomena under investigation.

The dependent variable of this study is the implementation of biotechnology instruction in secondary school level technology education classrooms. To measure the dependent variable, this study used the *Attitude Toward Teaching Biotechnology* (*ATTB*) questionnaire focused on investigating technology education teachers' concerns toward teaching biotechnology.

The independent variables (predictors) in this study are: (1) technology education teachers' motivation toward the implementation of biotechnology instruction, (2) technology teachers' professional development associated with biotechnology and its instruction, and (3) the school infrastructure supporting biotechnology instruction. Data sources and analysis methods were identified from the sub-questions in this study, as presented in Table 5.

Table 5.

Research Questions, Data Sources, and Data Analysis

Research Questions	Data Source	Data Analysis
SQ-1. How do motivational constructs of technology education teachers affect the implementation of biotechnology instruction in their secondary school level Technology Education classrooms?	Instrument Open-ended Questions 1 & 3	Statistical Analysis Theme Analysis
SQ-2. How does the preparation (pre-service and in-service professional development) of technology education teachers affect their decision to implement biotechnology instruction in their secondary school level Technology Education classrooms?	Instrument Open-ended Questions 2 & 4	Statistical Analysis Theme Analysis
SQ-3. How does the infrastructure (local, state, and national level) supporting technology education programs affect technology education teachers' implementation of biotechnology instruction in their secondary school level Technology Education classroom?	Open-ended Question 5	Theme Analysis

Quantitative data (demographic data, attitudinal data toward teaching biotechnology, and motivational data to teach biotechnology) and qualitative data (five open ended questions) were collected through a composite on-line survey to answer the sub-questions posed in this study.

The data were analyzed using a mean comparison test, exploratory factor analysis, correlation, multiple regressions, and theme analyses. The remainder of this chapter describes the study participants, instruments, and the procedures followed in data collection and analysis.

Participants

Participants for this study were drawn from technology education teachers currently practicing at the secondary school level in five states (Connecticut, New Jersey, New York, Pennsylvania, and Virginia) in the eastern seaboard region of the United States. As prior studies (Rogers, 1996; Sanders, 2001) pointed out, there has been insufficient practice regarding the implementation of biotechnology instruction in the secondary technology education classrooms. Consequently, the distribution of the technology education teachers in many states is skewed regarding the implementation of biotechnology instruction. In order to obtain a reasonable participant sample, secondary school level technology education teachers were drawn from the five eastern seaboard states which had at some time participated in the *Technology Education Biotechnology Curriculum (TEBC)* professional development project.

Instrumentation

The *Technology Teachers' Belief To Teach Biotechnology (TTBTTB*) survey is a composite of four separate instruments combined specifically to collect data for this study. The composite *TTBTTB* instrument (Appendix A) consists of four parts. Part I is designed to collect demographic data across the following categories: (1) teachers' general data, (2) professional development, and (3) school environment. This information is used to identify key independent variables affecting the implementation of biotechnology instruction. Part II, *Attitude Toward Teaching Biotechnology (ATTB),* is a modified version of the *Stages of Concern Instrument* (Hall et al., 1977) and is used to measure attitudes toward biotechnology instruction as a dependent variable. Part III, *Belief To Teach Biotechnology (BTTB)*, a modified version of *Children's Self and Task Perception Instrument (CSTP)* (Eccles & Wigfield, 1995) and is used to measure technology teachers' motivation toward teaching biotechnology. Part IV is an *Open Ended Questionnaire* used to pose five questions related to motivational, preparatory, and infrastructure issues in teaching biotechnology. The following sections present a more detailed description of all four parts of the *TTBTTB* instrument.

Demographic Data

Part I of the *TTBTTB* instrument is designed to collect demographic data across three categories: (1) teachers' general data (gender, teaching grades, educational degree, teaching subject licensed, teaching experience for secondary school level Technology Education, and experience teaching biotechnology), (2) professional development (in-service training and pre-service courses) for teaching biotechnology in secondary school level Technology Education classroom , and (3) school environment (location & class size). A total of 10 demographic items (Table 6) collected data across these categories.

Table 6.

Categories and Data Types of Participant Demographics in Part I of the TTBTTB

Categories	Data Types
General Data	1. Teachers' Gender 2. Teaching Experience 2-1. Years of teaching technology education 2-2. Years of teaching biotechnology content 3. Teaching Grade 3-1. Teaching Grade taught technology education 3-2. Teaching Grade taught biotechnology content 4. Teaching License 5. Educational Degree
Professional Development	6. Teachers' Pre-service Courses 6-1. The number of courses related to biotechnology 7. Teachers' In-service Training 7-1. Types of in-service training related to biotechnology 7-2. Hours of in-service training related to biotechnology
School Environment	8. School Physical Environment 8-1. School location 8-2. Class size

Attitude Toward Teaching Biotechnology (ATTB)

Part II (*ATTB*) of the *TTBTTB* uses a modified *Stages of Concern (SoC)* Instrument developed by Hall, George, and Rutherford (1977) to measure the dependent variable (secondary school level technology education teachers' implementation of biotechnology instruction) in this study. The *SoC* instrument was originally designed to describe the levels of concern regarding the adoption of an educational innovation and in particular measure teachers' attitudinal positions concerning that educational innovation (Hall et al., 1977). A number of studies (Christou et al., 2004; Dunn, 2008; Lemani, 2004; Liu & Huang, 2005; Perkins & McKnight, 2005; Wells, 2000) have investigated teachers' attitude toward an innovation using the *SoC* instrument.

In the Hall et al. (1997) seminal studies, the original reliability (alpha coefficients) for each of the seven scales ranged from .64 to .83 and test-retest reliability on the seven scales ranged from .65 to .86. Furthermore, the *SoC* instrument has been widely utilized in a variety of previous research studies and continues to be found reliable and valid (Lemani, 2004; Perkins & McKnight, 2005; Wells, 2000; Wells & Anderson, 1997).

The *SoC* instrument does not measure teachers' concerns at a single stage along an adoption/diffusion continuum, but rather across seven different stages. It contains 35 items that are scored using an eight point Likert scale (0="not true of me now" and 7="very true of me now"), with 5 questions aligned with each of the 7 stages of concerns (Hall et al., 1977). The seven stages of concern are presented in Figure 3.

According to Hall et al. (1977), the first four stages of the instrument address internal concerns while the last three stages of the instrument deal with external concerns. Nonusers of an innovation tend to indicate high internal concerns (Stage 0: Awareness, Stage 1: Informational, Stage 2: Personal, and Stage 3: Management), and low external concerns (Stage 4: Consequence, Stage 5: Collaboration, and Stage 6: Refocusing). Likewise, users having more experience with an innovation tend to present elevated external concerns (stages 4, 5, and 6) and increasingly lower internal concerns (stages 0, 1, and 2). Hall et al. (1977) concluded that in-service workshops, resource support, past experience and personality factors all had a positive influence on teachers' attitudes toward an innovation. Teachers who were involved in such experiences typically demonstrate decreased internal concerns during/after the experience, and a general increase in external concerns as they anticipate implementation of instruction using the innovation.

6. REFOCUSING	The focus is on exploration of more universal benefits from the innovation, including the possibility of major changes or replacement with a more powerful alternative.
5. COLLABORATION	The focus on coordination and cooperation with others regarding use of the innovation
4. CONSEQUENCE	Attention focuses on impact of the innovation on students in his/her immediate sphere of influence
3. MANAGEMENT	Attention is focused on the process and tasks of using the innovation and the best use of information and resources
2 PERSONAL	Individual is uncertain about the demands of the innovation, his/her inadequacy to meet those demands, and role with the innovation
1 INFORMATIONAL	A general awareness of the innovation and interest in learning more detail about its is indicated
0 AWARENESS	Little concern about or involvement with the innovation is indicated

Figure 3. Stages of concern about the innovation (Hall et al., 1977)

The current study utilized the modified SoC instrument, "*Attitudes Toward Teaching Biotechnology (ATTB)*" that Wells (1999c) employed for measuring technology teachers' attitude toward teaching biotechnology pre/post delivery of a *TEBC* professional development event. The *ATTB* (Part II of the *TTBTTB*) is presented in Appendix A. The seven stages and associated items in the *ATTB* are described below.

The first stage of concern, ***awareness*** (Stage 0: items 3, 12, 21, 23, & 30) measures teachers' knowledge regarding the existence of biotechnology and the teaching of that content in technology education. Items targeting the ***informational*** stage of concern (Stage 1: items 6, 14, 15, 26, & 35) ask if technology teachers want to know about biotechnology and the teaching of that content. Items associated with the ***personal*** stage of concern (Stage 2: items 7, 13, 17, 28, & 33) refer to technology teachers' perceptions about how biotechnology teaching will affect them personally. ***Management*** items (Stage 3: items 4, 8, 16, 25, & 34) focus on concerns about the technical challenges related to teaching biotechnology. Items that correlated with the ***consequence*** stage of concern (Stage 4: items 1, 11, 19, 24, & 32) ask teachers how their teaching of biotechnology might affect their students. The ***collaboration*** stage (Stage 5: items 5, 10, 18, 27, & 29) attempts to measure concerns regarding technology teachers working with others in the process of biotechnology teaching. The final stage, ***refocusing*** (Stage 6: items 2, 9, 20, 22, & 31), asks teachers questions related to their attitudes toward improving their biotechnology teaching.

Belief To Teach Biotechnology (BTTB)

The third section in the *TTBTTB* is the *Belief To Teach Biotechnology (BTTB)*, a composite of 12 items (Figure 4), all of which were drawn from the following two sources: 1) nine modified items from the *Children's Self and Task Perception Instrument (CSTP)* (Eccles & Wigfield, 1995), and 2) three item developed from Eccles' (2005) definition of the *Cost*.

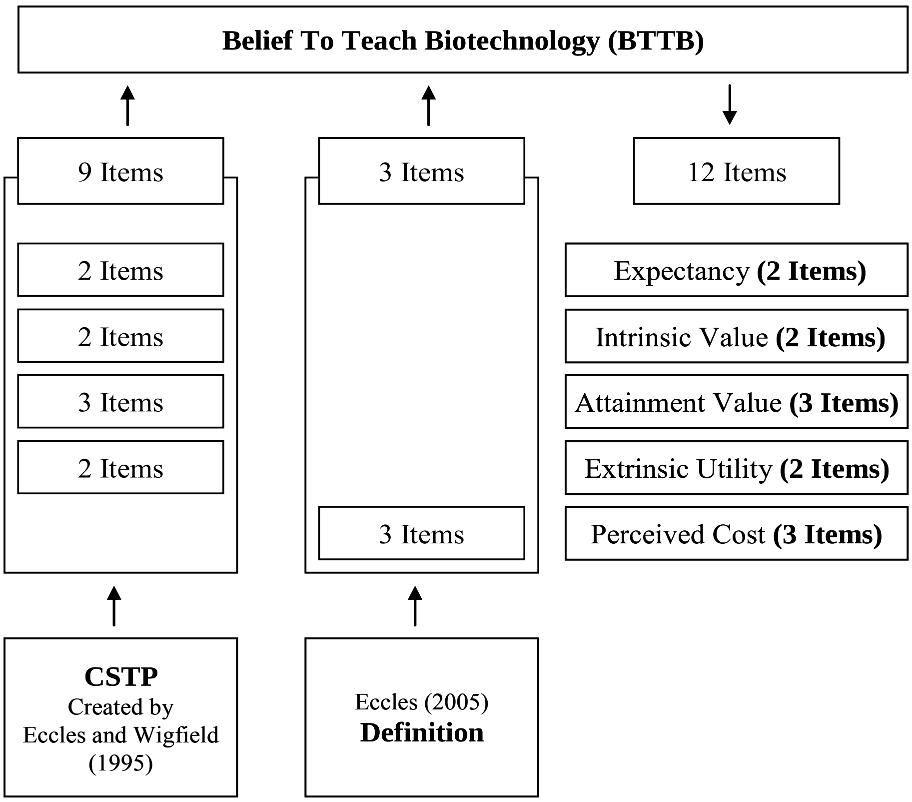

Figure 4. Method used in selecting items for the *BTTB*

Expectancy-Value constructs have been widely used to investigate key factors affecting students' performance, achievement, and choice (Eccles, 2005; Graham & Taylor, 2002; Wigfield et al., 2004). Research conducted by Eccles & Wigfield (1995) and Eccles (2005) determined that these constructs were best represented by the following five sub-categories: 1) Expectancy, 2) Intrinsic interest value, 3) Attainment value, 4) Extrinsic utility value, and 5) Cost. Based on these sub-categories, the *BTTB* used in this study was developed to measure technology education teachers' five motivational constructs (Expectancy, Intrinsic interest value, Attainment value, Extrinsic utility value, Perceived cost) as suggested by the Expectancy-Value theory (Eccles & Wigfield, 1995; Eccles, 2005). Nine items were included in the *BTTB* section, each having been drawn from the 19 item survey Eccles and Wigfield (1995) developed to measure children' perception in the domain of mathematics. The Eccles and Wigfield (1995) instrument measured three different constructs: 1) perceived task value with 3 sub-constructs (intrinsic interest value: α =.76, attainment value: α =.70, and extrinsic utility value: α =.62), 2) ability/expectancy: α =.92, and 3) perceived task difficulty: α =.80. For use in the current study, 2 expectancy items and 7 perceived task value items (2 intrinsic interest value items, 3 attainment value items, and 2 extrinsic utility value items) were selected and reworded for the *BTTB* as presented in Table 7. The other 10 items (ability and the perceived task difficulty) were not included in the *BTTB* because they were not motivation constructs (Expectancy and Value) that were relevant to the study.

Table 7

Modifications of Items Selected from Eccles and Wigfield (1995)' CSTP

Original Items (9 items)	Modified Items (9 items)
Expectancy	***Expectancy***
1) Compared to other students, how well do you expect to do in math this year? (much worse than other students, much better than other students)	1) Compared to other teachers, how well do you expect to do at teaching biotechnology in your classrooms this year?
2) How well do you think you will do in your math course this year? (very poorly, very well)	2) How well do you think you will do at teaching biotechnology this year?
Intrinsic Interest Value	***Intrinsic Interest Value***
3) In general, I find working on math assignments (very boring, very interesting)	3) In general, I find teaching biotechnology content very interesting
4) How much do you like doing math? (not very much, very much)	4) How much do you like teaching biotechnology content?
Attainment Value	***Attainment Value***
5) Is the amount of effort it will take to do well in advanced high school math courses worthwhile to you (not vey worthwhile, very worthwhile)	5) Is the amount of effort it will take to teach biotechnology content well worthwhile to you
6) I feel that, to me, being good at solving problems which involve math or reasoning mathematically is (not at all important, very important)	6) I feel that, to me, being good at teaching biotechnology is very important
7) How important is it to you to get good grades in math?	7) How important is it to you to teach biotechnology in your classes?
Extrinsic Utility Value	***Extrinsic Utility Value***
8) How useful is learning advanced high school math for what you want to do after you graduate and go to work? (not very useful, very useful)	8) How useful is learning biotechnology for what your students want to do after they graduate and go to work?
9) How useful is what you learn in advanced high school math for your daily life outside school? (not at all useful, very useful)	9) How useful is what you students learn in biotechnology classes for their' daily life outside school?

* Highlight indicates modified portion.

In order to measure constructs missing in the CSTP instruments, it was necessary to develop the final three items included in the *BTTB* based on Eccles' construct definition in order to measure constructs missing in the *CSTP* instruments. Eccles categorized subject task value into four components: "1) attainment value or the value an activity has, 2) intrinsic or interest value expected enjoyment of engaging in the task, 3) the utility value of the task for external rewards, and 4) the cost of engaging in the activity" (2005, p. 109). A review of the initial nine items in the *BTTB* indicated the perceived cost items (measuring preparation time, effort, and material/equipment cost) were missing. Therefore, three cost items were added (Table 8) to the *BTTB* based on the definition of the perceived cost.

Table 8

Item Development from Eccles' (2005) Definitions

Construct Definition	MTTB Items
Perceived Cost "The value of a task should also depend on a set of beliefs that can best be characterized as the cost of participating in the activity" (p. 112). Also, "cost can be conceptualized in terms of the loss of time and energy for other activities" (p. 113).	***Perceived Cost*** 1) Teaching biotechnology takes too much preparation time. 2) Teaching biotechnology in my Technology Education courses requires a great deal of effort. 3) Teaching biotechnology in my Technology Education courses requires specialized materials and equipments

As a result, Part III of the *TTBTTB* instrument addressing motivation ultimately consisted of 12 items covering the following five different constructs: 1) expectancy (2 items), 2) intrinsic interest value (2 items), 3) attainment value (3 items), 4) extrinsic utility value (2 items), and 5) perceived cost (3 items). Permission to conduct a modified motivational inventory based on the instrument developed by Eccles and Wigfield (1995) was granted by one of the authors (Appendix B)

Open Ended Questionnaire

The final part of the *TTBTTB* consisted of open ended questions. Grounded in the three research sub-questions (motivation, professional development, and infrastructure) guiding this study, five open ended questions were developed.

The five open ended questions were employed as data sources to answer the three research sub-questions as shown in Table 9. For example, open ended question 1 (students' benefits of learning biotechnology) and open ended question 3 (teachers' self-competency toward teaching biotechnology) were developed to more deeply investigate the motivational issue for teaching biotechnology. Furthermore, open ended question 2 (level of preparation for teaching biotechnology) and open ended question 4 (role of professional development related biotechnology instruction) were posed to investigate the issues associated with the professional development. And finally, open ended question 5 (infrastructure issues related to biotechnology instruction) was designed to answer research sub-question 3.

Table 9

Open Ended Questionnaire in the TTBTTB.

Research Sub-Questions	Open Ended Questions
Research Sub-Question 1.	1. What benefits are there for developing students who are more biotechnology literate specifically through technology education programs? 3. How competent do you feel you are to teach about biotechnology literacy in you classroom?
Research Sub-Question 2.	2. What level of preparation do you feel technology education teachers need in order to prepare students to be more technologically literate about biotechnology? 4. What role should professional development (pre-service programs and/or in-service workshops/college courses) play in preparing technology education teachers to help students become more technologically literate about biotechnology?
Research Sub-Question 3.	5. In what way(s) does you administration, school, or other colleagues support or encourage teaching about biotechnology in your technology education program?

Pilot Study

To establish the reliability and validity of the TTBTTB instrument, this study employed two strategies: 1) a review by a panel of experts and 2) a pilot study by a small group of technology education teachers. The final composite survey instrument (*TTBTTB*) used in this study was reviewed by a group of experts (biotechnology education, educational psychology, and educational measurement) to confirm the construct validity of the survey. Also, permission to conduct a motivational inventory based on the instrument developed by Eccles and Wigfield (1995) was received from one of the authors (Appendix B). Once a consensus had been reached on the content and the format of the survey instrument had been confirmed, the *Technology Teachers' Belief To Teach Biotechnology (TTBTTB)* survey was converted into an online format.

In January 2009, the researcher participated in the professional development (one week in-service training) for 30 technology education teachers in South Korea. The TTBTTB survey was translated into Korean by researcher on December 2008 and the translated survey was reviewed by two middle school English teachers in South Korea. Two formats of the pilot study (paper and on-line) were administered. In the first day of the training, 26 technology education teachers participated in this pilot study using the paper format of the *TTBTTB* survey. Participants were asked to complete the four different parts (demographic data, *ATTB*, *BTTB*, and open ended questions) of the *TTBTTB* survey. Results were analyzed to assess the instrument reliability (*Cronbach's Alpha*). Preliminary findings from this pilot study are provided in Chapter IV. *Cronbach's Alpha* for the *ATTB* and *BTTB* in this pilot study indicated high reliability (.791 and .831, respectively). Four of the technology education teachers used the online format survey and provided the researcher with feedback on completing the survey in this format. Based on this feedback, the survey introduction was modified to include some necessary additional information and the limitations for the number of words allowed for responses to the open ended questions was increased from 20 words to 50 words.

Data Collection Procedure

The procedures used in the data collection are as follows: IRB approval obtained, e-mail requests sent asking for permission to access technology education teachers' listservs in five states, e-mail invitations posted to the listservs inviting technology education teachers in the five states to participate in the *TTBTTB* survey, and participant data collected from completed survey (Figure 5).

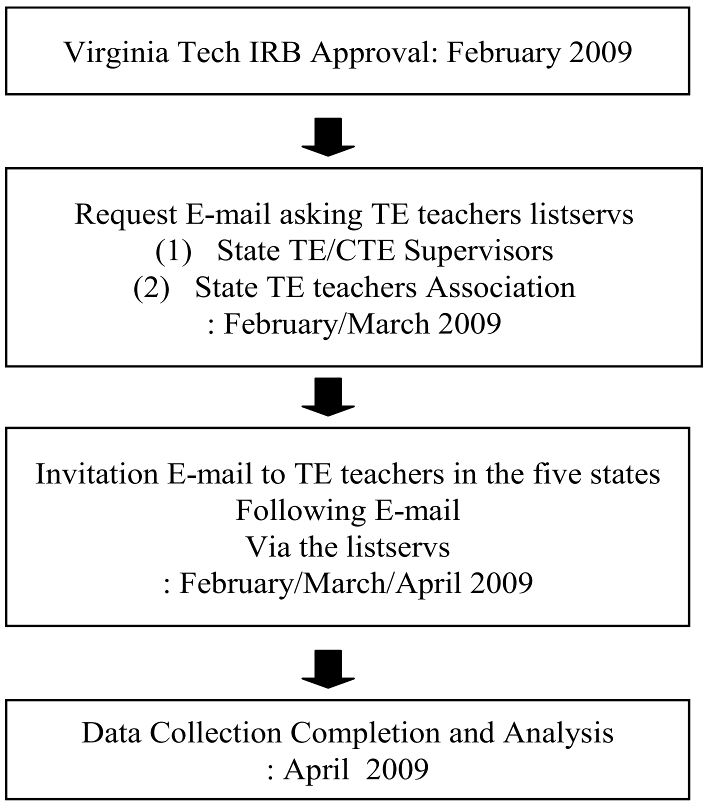

Figure 5. Data collection procedure

Upon receiving approval (Appendix C) from the Board of Human Subjects at Virginia

Polytechnic Institute and State University in February 2009 to conduct this study, a request e-mail (Appendix D) asking for permission to post on key technology education teachers' listservs in the targeted states was sent to each of the state supervisors using the contact information presented in the ITEA website. The supervisors in two states (Virginia and Connecticut) agreed to help this research by sending an e-mail invitation letter containing a URL of the *TTBTTB* survey to their listservs that they managed. The supervisors in other states did not manage the listserv but they recommended the researcher contact the president of the technology education teachers' association in each state. By communicating with person responsible for giving permission to use the listserv, the researcher thus gained permission to use the listserv from each state. The state supervisors or state technology education association mailed the TTBTTB survey invitation to all the technology education teachers in their states, so it was not possible to calculate a precise value for the survey response rates by state. Following the initial distribution of the survey, the researcher asked the person responsible for the listservs for the number of technology education teachers currently enrolled in their listservs. The listserv administrators provided approximated numbers as follows: VA (400), NY (900), CT (250), NJ (360), and PA (300).

After obtaining all the necessary permissions for distributing the *TTBTTB* survey to the listservs in the five states, the survey was separated into five distinct state collectors, each of which used a different link. Data from the survey were collected using a commercial online survey service. An e-mail invitation letter (Appendix E) providing a brief introduction to the study and directions for completing the survey, along with a link to the *TTBTTB* instrument was sent to potential participants via the identified person who managed the listserv in the five states. A follow up e-mail was sent every 7 days to encourage participation. On 9 April 2009 data collection was completed and the on-line survey link was closed. The data gathered for the first three parts (demographic data, *ATTB*, and *BTTB*) of the *TTBTTB* survey were downloaded into a file for SPSS software processing and the open ended data in the last part of the *TTBTTB* survey were entered into a Microsoft Excel file for further data analysis.

Data Analysis

Data collected in this study were analyzed to answer the main research question and the three sub-questions. Demographic data collected through Part I of the *TTBTTB* instrument were analyzed to identify general participant characteristics and as independent variables (professional development: pre-service course and in-service training) for answering research sub-question 2.

Participants' attitudinal data toward teaching biotechnology were collected from the 35 *ATTB* items in Part II using an eight point Likert scale as dependent variable, each with response options ranging from 0 "Not true of me" to 7 "Very true of me now". Each statement represents one of seven stages of concern regarding the teaching of biotechnology in secondary school level technology education classrooms. Possible scores for Part II ranged from 0 to 35, with composite mean scores for each of the seven stages (awareness, informational, personal, management, consequence, collaboration, and refocusing) taken into consideration for statistical analysis. Also, the composite mean scores of the internal concerns (awareness, informational, personal, and management) and the external concerns (consequence, collaboration, and refocusing) were calculated for statistical analysis to answer research sub-questions 1 and 2.

Using a 7 point Likert scale, 12 items were used in Part III (*BTTB*) of the *TTBTTB* to collect motivational data presented through five key motivational constructs: Expectancy (item 1 & 2), intrinsic interest value (item 3 & 4), attainment value (item 5, 6, & 7), extrinsic utility value (item 8 & 9), and cost (item 10, 11, & 12). The motivational data were used as the independent variable, answering research sub-question 1. Following data collection, the constructs had to be validated because 12 items were developed based on the five constructs validated by Eccles (2005). In this study, a validation of the five motivation constructs was conducted using an exploratory factor analysis. After the factor analysis, composite mean scores for each motivational construct were used for correlational analyses and multiple regressions.

Finally, the qualitative data in the last part of the *TTBTTB* survey gathered the written responses to the five open-ended questions regarding students' benefits and teachers' competency for teaching biotechnology, the level and role of professional development for teaching biotechnology, and the infrastructure issue related to the implementation of biotechnology instruction. Answers given to the open-ended items were analyzed in a qualitative manner. This analysis followed a three step procedure. First, the initial coding of written responses was examined for emergent themes and concepts for each open-ended question (Strauss, 1987; Yin, 2003). Second, a discussion with an expert in the field of biotechnology education created a list of emergent themes and concepts for each open-ended question. Finally, the researcher examined the frequency of the themes (Bogdan & Biklen, 1998).

To answer the research question and sub-questions, the data collected from Parts I, II, III, and IV of the *TTBTTB* instrument were examined using descriptive statistics, mean comparison tests, correlational analyses, multiple regression analyses, and theme analysis to assess the relationships between one dependent variable (DV) and several independent variables (IVs) (Johnson & Christensen, 2008). Findings from the analysis of data collected as described in this methods chapter are presented in Chapter IV of this document.

CHAPTER FOUR: RESULTS

This chapter presents the analysis of data obtained from the composite on-line survey developed for this study. The TTBTTB instrument was composed of the following sections, (1) Demographics, (2) *Attitude Toward Teaching Biotechnology* (ATTB), (3) *Belief To Teach Biotechnology* (BTTB), and (4) Open ended Questionnaires, and was used to collect both quantitative and qualitative data. Specifically, reported in this chapter are the results of the statistical and thematic data analysis performed to answer the main guiding research question and the three research sub-questions guiding this study. The main research question and sub-questions investigated through this study are:

RQ-1. What predictive values do the identified key factors that affect the implementation of biotechnology instruction in secondary school level technology education classrooms?

SQ-1. How do motivational constructs of technology education teachers affect the implementation of biotechnology instruction in their secondary level technology education classrooms?

SQ-2. How does the preparation (pre-service and in-service professional development) of technology education teachers affect their decision to implement biotechnology instruction in their secondary level technology education classrooms?

SQ-3. How does the infrastructure (local, state, and national level) supporting technology education programs affect technology education teachers' implementation of biotechnology instruction in their secondary technology education classrooms?

The remainder of this chapter will begin with the analyses of the pilot study, presenting the instrument reliability, validity, and the data analysis process. The findings of the major study will then follow, presented in the following order: participants, instrument, independent variable, research question and sub-questions. In addition, statistical and thematic analyses of each research sub-question will be discussed.

Pilot Study

It is vital that the reliability and validity of the instrument(s) to be used in a study should be established before the research is undertaken (McMillan, 2004), hence this pilot study was conducted to fulfill this requirement. Specifically, the data gathered for the pilot study was examined to test the procedure to be used for the data analysis. The analyses are described below in the following order: participant demographics, reliability estimates of the instruments (*ATTB* & *BTTB*), and summary. The demographic data, *ATTB*, and *BTTB* survey data collected from the 26 Korean technology education teachers who participated in the pilot study were analyzed using statistical software (SPSS, v 16.0). Responses to the open ended questions of the survey were analyzed using theme analysis.

Participants of the Pilot Study

A pilot study was conducted with the assistance of a small group of technology education teachers in South Korea. Prior to the data collection for the major study, the researcher participated in a professional development session for Korean technology educators as a lecturer and took advantage of the opportunity to gather data for the pilot study. All those attending the training session agreed to participated, for a response rate of 100%. Table 10 summarizes the demographic data for the 26 respondents.

Of the 26 participants, 14 (53.8%) were male and 12 (46.2%) were female. At the time of the study, 22 (84.6%) were teaching in middle schools and 4 (15.4%) were teaching in high schools. Among the 26 respondents, 18 (69.2%) held bachelor’s degrees and 8 (30.8%) held master’s degrees. The majority of respondents (n=21, 80.8%) had prior experience teaching biotechnology as it has been a required content area in the Korean national technology education curriculum since 1970 (Wells & Kwon, 2008). However, only 10 (38.5%) had participated in professional development in preparation for teaching biotechnology.

Table 10

Demographic Data for Participants of the Pilot Study

Demographic Data		Participant (Percentage)
Gender	Male	14 (53.8%)
	Female	12 (46.2%)
Teaching Grade	Middle School	22 (84.6%)
	High School	4 (15.4%)
Degree	Bachelor’s	18 (69.2%)
	Master’s	8 (30.8%)
Experience Teaching Biotechnology	Yes	21 (80.8%)
	No	5 (19.2%)
Professional Development	Yes	10 (38.5%)
Related to Biotechnology Teaching	No	16 (38.5%)

Instrument Reliability Estimates and Validity

The *TTBTTB* instrument used in this pilot study was a combination of two instruments (*ATTB)* and (*BTTB*) modified from the Stages of Concern (Hall et al, 1970) and motivational scale (Eccles & Wigfield, 1995), respectively. It was thus necessary to examine the reliability and validity of the two instruments (*ATTB* and *BTTB*) before the major study could proceed. Results of the reliability and validity estimates measured for the *ATTB* and *BTTB* in the pilot study are discussed below.

The *ATTB* is designed to measure technology education teachers' concerns toward teaching biotechnology as the dependent variable in the major study. The *ATTB* in the pilot study had a high reliability, indicating a fairly good Cronbach's Alpha . The seven stages of concern all indicated good reliabilities: awareness (α = 0.811), informational (α = 0.771), personal (α = 0.813), management (α = 0.775), consequence (α = 0.821), collaboration (α = 0.789), and refocusing (α = 0.757). McMillan (2004) recommended the estimates of 0.65 or above for measuring personality trait should be used as the criterion for acceptable reliability. Therefore, all the measures collected from the *ATTB* in the pilot study were deemed reliable and deemed appropriate for use in the major study.

The 12 items in the BTTB measure technology education teachers' motivations (expectancy, value, and cost) toward teaching biotechnology. The data gathered using the *BTTB* in the pilot study also had good reliability. However, it is important to examine the statistical validity for the *BTTB* using a factor analysis (in this case, the *Principal Components* and *Varimax* rotated method) to confirm the inter-relationships among items of each of the three motivational constructs (expectancy, value, and cost). Hence, the three motivational constructs (expectancy, value, and cost) of the *BTTB* were analyzed and the results revealed that most of the items for each construct displayed high factor loadings, as shown in Table 11. In addition, the reliability estimates indicated good Cronbach's Alphas for the following sub-factors: expectancy (α =

0.930), value (α = 0.866), and cost (α = 0.682) of the *BTTB*. Therefore, the *BTTB* used in this pilot study was demonstrated to have adequate reliabilities and validity and was thus deemed suitable for use in the major study.

Table 11

Factor Loadings for Three Motivational Constructs

Factor	BTTB Item	Factor Loading
Expectancy (α = 0.930)	Item 1	0.828
	Item 2	0.789
Value (α = 0.866)	Item 3	0.817
	Item 4	0.829
	Item 5	0.676
	Item 6	0.686
	Item 7	0.781
	Item 8	0.878
	Item 9	0.847
Cost (α = 0.682)	Item 10	0.892
	Item 11	0.712
	Item 12	0.718

Based on the reliability estimates and validity, a series of data analyses for the pilot study were conducted to address the major research question and three sub-questions. Following the planned data analyses, the researcher examined the results to confirm that the proposed procedure to be used in the major study was appropriate. These data analyses also provided valuable data-handling experience that prepared the researcher for the data analyses in the major study

Summary

A pilot study was conducted using 26 technology education teachers in South Korea to establish the instrument reliability and validity. According to the instrument reliability and validity estimates, all measures of the *ATTB* and *BTTB* were statistically reliable and valid for the data gathered in the pilot study. Specifically, the reliability estimates for all the scales (*ATTB* & *BTTB*) and subscales (seven stages of concerns: awareness, informational, personal, management, consequence, collaboration, and refocusing & three motivational constructs: expectancy, value, and cost) indicated high reliabilities. Moreover, the statistical validity in the pilot study was established using a factor analysis (*Principal Components* and *Varimax* rotated method). The result revealed three motivational constructs (expectancy, value, and cost) in the *BTTB*. Even though the participants in the pilot study were based in South Korea, and hence culturally different from those expected to participate in the major study, the procedure used to examine the reliability and validity was not compromised and provided helpful experience that contributed to the data analysis process used for the major study.

Major Study

The pilot study provided quality measurements for the instrument, indicating good instrument reliability and validity. The reliability and validity of the instrument from the pilot study gave the researcher confidence regarding the instrumentation and analysis in the major study. With this in mind, data collected from the *TTBTTB* survey were analyzed as explained in Chapter III. This section presents the findings regarding participant demographics and data gathered using the TTBTTB that addressed the research question and sub-questions.

Participants

The demographic data for the participants in the major study will be presented in the following order: general demographic data (state, teaching grade, degree, license, average years of teaching), data regarding the participants' preparation (pre-service preparation and in-service training) for teaching biotechnology, and their experience teaching biotechnology in secondary school level technology education classrooms.

Respondents for this study were 402 technology education teachers practicing secondary school level technology education within five purposefully selected eastern seaboard states. Of the 402 surveys returned, seven were incomplete and lacked critical data. These seven incomplete surveys were omitted from the study, leaving 395 usable responses. Table 12 summarizes the general demographic data provided by the 395 respondents across the following five selected states: Virginia (161), New York (94), Connecticut (56), New Jersey (42), and Pennsylvania (42).

Table 12

General Demographic Data for Participants

Demographic Data		States					Total
		VA 161(%)	NY 94(%)	CT 56(%)	NJ 42(%)	PA 42(%)	395(%)
Gender	Male	127(32.2)	77(19.5)	52(13.2)	32(8.1)	36(9.1)	324(82)
	Female	34(8.6)	17(4.3)	4(1)	10(2.5)	6(1.5)	71(18)
Grade	Middle S.	57(14.4)	40(10.1)	22(5.6)	16(4.1)	13(3.3)	148(37.5)
	High S.	98(24.8)	39(9.9)	30(7.6)	24(6.1)	28(7.1)	219(55.4)
	Both	6(1.5)	15(3.8)	4(1)	2(0.5)	1(0.3)	28(7.1)
Degree	Bachelor's	75(19)	19(4.8)	13(3.3)	23(5.8)	15(3.8)	145(36.7)
	Master's	83(21)	73(18.5)	38(9.6)	19(4.8)	23(5.8)	236(59.7)
	Doctoral	3(0.8)	2(0.6)	5(1.3)	0(0)	4(1)	14(3.6)
License	TE	130(32.9)	89(22.5)	54(13.7)	40(10.1)	42(10.6)	355(89.9)
	Car. & Tech.	26(6.6)	4(1)	2(0.5)	2(0.5)	0(0)	34(8.6)
	Science	5(1.3)	1(0.3)	0(0)	0(0)	0(0)	6(1.5)
Average	Middle S.	10.08	10.87	8.47	8.25	7.84	9.58
Yrs of	High S.	9.48	8.20	11.17	8.32	14.34	9.86
Teaching	Both	13.45	15.73	8.14	16.78	4.80	12.97

Among the 395 technology education teachers who responded to the composite online survey, 324 (82%) were male and 71 (18%) were female. At the time of the study, 148 (37.5%) were teaching middle school grades, 219 (55.4%) were teaching high school grades, and 28 (7.1%) were teaching both. Of the 395 teachers, 145 (36.7%) held bachelor's degrees, 236 (59.7%) held master's degrees, and 14 (3.6%) held doctoral degrees. Furthermore, 355 (89.9%) were licensed in technology education. The average number of years of teaching was 10 at the middle school, 10 at the high school, and 13 in both.

In terms of the technology education teachers' preparation and experience for teaching biotechnology, this information was organized into three sets of data (pre-service preparation, in-service professional development, and experience teaching biotechnology) as presented in Table 13. Among the 395 respondents, 328 (83%) technology teachers had never participated in formal coursework relevant to the teaching of biotechnology in their pre-service teacher programs. The remaining 67 (17%) respondents had taken one or more course(s) aimed at teaching biotechnology in their teacher preparation programs. Among the 67 respondents, 56 took one course, 8 took two courses, and 3 took five or more courses. It is interesting to note that the amount of course work teacher takes across states: 14 (33.3%) of the respondents in Pennsylvania and 13 (31%) of the respondents in New Jersey took one or more course(s), while 19 (11.8%) in Virginia, 11 (11.7%) in New York, and 10 (17.9%) in Connecticut took one or more course(s) relevant to the teaching of biotechnology in their pre-service teacher programs.

Table 13

Participants' Preparation and Experience for Teaching Biotechnology

Category		States					Total
		VA	NY	CT	NJ	PA	395(%)
		161(%)	94(%)	56(%)	42(%)	42(%)	
Pre-service	None	142(35.9)	83(21)	46(11.6)	29(7.3)	28(7.1)	328(83)
	1 or more	19(4.8)	11(2.8)	10(2.5)	13(3.3)	14(3.5)	67(17)
In-service	None	128(32.4)	79(20)	52(13.2)	29(7.3)	26(6.6)	314(79.5)
	Participation	33(8.4)	15(3.8)	4(1)	13(3.3)	16(4.1)	81(20.5)
Teaching Biotech.	None	126(31.9)	76(19.2)	50(12.7)	34(8.6)	30(7.6)	316(80)
	Experience	35(8.9)	18(4.6)	6(1.5)	8(2)	12(3)	79(20)

Concerning the in-service professional development (PD) for teaching biotechnology, of the 395 technology education teachers 314 (79.5%) had no in-service PD and 81 (20.5%) attended a variety of in-service PD sessions for teaching biotechnology in their technology education classrooms. The types of in-service PD for teaching biotechnology included the following: one-day workshop (53), two-day workshop (16), one-week workshop (10), two-week workshop (4), course (8), and other (21). Sixteen (38.1%) respondents in Pennsylvania and 13 (31%) respondents in New Jersey had participated in in-service PD for teaching biotechnology, while only 4 (7.1%) in Connecticut had done so.

Finally, 316 (80%) of the respondents had no experience teaching biotechnology in their classrooms, while the remaining 79 (20%) respondents have some experience teaching biotechnology in their classrooms. Of these 79 respondents, the average number of years of teaching biotechnology at the middle school level, high school level, ,and both middle and high school levels were 5, 3, and 6, respectively. Twelve (28.6%) of the teachers from Pennsylvania and 35 (21.7%) from Virginia had experience teaching biotechnology, but only 6 (10.7%) of the Connecticut teachers had experience teaching biotechnology in their classrooms.

Instrument

The online composite survey (*TTBTTB*) developed for this study consists of four separate instruments that collect demographic data, teachers' attitudinal data, teachers' motivational data, and open ended data. The reliability estimates and analysis for the *TTBTTB* instrument in the major study were conducted using Cronbach's Alpha and descriptive statistics. The results of the analysis for the *ATTB*, *BTTB*, and open ended data are presented in the following section

Data examining teachers' attitudes toward biotechnology were collected using the 35 item *Attitude Toward Teaching Biotechnology* (*ATTB*) instrument that measures the seven stages of technology teachers' concern toward teaching biotechnology. This instrument presents items in mixed order and is scored (as explained in Chapter III) using an 8 point Likert scale ranging from “not true of me now” (0) to “very true of me” (7). Each stage of concern is measured by analyzing the scores of five specific items, resulting in composite scores for the seven stages (awareness, informational, personal, management, consequence, collaboration, and refocusing). The possible range of scores in each stage is 0 to 35, which can then be converted into percentile scores as recommended by Hall & Rutherford (1977) in order to generate graphic representations of the concern profiles. The *ATTB* in this major study had a high internal consistency for the 35 items, indicating a fairly good reliability (*Cronbach's Alpha* = 0.890). Furthermore, the reliability for each of the seven stages ranged from 0.731 to 0.899, which is consistent with those from previous studies (Christou et al., 2004; Dunn, 2008, George, Hall, & Stiegelbauer, 2006) and pilot study using the Stages of Concern instrument. The means, Standard Deviations (SD), minimum/maximum, reliability, and percentile means for all seven stages are presented in Table 14.

Table 14

Descriptive Statistics for the Seven Stages

Stages of Concern	Mean	SD	Reliability
Awareness	14.44	9.22	.804
Informational	19.42	8.20	.753
Personal	17.14	9.23	.841
Management	15.25	7.81	.717
Consequence	15.85	8.85	.819
Collaboration	16.16	9.92	.897
Refocusing	14.60	9.46	.879

The *ATTB* was used to measure technology teachers' attitudes toward teaching biotechnology in secondary school level technology education classrooms as the dependent variable in this study. In general, it would be expected that technology teachers are more likely to have high internal concerns and low external concerns toward teaching biotechnology during the pre-stage and early stages, while in the late phase there would tend to be a shift towards external concerns that concentrate on student learning and development. For participants in this study, composite mean scores for internal concerns (awareness, informational, personal, and management) and external concerns (consequence, collaboration, and refocusing) are expressed as percentile scores and were calculated in order to measure the implementation of biotechnology instruction as the dependent variables. The composite mean scores, percentile mean scores, standard deviations, and reliabilities for both sets of concerns are presented in Table 15.

Table 15

Descriptive Statistics for Internal and External Concerns

Concerns	Mean	SD	Reliability
Internal Concerns	15.03	8.95	0.856
(4 stages, 20 items)			
External Concerns	16.61	6.17	0.924
(3 stages, 15 items)			

A factor analysis was used to examine the subscale of the *Belief To Teach Biotechnology* (*BTTB*) instrument in order to determine the number of sub-factors in the motivational scale (*BTTB*). Factor analysis for all 12 items in the *BTTB* was conducted using *Principal Components Method* (*Varimax Rotated*) in SPSS v. 16. Based on the results of the factor analysis, the mean score of the items within each factor was calculated. The in-depth results of the descriptive statistics and factor analysis will be presented in the beginning part of the analysis section for research sub-question 1.

Qualitative analysis was conducted for the open ended question relevant to each research sub-question. Thematic analysis of the written responses was conducted through the creation of emergent themes or concepts and presented in terms of the frequency each occurred.

Dependent Variable

As the dependent variable, the *ATTB* was analyzed statistically to confirm the patterns of internal concerns and external concerns among the participants. Hall et al. (1977) differentiated these in terms of two graphic presentations: 1) "non-users", who manifested higher internal concerns at the awareness, informational, personal, and management stages and lower external concerns at the consequence, collaboration, and refocusing stages, and 2) "users", who manifested higher external concerns at the consequence, collaboration, and refocusing stages and lower internal concerns at the awareness, informational, personal, management stages. With this in mind, the *ATTB* data were analyzed using an independent *t*-test for whether or not the participants had experience teaching biotechnology.

The results of the independent *t*-test between experienced and non-experienced groups revealed that six significant differences were found in the stages of awareness ($t = 12.575$, $p < .001$), personal ($t = 2.315$, $p < .05$), management ($t = 3.489$, $p < .001$), consequence ($t = -8.686$, $p < .001$), collaboration ($t = -8.693$, $p < .001$), and refocusing ($t = -12.105$, $p < .001$), as presented in Table 16.

Table 16

Mean Comparison by Teachers' Experience of Teaching Biotechnology

Internal/External Concern	Stages of Concern	Non-Experienced (N=79)	Experienced (N=316)	*t*
Internal Concern	Awareness	47.06	18.11	12.575***
	Informational	56.30	52.22	1.578
	Personal	50.31	43.65	2.315*
	Management	45.50	35.84	3.489***
External Concern	Consequence	40.64	63.86	-8.686***
	Collaboration	41.10	66.54	-8.693***
	Refocusing	35.70	65.82	-12.105***

* Significant mean difference at the 0.05 level

*** Significant mean difference at the 0.001 level

Specifically, the technology teachers who had experience teaching biotechnology had significantly higher scores in the awareness, personal, and management stages than the technology teachers who had no experience teaching biotechnology. On the other hand, the technology teachers who had no experience teaching biotechnology had significantly lower scores in the consequence, collaboration, and refocusing stages than the experienced teachers.

These results are consistent with Hall et al.'s (1977) distribution of internal and external concerns. High internal concerns (awareness, informational, personal, and management) are related to the non-implementation of biotechnology instruction and external concerns (consequence, collaboration, and management) are strongly connected to the adoption and diffusion of the biotechnology teaching. Based on the stages of concerns of the two groups (experienced and non-experienced), Figure 6 provides a graphic presentation of the teachers' concerns.

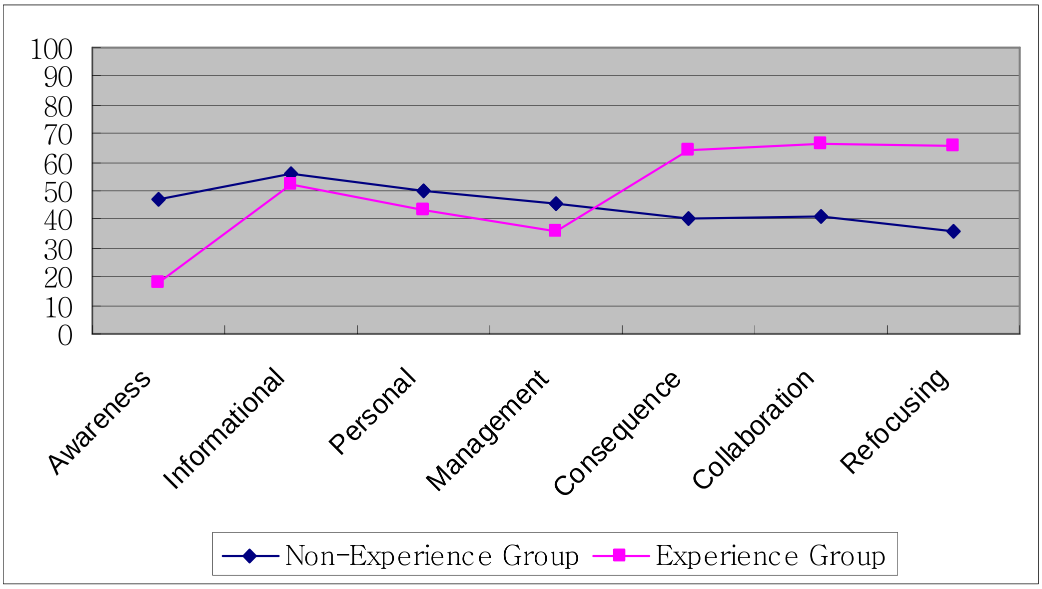

Figure 6. Stages of concern profiles for experienced/non-experienced groups

To identify the mean differences of the teachers' concerns, the *ATTB* were statistically tested using the following key demographic variables: state, gender, and school grade level. Mean comparison tests (independent *t*-test and one-way ANOVA) were used for this analysis. The results indicate that the means of the stages of concerns by gender, state and school grade level differed significantly as follows.

Mean Comparison by Gender One significant difference was found in the stage of awareness ($t = 2.106$, $p < 0.05$) in terms of the participants' gender. The independent *t*-test indicated that the awareness scores of male teachers ($\bar{x} = 42.57$) were significantly greater than those of the female teachers ($\bar{x} = 35.33$).

Mean Comparison by States This study examined the equal variances of teachers' stages of concerns among the five states with *Levene*'s test (homogeneity of variance test) because the homogeneity of variance of the dependent variable is the basic assumption underlying the ANOVA test (Howell, 2007). The results of the *Levene*'s test found no significant differences, as shown in Table 17.

Table 17

Test of Homogeneity of Variances for Teachers' Stages of Concerns

Stages of Concern	df1	df2	*Levene Statistic*	*p*
Awareness	4	390	1.304	.268
Informational	4	390	1.513	.198
Personal	4	390	1.444	.219
Management	4	390	.569	.685
Consequence	4	390	.753	.556
Collaboration	4	390	.244	.913
Refocusing	4	390	.179	.949

Mean comparison tests (one-way ANOVA) and multiple comparison (post hoc test: *Scheffe*) were conducted to compare teachers' stages of concerns among the five states (VA, NY, CT, NJ, & PA) and revealed two significant differences in the awareness ($F = 3.728, p < 0.01$) and refocusing ($F = 3.865, p < 0.01$) stages.

The ANOVA and post hoc test (*Scheffe*) indicated that the awareness scores for NJ (μ = 49. 31) and CT ($\bar{x}$ = 49.23) were significantly greater than for PA ($\bar{x}$ = 32.78), and the refocusing scores for PA ($\bar{x}$ = 54.69) were significantly greater than those for NJ ($\bar{x}$ = 36.80) and CT ($\bar{x}$ = 35.05), as shown in Table 18 and Figure 7.

Table 18

Mean Comparison of the Seven Stages of Concerns for the Five States

Stages of Concern	VA	NY	CT	NJ	PA	*F*
Awareness	40.00	38.90	49.23	49.31	32.78	3.728**
Informational	54.49	51.17	57.90	57.45	51.80	1.560
Personal	47.13	51.55	48.97	45.03	48.55	1.081
Management	42.09	46.20	43.62	40.27	46.59	.923
Consequence	44.56	45.74	41.68	.42.10	55.03	2.070
Collaboration	44.56	49.33	43.72	39.65	55.23	2.180
Refocusing	40.90	43.52	35.05	36.80	54.69	3.865**

** Significant mean difference at the 0.01 level

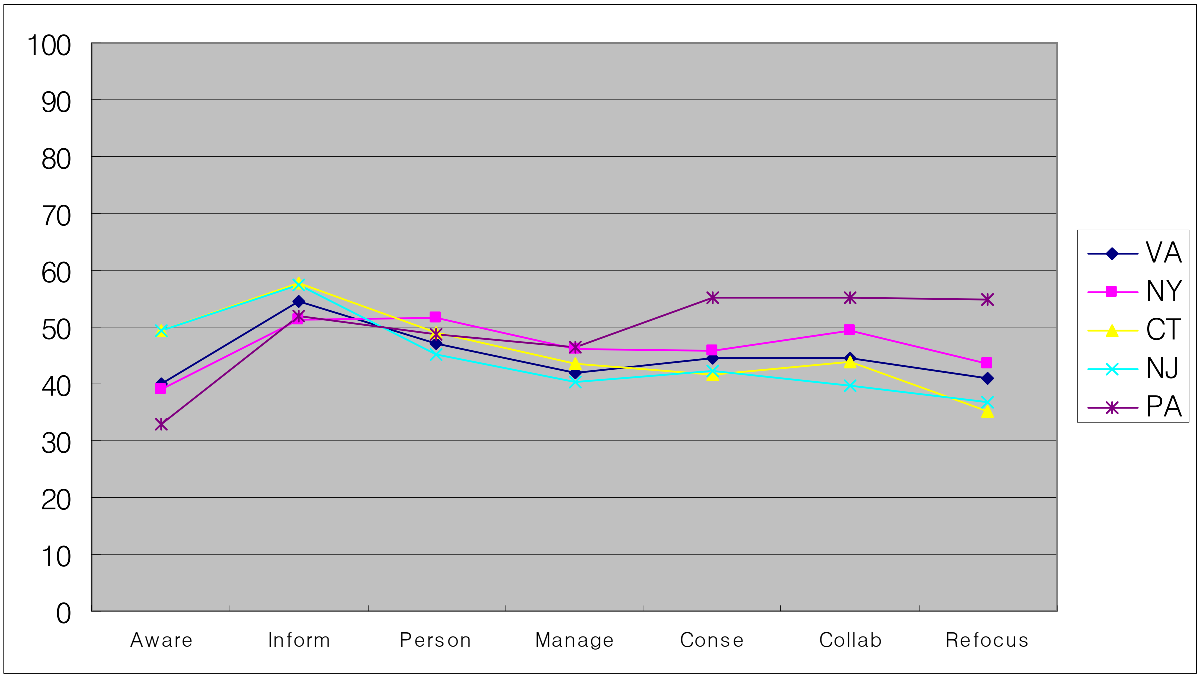

Figure 7. Stages of concerns for the five states

Mean Comparison by School Grade According to the mean comparison test (independent *t*-test) by school grade, three significant differences were found in the stages of awareness (t = -2.210, $p < 0.05$), consequence (t = 2.355, $p < 0.05$), and refocusing (t = 2.355, $p < 0.01$), as shown in Table 19. The independent *t*-test indicated that the awareness scores of the high school teachers ($\bar{x}$ = 44.37) were significantly greater than those of the middle school teachers ($\bar{x}$ = 38.14) and the consequence and refocusing scores of the middle school teachers ($\bar{x}$ = 48.91 and $\bar{x}$ = 46.94 respectively) were significantly greater than those of the high school teachers ($\bar{x}$ = 42.58 and $\bar{x}$ = 37.18 respectively). The teachers' concerns by school grades taught are presented in Figure 8.

Table 19

Mean Comparison of the Seven Stages of Concern by School Grades Taught

Stages of Concern	Middle School (N=148)	High School (N=219)	*t*
Awareness	38.14	44.37	-2.210*
Informational	56.81	53.34	1.384
Personal	50.94	47.21	1.310
Management	43.68	43.37	.135
Consequence	48.91	42.58	2.355*
Collaboration	48.20	43.63	1.506
Refocusing	46.94	37.18	3.424**

* Significant mean difference at the 0.05 level

** Significant mean difference at the 0.01 level

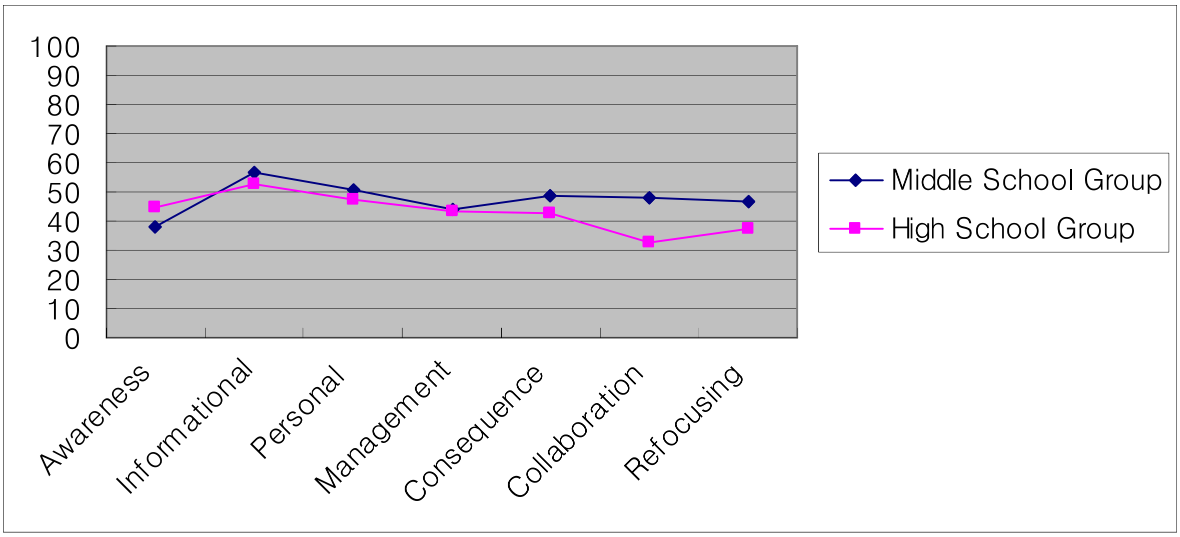

Figure 8. Stages of concern by school grades taught

Research Question and Sub-Questions

This study was guided by a main research question and three Research Sub-Questions, as described in the first section of this chapter. This section presents an outline of the analysis for each research sub-question.

This study employed *ATTB* as the dependent variable with which to measure the technology education teachers' concerns toward teaching biotechnology. In particular, two sets of scores, internal concerns and external concerns, were used to measure propensity to implement biotechnology instruction. To answer the Research Question and Sub-Questions, three key independent variables (teachers' motivation, professional development, and infrastructure) were collected from demographic data, *BTTB*, and open ended questions in the on-line survey. Descriptive statistics, mean comparison tests (independent t-test and one-way ANOVA), correlation analyses, multiple regressions, and theme analyses were performed in answering the three Research Sub-Questions. The independent variables, dependent variables, and analysis for each Research Sub-Question are presented in Tables 20, 21, and 22.

The first Research Sub-Question, "How do motivational constructs of technology education teachers affect the implementation of biotechnology instruction in the secondary level technology education classrooms?" was answered by conducting multiple regressions and correlations to determine the extent to which the motivational constructs (predictors) contributed to the teachers' implementation of biotechnology instruction as shown in Table 20.

Table 20

Analysis for Research Sub-Question 1

Independent Variables	Dependent Variables	Analyses
Motivational constructs	Two Concerns (*ATTB*)	Factor Analysis
(*BTTB*)	1. Internal concerns	Descriptive Statistics
1. Expectancy	2. External concerns	Mean Comparison Tests
2. Value		Correlations
3. Cost		Multiple Regressions
		Theme Analysis

The motivational constructs were drawn from the results of a factor analysis and the descriptive statistics (mean, standard deviation, and minimum/maximum) of the motivational constructs presented. Also, correlations and multiple regressions between the motivational constructs and two concerns (internal and external) were conducted. Finally, the qualitative findings of the thematic analysis for two open-ended questions (#1 & #3) were presented, along with the quantitative findings investigated above.

The second Research Sub-Question, “How does the preparation (pre-service and in-service professional development) of technology education teachers affect their decision to implement biotechnology instruction in their secondary level technology education classrooms?” was answered by presenting profiles of technology teachers’ concerns toward teaching biotechnology based on the pre-service courses and in-service training they had received (Table 21). These profiles were prepared using descriptive statistics and mean comparison tests (independent *t*-test and one-way ANOVA). Also, thematic analyses of two open-ended questions (#2 & #4) were performed and the results were presented.

Table 21

Analysis for Research Sub-Question 2

Independent Variables	Dependent Variables	Analyses
Professional Development	Seven Stages of Concern	Descriptive Statistics
1. Pre-service courses	Two Concerns (*ATTB*)	Mean Comparison Tests
2. In-service training	1. Internal concerns	Theme Analysis
	2. External concerns	

The third Research Sub-Question, “How does the infrastructure supporting technology education program affect technology teachers’ implementation of biotechnology instruction in their secondary technology education classroom?” was answered by examining the findings of the thematic analysis of open-ended question #5 (Table 22).

Table 22

Analysis for Research Sub-Question 3

Independent Variables	Dependent Variable	Analyses
Infrastructure Issues	Implementation of Biotechnology Instruction	Theme Analysis

Summary

The participants, instrument, dependent variable (ATTB), and Research Question and Sub-Questions of the main survey were described in this section. The participants were 395 technology education teachers within five purposefully selected eastern seaboard states of the U.S. The data collected from the online composite survey consisted of four distinct parts (demographic data, *ATTB*, *BTTB,* and open ended data).

General demographic data (state, teaching grade, degree, license, average years of teaching), participants' data regarding their preparation for teaching biotechnology (pre-service preparation and in-service Professional Development), and their experience teaching biotechnology in secondary level technology education programs were presented. Specifically, participants' experience teaching biotechnology in this major study presented insufficient implementation of biotechnology instruction in the secondary level technology education programs. This was followed by an analysis of the data gathered by the *ATTB* and *BTTB* to confirm the instruments' reliability and the results indicated that fairly good reliabilities were obtained for both data sets. Specifically, the *ATTB* as the dependent variable was analyzed using both descriptive statistics and mean comparison tests. Finally, the Research Question and Sub-Questions were analyzed to frame the data analysis. The findings of these analyses indicated problematic status regarding biotechnology teaching, indicating low implementation of biotechnology instruction and low participation of PD related to biotechnology instruction. These findings were consistent with prior studies that presented low implementation of biotechnology instruction (Brown et al., 1998; Sanders, 2001). The main Research Question investigated predictive value of key factors that affect the implementation of biotechnology instruction. The data collected through focusing on the three identified factors (motivation, professional development, and infrastructure) will be analyzed to answer the Research Sub-Questions. Specific analyses were used to answer each Research Sub-Question and the results will be presented in the next section.

Research Sub-Question 1

Research Sub-Question 1, "How do motivational constructs of technology education teachers affect the implementation of biotechnology instruction in their secondary level technology education classrooms?" investigated the impact of technology teachers' motivation on the biotechnology teaching. The technology education teachers' motivational data were collected from the *BTTB* of the *TTBTTB* survey. The implementation of the biotechnology instruction was measured by the *ATTB* of the *TTBTTB* survey.

To answer the Research Sub-Question 1, an exploratory factor analysis, descriptive statistics, mean comparison tests, correlations, multiple regressions, and theme analysis were conducted. The motivational data collected from the *BTTB* were first analyzed by exploring the motivational constructs through an exploratory factor analysis and investigated through descriptive statistics and mean comparison tests. In addition, in order to examine the impact of the motivational constructs (the independent variable) on the biotechnology teaching (the dependent variable), correlations and multiple regressions were conducted. Finally, the thematic analysis of the open-ended questions (#1: students' benefits for being biotechnologically literate & #3: teachers' competence toward teaching biotechnology) investigated the impact of the motivational constructs on biotechnology teaching.

Motivational Constructs

The motivational data from *BTTB* (12 items) was first categorized into motivational constructs for further analysis (correlations and multiple regressions). The motivational constructs were discussed with the instrumentation process of the *BTTB* and was drawn from an exploratory factor analysis.

The *BTTB* was developed according to the instrument and definition proposed by Eccles & Wigfield (1995) and consisted of five intended motivational constructs (expectancy, intrinsic interest, attainment, utility, and cost). In particular, the three motivational constructs of intrinsic interest, attainment, and utility were specified as the sub-factors of the value construct. Therefore, motivational factors in the *BTTB* could consist of either two factors (expectancy and value) or five factors (expectancy, intrinsic interest, attainment, utility, and cost). With this in mind, an exploratory factor analysis was used to examine the sub-factors of the *BTTB* (motivational instrument) in order to determine whether the current data best fit the five factors or three factors model using the *Principal Components* and *Varimax* rotated method in SPSS 16. The results revealed that three factors had clear loadings of all items, namely the three motivational constructs shown in Table 23.

Table 23

Motivational Constructs Drawn from Factor Analysis

Item Number	Motivational Constructs	Sub-Constructs	Factors		
			Factor 1	Factor 2	Factor 3
Item 1	Expectancy	Expectancy	**0.903**	0.336	-0.110
Item 2		Expectancy	**0.902**	0.359	-0.082
Item 3	Value	Intrinsic Interest	0.327	**0.815**	-0.042
Item 4		Intrinsic Interest	0.328	**0.817**	-0.046
Item 5		Attainment	0.273	**0.850**	0.001
Item 6		Attainment	0.184	**0.878**	0.009
Item 7		Attainment	0.242	**0.871**	-0.027
Item 8		Utility	0.095	**0.889**	0.036
Item 9		Utility	0.112	**0.883**	0.045
Item 10	Cost	Cost	-0.121	-0.074	**0.870**
Item 11		Cost	-0.052	0.064	**0.907**
Item 12		Cost	-0.001	0.016	**0.783**

According to the factor loading scores in Table 23, items 1 and 2 were grouped into factor 1 (expectancy), items 3, 4, 5, 6, 7, 8, and 9 were grouped into factor 2 (value), and items 10, 11, and 12 were grouped into factor 3 (cost). In particular, three sub-constructs (intrinsic interest, attainment, and utility) of the value were categorized into one factor: all had high loading scores. Even though the instrument was originally developed for the five factors model (expectancy, intrinsic interest, attainment, utility, and cost), this study accepted the three factors model based on the clear results from the exploratory factor analysis. The three motivational factors identified were expectancy, value, and cost. The descriptive statistics for these three motivation constructs are shown in Table 24. The reliabilities for expectancy (α = .975), value (α = .958), and cost (α = .819) confirmed that these were reliable measurements.

Table 24

Descriptive Statistics for Three Motivational Constructs

Constructs	Reliability	Minimum	Maximum	Mean	Std. Deviation
Expectancy	.975	1	7	3.51	1.497
Value	.958	1	7	3.90	1.588
Cost	.819	1	7	4.51	1.378

Once the three motivational constructs had been confirmed, mean comparison tests (independent *t*-test and one-way ANOVA) for key demographic variables were conducted in order to identify the technology education teachers' motivation toward teaching biotechnology. The key demographic variables were state, gender, school grade, experience of teaching biotechnology, and in-service training participation. In terms of gender, experience of teaching biotechnology, and in-service training participation, the means of the three motivational constructs were significantly different, as shown in Table 25.

Table 25

Mean Comparison Tests for Key Demographics (Independent t-tests)

Demographic Data		Expectancy		Value		Cost	
		Mean	*t*	Mean	*t*	Mean	*t*
Gender	Male	3.48	-1.141	3.81	-1.179*	4.52	-2.036
	Female	3.70		4.25		4.74	
Biotech Teaching	Experience	4.81	-8.868***	5.15	-7.808***	4.06	3.750***
	Non-Exper.	3.22		3.60		4.68	
In-service Training	Participant	4.44	-5.905***	4.77	1.392***	4.36	1.392
	Non-Partici.	3.31		3.69		4.61	

* Significant mean difference at the 0.05 level

*** Significant mean difference at the 0.001 level

The result of the independent t-test for gender (t = -1.179, p < .05) indicated that the value score for female teachers ($\bar{x}$ = 4.25) was significantly greater than that for male teachers ($\bar{x}$ = 3.81). In addition, the results of the independent t-test for biotechnology teaching experience presented clear mean differences for expectancy (t = -8.868, p < .001), value (t = -7.808, p < .001), and cost (t = 3.750, p < .001). Specifically, the expectancy score of biotechnology teaching for experienced teachers ($\bar{x}$ = 4.81) was significantly greater than that for the non-experienced group ($\bar{x}$ = 3.22) and the value score of biotechnology teaching for experienced teachers ($\bar{x}$ = 5.15) was also significantly greater than that for the non-experienced group ($\bar{x}$ = 3.60). However, the cost score for the non-experienced group ($\bar{x}$ = 4.68) was significantly greater than that for the group of experienced biotechnology teaching ($\bar{x}$ = 4.06). Lastly, the expectancy and value for teachers who had participated in in-service training were significantly greater than those for non-participants (t = -5.905, p < .001; t = -5.161, p < .001, respectively).

Correlational Analyses

Two correlational analyses between the identified motivational constructs and concerns were conducted for two multiple regression analyses. The relationships of the motivational constructs with two concerns toward teaching biotechnology are reported as Pearson r values in Table 26.

Table 26

Correlation between Motivational Constructs and Two Concerns

		Expectancy	Value	Cost
Internal Concerns	Pearson Correlation	-.246***	-.005	.265***
	Sig. (2-tailed)	.000	.932	.000
	N	395	395	395
External Concerns	Pearson Correlation	.518***	.639***	-.215***
	Sig. (2-tailed)	.000	.000	.000

N	395	395	395

When the predictors (three motivational constructs: expectancy, value, and cost) were examined regarding their relationship to the two types of concerns (internal and external), the following motivational constructs were found to be significantly correlated to internal concerns: 1) expectancy (r = -.246, $p < 0.001$) and 2) cost (r = .265, $p < 0.001$). In addition, all motivational constructs were found to be significantly correlated to external concerns: 1) expectancy (r = .518, $p < 0.001$), 2) value (r = .639, $p < 0.001$), and 3) cost (r = -.215, $p < 0.001$). The internal concerns toward teaching biotechnology had a negative correlation with expectancy but a positive correlation with cost. Also, the external concerns toward teaching biotechnology had a positive correlation with two motivational constructs (expectancy and value) but a negative correlation with cost.

Hierarchical Multiple Regressions

Based on the correlational analyses, two hierarchical multiple regression analyses were conducted by regressing three motivational constructs on the internal concerns and external concerns. The two hierarchical multiple regressions with which the effects of independent variables can be examined after controlling for the effects of demographic variables step by step were conducted in this study. The analysis model first controlled for the effect of teacher gender and grade, then added motivational constructs (expectancy, value, and cost) onto the model, one by one. These analyses investigated the extent to which the three motivational constructs (predictors) contributed to the implementation of biotechnology instruction.

The multiple regression result for internal concerns toward teaching biotechnology showed that three independent variables (expectancy, value, and cost) successfully predicted the technology teachers' internal concerns toward teaching biotechnology, as indicated by the F-value of 20.248 ($p < .001$) and R-square of 0.134 shown in Table 27. The R square value suggests that 13.4% of the variance in the teachers' internal concerns is explained by this model (expectancy, value, and cost). The coefficients for the teachers' expectancy (β = -3.970, $p < .001$), value (β = 3.260, $p < .001$), and cost (β = 3.946, $p < .001$) were all significant, and this was also verified by the significant Pearson's Coefficients in Table 26. The technology education teachers' expectancy and values tend to increase as the internal concerns decrease, while their perceived cost increases as the internal concerns increase.

Specifically, the results of the hierarchical multiple regression indicated the impact of each motivational construct on internal concerns as follows: 1) 5.9% of the variance in the technology education teachers' internal concerns is explained by their' expectancy, 2) 2.8% of the variance in the technology education teachers' internal concerns is explained by their value, and 3) 4.8% of the variance in the technology education teachers' internal concerns is explained by their perceived cost.

Table 27

Hierarchical Multiple Regression Analysis Summary for Internal Concerns (N=395)

Variable	B	SEB	β	R^2	$\triangle R^2$
Step 1				0.002	
Gender	-2.450	3.209	-0.039		
Grade	0.351	0.903	0.020		
Step 2				0.061***	0.059***
Expectancy	-3.970	0.803	-0.244		
Step 3				0.080***	0.028***
Value	3.260	0.934	0.212		
Step 4				0.137***	0.048***
Cost	3.946	0.851	0.223		

*** $p < 0.001$

The multiple regression result for external concerns toward teaching biotechnology showed that three independent variables (expectancy, value, and cost) predicted the teachers' external concerns toward teaching biotechnology, as indicated by F-value of 111.388 ($p < .001$) and R-square of 0.466 shown in Table 28. The R square value suggests that 46.6% of the variance in the teachers' external concerns is predicted by this model (expectancy, value, and cost). The first two motivational constructs (expectancy and value) tend to increase as teachers' external concerns increase, while the perceived cost decreases as teachers' external concerns increase. The coefficients for the teachers' expectancy ($\beta = 9.362$, $p < .01$), value ($\beta = 8.683$, $p < .001$), and cost ($\beta = -3.078$, $p < .001$) were all significant, and this was once again confirmed by the significant Pearson's Coefficient in Table 26.

Table 28

Hierarchical Multiple Regression Analysis Summary for External Concerns (N=395)

Variable	B	SEB	β	R^2	$\triangle R^2$
Step 1				0.011	
Gender	5.959	3.538	0.085		
Grade	1.312	0.996	0.066		
Step 2				0.277***	0.266***
Expectancy	9.362	0.780	0.519		
Step 3				0.442***	0.165***
Value	8.683	0.809	0.510		
Step 4				0.466***	0.024***
Cost	-3.078	0.741	-0.157		

*** $p < 0.001$

Specifically, the results of the hierarchical multiple regression indicated the impact of each motivational construct on external concerns as follows: 1) 26.6% of the variance in the technology education teachers' external concerns is explained by their' expectancy, 2) 16.5% of the variance in the technology education teachers' external concerns is explained by their value, and 3) 2.4% of the variance in the technology education teachers' external concerns is explained by their perceived cost.

Sub-Question 1: Theme Analysis of the Two Open-Ended Questions

An in-depth investigation into (a) students' benefits for being biotechnologically literate (open-ended question #1) and (b) teachers' competency toward teaching biotechnology (open-ended question #3) was performed in order to investigate motivational issues related to biotechnology teaching. The two open-ended questions were included in the survey to elicit responses that would shed light on the extrinsic utility and expectancy raised by Research Sub-Question 1. The responses from the two open ended questions were analyzed using "theme analysis", identifying the themes and examining frequencies (Bogdan & Biklen, 1998).

The first open ended question #1, "What benefits are there for developing students who are more biotechnological literate specifically through technology education programs?" concerns the benefits the students gain as a result of enhancing their biotechnological literacy through technology education programs. Of the 395 survey participants, 210 (53.16%) technology teachers responded to open ended question #1, although only 193 (48.86%) of these responses were usable for the theme analysis. The analysis (Table 29 and Figure 9) revealed four emergent themes: Technological world (f = 48), students' job/career (f = 48), hands-on experience ($f = 24$), and integration ($f = 19$)

Table 29

Key Themes of Students' Benefits through Being Biotechnologically Literate

Emergent Themes	Explanation of the Emergent Themes	*F*
Technological World	Significance and usefulness of the biotechnology in our contemporary /future ***technological world.***	48
Career/Job	Usefulness for exploring and preparing for students' ***career and job*** related to biotechnology.	48
Hands-on Experience	Students' ***hands-on***/practical experience	24
Integration	Students' experience of the ***integrated*** instruction with science (biology) and mathematics	19

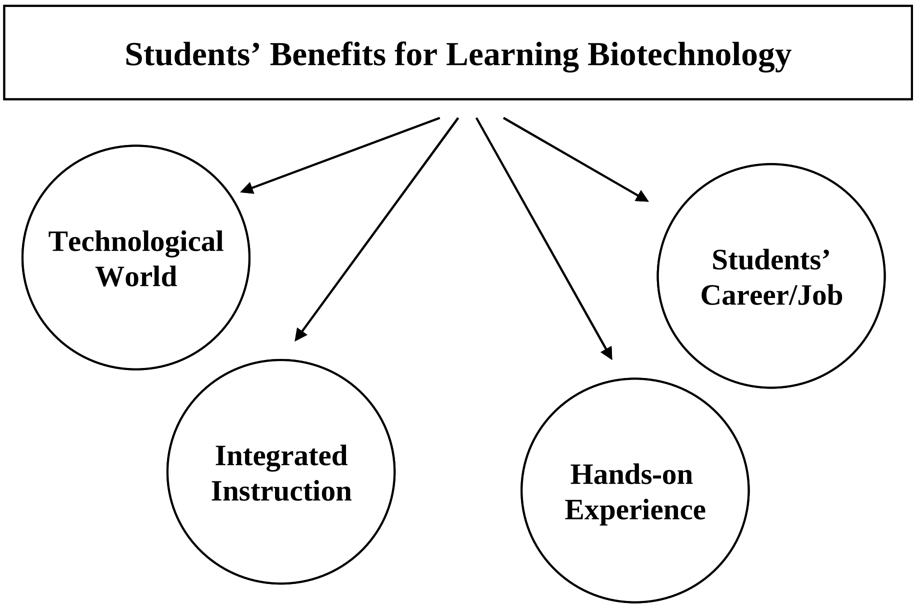

Figure 9. Four themes of the students' benefits from learning biotechnology

Technology education teachers participated in this study emphasized the significance and usefulness of being biotechnologically literate in our ***contemporary and future technological world*** (*f* = 48). Typical examples selected from the 48 responses reflecting this concern are as follow:

> Areas of biotechnology are discussed everyday/everywhere in our contemporary and future technological society and therefore that learning about biotechnology concepts is a necessary part of modern education. I believe its' emerging technology in our technological world (society) to be literate for all people.

> Our technological word has emphasized "green" technology. Environmental protection, energy dependence, health concerns have been significant issues in our society. I believe that biotechnology content in our TE classrooms could work well with the topics.

The second benefit of becoming biotechnologically literate was the anticipated usefulness of exploring and preparing for the ***students' future career/job*** (*f* = 48). Technology education teachers in this study indicate the exploration and preparation for students' future career/job as a critical students' benefit through learning biotechnology. The following select statements are typical examples that reflect participants' perspectives regarding students' benefits of being biotechnologically literate:

In order to develop a literate workforce, students have to be prepared for the biotechnology areas that are the hottest technology. Also, more and more jobs will be in the biotechnology areas. Therefore, we should teach biotechnology in our technology education programs.

> It assists the development of students who understand how biotechnology is used to ensure that certain technologies are not doing damage to our environment. Likewise it ensures that my students have more of an appreciation of careers related to biotechnology and agriculture technology.

The third benefit was the experience gained as a result of the ***integrated instruction with science and mathematics*** (*f* = 16). Typical examples of these type responses are as follows: "Students would have a better understanding for modern technology, how biology and technology are interconnected, and the future innovations that are possible through biotechnology," "Biotechnology instruction perfectly provides experience of integrating biology and technology for my students," and "It's a good example for implementing STEM education in my TE classroom."

The students' ***hands-on experience*** (*f* = 14) was the final benefit identified that was linked to biotechnology literacy. The following select statements are typical examples that reflect this concern:

In technology education, students learn biotechnology by applying hands-on application of theory. In other words, the justification for incorporating biotechnology content into technology education is to bringing hands-on (interesting, practical, and meaningful) experience in the technology education programs.

TE allows a much more hands on approach than may otherwise be available to students in other subjects. The application of these skills is important to implement biotechnology instruction in TE classrooms. Hands-on approach is a beauty for TE.

Another open ended question #3, “How competent do you feel you are to teach about biotechnology literacy in you classroom?” asked the teachers about their competency to teach biotechnology. Of the 395 survey participants, 201 (50.88%) technology teachers responded to the open ended question #3, of which 189 (47.84%) responses were usable for the theme analysis. Of the 189 respondents, 119 (62.96%) expressed negative feelings about their competency, 50 (26.45%) expressed positive feelings, 10 (5.29%) considered hey had an average competence, and 10 (5.29%) simply replied “Don’t know.” The theme analysis revealed five emergent themes (training, support, experience, information, and interest), indicating why technology teachers did or did not consider themselves competent to teach biotechnology (Table 30 and Figure 10).

Table 30

Key Themes of Teachers' Competency toward Teaching Biotechnology

Emergent Themes	Explanation of the Emergent Themes	*F*
Professional Development	***Professional development*** (pre-service/in-service training) related to the biotechnology teaching	32
Information	***Information*** for teaching biotechnology	14
Support	School environment, colleagues, administration for ***supporting*** biotechnology teaching	11
Experience	***Experience*** teaching biotechnology content	10
Interest	***Enjoying*** biotechnology content or its teaching	7

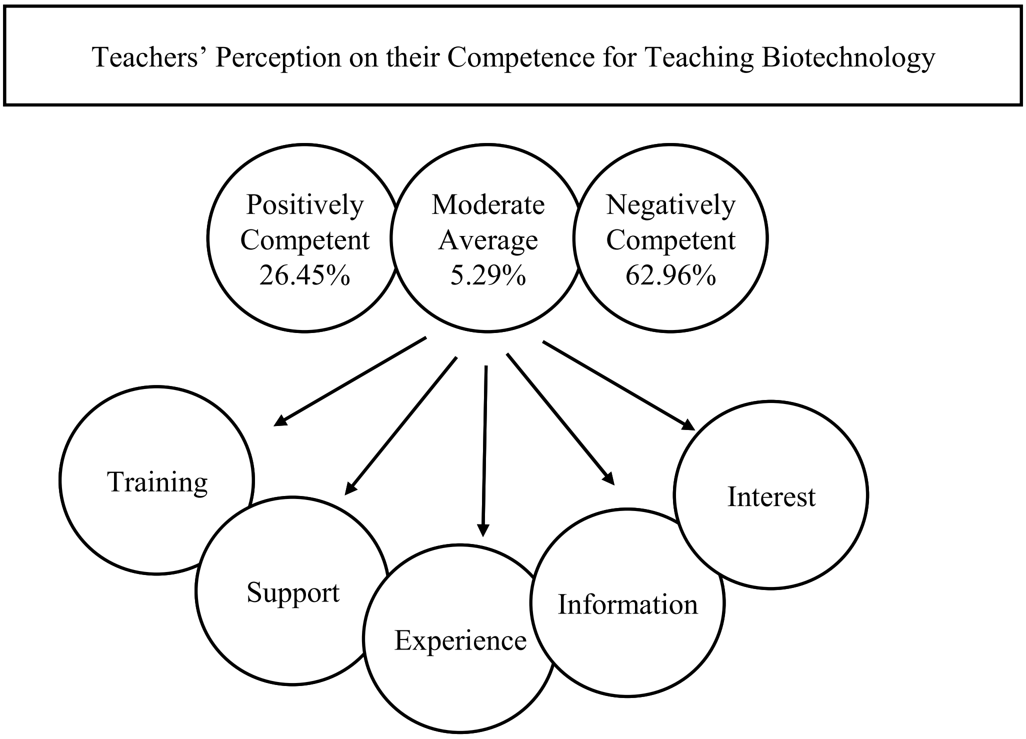

Figure 10. Five themes of the teachers' competency for teaching biotechnology

Technology education teachers in this study emphasized the value of in-service ***professional development*** (workshop, seminar, etc) or pre-service courses (*f* = 32) as a pathway for improving their competence to teach biotechnology. The following examples are typical responses that reflect the importance of professional development:

> Not competent at all, however like most technology education instructors, would give it my best if I were told to teach it. Proper education and training would be a must and a major criterion for teaching it. In my case, if taught the biotechnology content in a training seminar I could successfully teach it.

> I feel competent that I could teach any topics of biotechnology under the TE umbrella with proper training. Personally, I did not have any course related to biotechnology in my TE preparation institute. However, I could get a chance of in-service workshop. It was greatly helpful for teaching biotechnology content in TE classroom.

The second theme for teachers' competence to teach was utilization of ***information or resource*** (*f* = 14) related to biotechnology and its instruction. A typical example selected from the 14 responses is that:

> I'm very competent because I have looked for the latest news to incorporate biotechnology in my technology education classroom. I can easily reach the resource or information of Internet, module, and well-developed curriculum to facilitate technology

teachers' biotechnology instruction.

Support (*f* = 11) was the third theme as a significant factor for improving technology teachers' competence to teach biotechnology. Respondents in this study emphasized the importance of supports such as school system, environment, and administration for improving their competence toward teaching biotechnology. Typical examples regarding this concern are as follow: "I feel confident with biotechnology teaching. However, getting time, laboratory, and funding from my school to implement it in TE classes was not easy."

> I presently do not have time planned for curriculum writing related to biotechnology. Also, finding inexpensive activities is a concern. A lack of sufficient physical resources such as time, recognition, funding, and facilities have been their major concerns regarding factors hampering the development of competence toward teaching biotechnology.

The fourth theme for teachers' competence to teach biotechnology was the ***experience teaching biotechnology*** (*f* = 10). The following responses are typical examples: "I have never taught biotechnology in the technology education, I do not feel very competent at this point" and "I taught hydroponics and bio-fuels before by modular activity. However, I'm not competent with other biotechnology topics"

The final major theme for improving teachers' competence is their ***interest*** (*f* = 7) toward biotechnology content and its instruction. For example; "I don't enjoy teaching biotechnology. I don't like biotechnology content."

Summary

The Research Question for this study was: What predictive values do identified key factors have for affecting the implementation of biotechnology instruction in secondary school level technology education classrooms? As one of the key factors, technology education teachers' motivational factor was investigated through answering Research Sub-Question #1, "What motivates technology teachers to implement biotechnology instruction in their secondary level technology education classrooms?" The technology education teachers' motivational data (*BTTB*) and attitudinal data (*ATTB*) were analyzed to answer the Research Sub-Question 1 through an exploratory factor analysis, correlations, and multiple regressions. The motivational data were analyzed by deriving three motivational constructs (expectancy, value, and cost) through an exploratory factor analysis (SPSS, v16). To examine the impact of the motivational constructs (independent variable) on the implementation of biotechnology instruction (dependent variable), the correlations and multiple regressions were conducted. Finally, the thematic analysis for the two open-ended questions was conducted to investigate the specific motivational issues (Student's benefits for being biotechnological literate & teachers' competency to teach biotechnology). According to the findings from these analyses, technology education teachers' motivations (expectancy, value, and cost) were found to be major predictors for the implementation of biotechnology instruction. However, the motivational constructs are not insufficient for explaining key factors affecting the implementation of biotechnology instruction. It is thus necessary for this research to investigate the impact of another factor (technology education teachers' preparation) on the implementation of biotechnology. Professional development related to biotechnology teaching will be investigated in the next section.

Research Sub-Question 2

The Research Sub-Question 2 for this study is: How does the preparation (pre-service and in-service professional development) of technology education teachers affect their decision to implement biotechnology instruction in their secondary level technology education classrooms? To investigate the impact of technology education teachers' preparation for implementation of biotechnology instruction, descriptive statistics and mean comparison tests (independent *t*-test) of the technology education teachers' attitudes toward teaching biotechnology (*ATTB*) were prepared using the data collected from the demographic part of the *TTBTTB*. The results of these analyses are presented in this section.

Preparation of the Pre-service Teachers

The frequency and percentage for the course(s) experience associated with the teaching of biotechnology in the pre-service teacher preparation program are presented in Table 31. Regarding course work taken that was related to the teaching of biotechnology, of the 395 technology education teachers, 328 (83.03%) never took course(s) and 67 (16.9%) had taken one or more. Among those technology education teachers who took one or more courses for teaching biotechnology, 56 teachers took one course, 8 teachers took two courses, and 3 teachers took five or more courses.

Table 31

Pre-service Courses Related to Biotechnology Teaching

	None	One Course	Two Course	Five or More
Frequency	328	56	8	3
Percentage	83.03%	14.17%	2.02%	0.75%

To investigate the impact of the course(s) in the pre-service teacher preparation program, the data were categorized into two groups: 1) Non-Course group - those who never took a course for teaching biotechnology and 2) Course group – those who took one or more courses for teaching biotechnology. An independent *t*-test for the seven stages (awareness, informational, personal, management, consequence, collaboration, and refocusing) by the two groups was conducted. Five significant differences at the following stages of awareness ($t = 6.827$, $p < .001$), consequence ($t = -7.412$, $p < .001$), collaboration ($t = -7.037$, $p < .001$), and refocusing ($t = -8.220$, $p < .001$) were found (Table 32).

Data analysis indicated that those technology education (TE) teachers who never took relevant course work for teaching biotechnology ($\bar{x} = 45.67$) reported a greater mean regarding the awareness stage than ones who had one or more courses ($\bar{x} = 24.23$). Graphic representation (Figure 11) of the stages of concern data between pre-service groups (Non-course vs. Course groups) indicated a clear distinction in terms of their concerns toward teaching biotechnology.

Table 32

Mean Comparison of Teachers' Stages of Concern for Pre-service Courses

Stages of Concern	Non-Course Group (N=328)	Course(s) Group (N=67)	*t*
Awareness	44.60	24.94	6.784***
Informational	55.97	53.09	.917
Personal	48.80	49.85	-0.342
Management	43.80	42.43	.459
Consequence	41.97	61.49	-6.003***
Collaboration	42.43	64.56	-6.082***
Refocusing	37.56	62.08	-7.845***

*** Significant mean difference at the 0.001 level

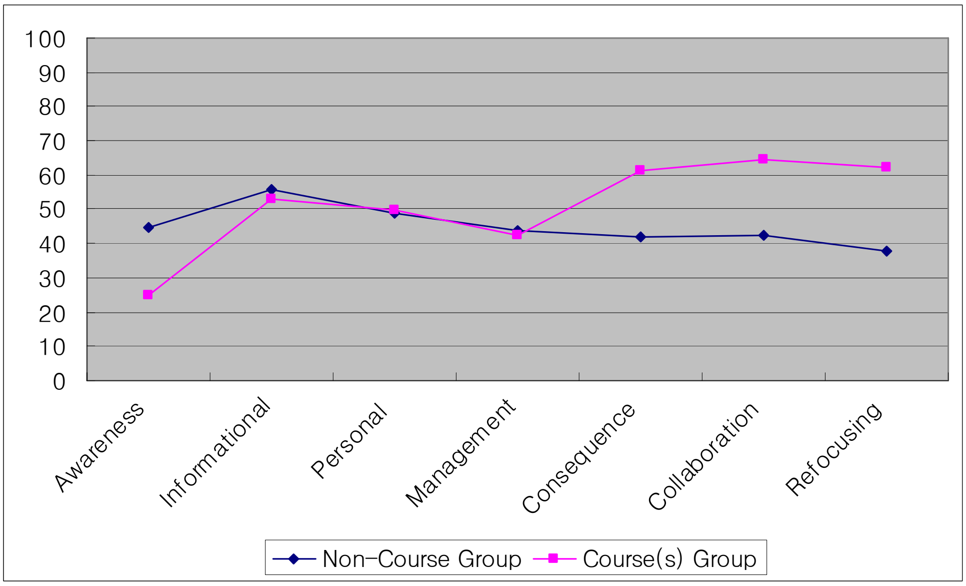

Figure 11. Stages of concern for non-course/course(s) group

In-service Professional Development (PD) Related to Biotechnology Instruction

Data regarding the frequency of in-service professional development (PD) for teaching biotechnology are presented in Table 33 according to the types (one-day, two-day, one-week, two-week, course, and others) of in-service PD received.

Table 33

Type of the In-service PD Related to Biotechnology Teaching

Type of the In-service PD	Frequency
One Day Biotechnology Workshop	53
Two Day Biotechnology Workshop	16
One Week Biotechnology Workshop	10
Two Week Biotechnology Workshop	4
Course (College/University/Graduate School)	8
Other Professional Development	21

Of the 395 technology education participants, 314 (79.5%) never participated in an in-service professional development (PD) related to teaching biotechnology and 81 (20.5%) participated in one or more in-service PD for teaching biotechnology. Among the types of the in-service PD offered for teaching biotechnology, the one-day workshop (53 respondents) is the most popular. Also, there were 21 respondents who described four unique professional development types: 1) lecture or workshop from their colleagues such as agriculture and biology teachers ($f = 9$), 2) web tutorial or resources related to biotechnology instruction ($f = 5$), 3) State or ITEA conference ($f = 4$), and 4) reading or reviewing the existing biotechnology curriculum ($f = 3$).

An investigation into the impact of in-service PD was conducted by analyzing the stage of concern data and performing an independent *t*-test on two PD groups (Participation vs. Non-participation groups). Results of this analysis (Table 34) indicated the following five significant differences: awareness ($t = 9.005$, $p < .001$), personal ($t = 2.045$, $p < .05$), consequence ($t = -6.455$, $p < .001$), collaboration ($t = -6.936$, $p < .001$), and refocusing ($t = -8.443$, $p < .001$).

Table 34

Mean Comparison of Teachers' Stages of Concern for In-service PD

Stages of Concern	Non-Participation Group (N=314)	Participation Group (N=81)	*t*
Awareness	46.74	20.07	10.499***
Informational	55.74	54.49	.425
Personal	49.76	45.96	1.193
Management	43.88	42.36	.546
Consequence	40.72	62.96	-8.033***
Collaboration	40.72	67.37	-9.081***
Refocusing	35.81	64.65	-10.326***

* Significant mean difference at the 0.05 level
*** Significant mean difference at the 0.001 level

In a graphic representation of the seven stages of concern across the two in-service PD groups (Non-participation vs. Participation groups) a clear distinction regarding internal and external concerns toward teaching biotechnology (Figure 12) is indicated. The non-participation group showed higher internal concerns scores (awareness, informational, personal, and management) toward teaching biotechnology than the participation group while the participation group showed higher scores for their external concerns (consequence, collaboration, and refocusing).

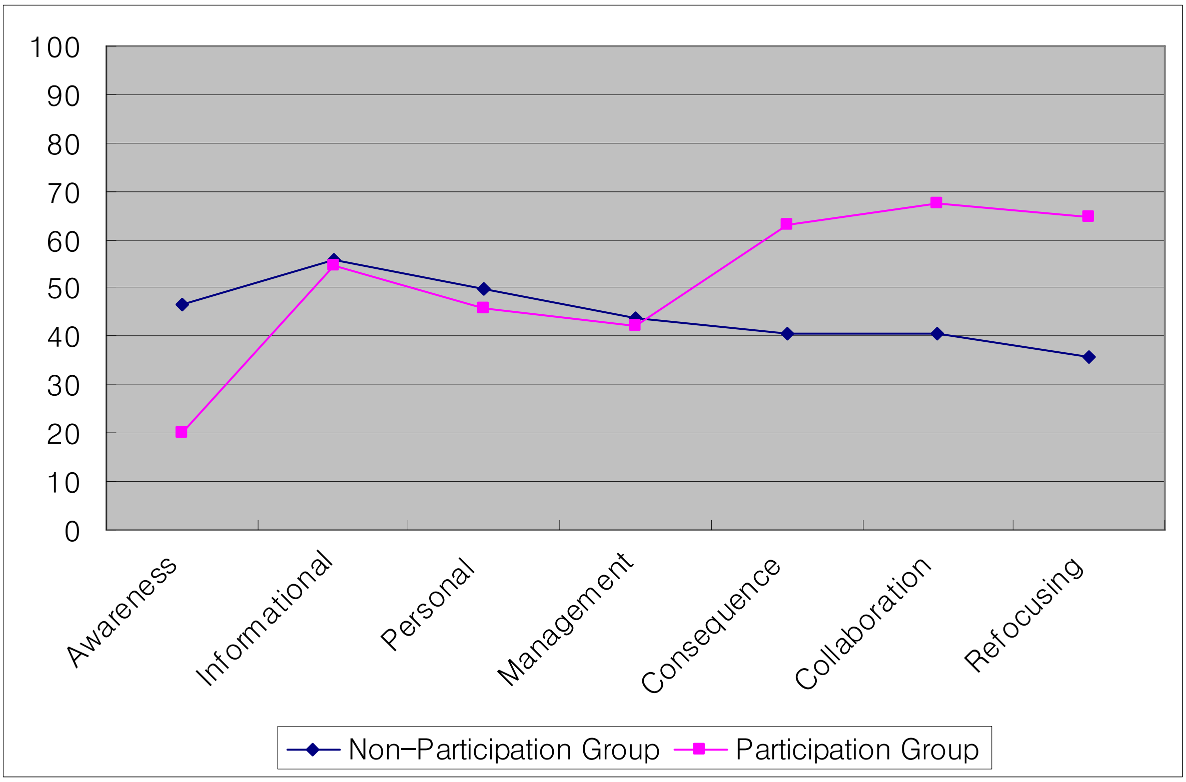

Figure 12. Stages of concern for in-service PD participation/non-participation group

Significant differences in the independent *t*-test across the five stages were as followings: 1) Awareness: non-participation group ($\bar{x}$ = 47.24) of the in-service PD for teaching biotechnology was significantly greater than the participation group ($\bar{x}$ = 21.25), 2) Personal: non-participation group ($\bar{x}$ = 49.75) of the in-service PD for teaching biotechnology was significantly greater than the participation group ($\bar{x}$ = 42.27), 3) Consequence: participation group ($\bar{x}$ = 60.49) of the in-service PD for teaching biotechnology was significantly greater than the non-participation group ($\bar{x}$ = 40.29), 4) Collaboration: participation group ($\bar{x}$ = 64.33) of the in-service PD for teaching biotechnology was significantly greater than the non-participation group ($\bar{x}$ = 40.55), and 5) Refocusing: participation group ($\bar{x}$ = 61.74) of the in-service PD for teaching biotechnology was significantly greater than the non-participation group ($\bar{x}$ = 35.11).

Sub-Question 2: Theme Analysis of the Two Open-Ended Questions

This section describes the analysis of data collected from open-ended questions #2 and #4 (Appendix A, p.) which were designed to address the need and role of the technology education teachers' preparation for teaching biotechnology.

Open-ended question (#2) asked, "What level of preparation do you feel technology education teachers need in order to prepare their students to be more technologically literate about biotechnology?" Of the 395 survey participants, 187 (47.34%) responded to open-ended question #2, though only 183 (46.32%) responses were usable for the theme analysis. The majority (f = 161, 87.97%) of the 183 respondents expressed the perceived needs for their professional development, with theme analysis findings revealing (Table 35 and Figure 13) the following two distinct perspectives: 1) preparation type (four themes) and 2) desired results (three themes).

Table 35

Key Themes of Teachers' Preparation toward Teaching Biotechnology

Category	*Emergent Themes*	*Explanation of the Emergent Themes*	f
Type	Course	***Course(s)*** in the pre-service teacher preparation	78
	Workshop	***In-service training*** at district/state/national level	55
	Self-Learning	***Reviewing/reading*** textbooks, module, developed curriculum, and on-line resource	23
	Collaboration	***Collaboration*** with colleagues & industry	11
Desired Results	Practical Issues	Incorporation into the lesson plan and its ***practice***	25
	Introductory	***What*** is biotechnology, ***why*** do we need biotechnologically literate students?	13
	Content/ Knowledge	Being knowledgeable about biotechnology ***content***.	13

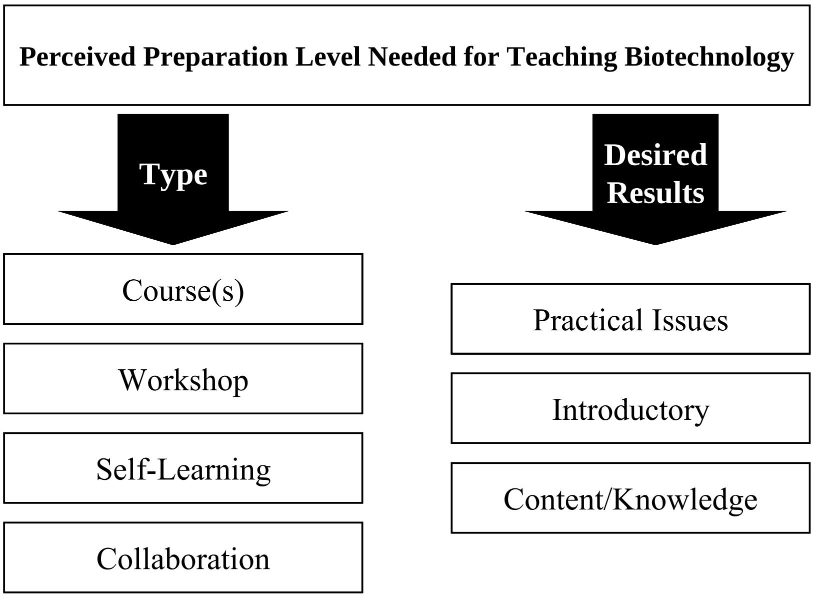

Figure 13. Themes for the perceived preparation level needed for teaching biotechnology

The four emergent themes for preparation types were course, workshop, self-learning, and collaboration. The first type of the professional development for teaching biotechnology was for a ***course*** (*f* = 78) offered as part of their pre-service TE teacher preparation programs. Participant teachers clearly recognized that the absence of a biotechnology course in the current pre-service TE teacher preparation programs is a problem. Typical examples selected from the 78 responses reflecting this concern are as follows: "Many college level programs do not specifically have a 'teaching biotechnology' or related course. But they should," "At least some teacher college training. It was not an option when I trained to become a teacher," and "TE teachers should take some college level science/biotechnology courses for teaching biotechnology."

PD workshop (*f* = 55) was the second most frequently discussed type of the professional development for preparing TE teachers to teach biotechnology. The following select examples are typical examples that reflect participants' perspectives regarding this type of PD: "In-service at the very least, biotechnology workshops around the state or university would be an idea," "I think in-service opportunities at the college or bio-institute levels would be helpful for teaching biotechnology in TE classes," and "Technology education teachers would need specific training or workshop in biotechnology."

The third theme was ***teachers' self-learning*** (*f* = 23). Respondents in this study indicated they could implement biotechnology instruction by reviewing the existing curriculum, lesson plan, and specific web-sites. Typical examples for these type responses are as follows: "I was able to implement a unit on prosthetics simply by reviewing the curriculum materials I received" and "I spent my summer vacation learning biotechnology and writing new biotechnology instructional materials for teaching biotechnology in the next semester."

Collaboration with school/district colleagues and industry (*f* = 13) was the fourth and final theme revealed through the analysis of open-ended responses regarding the type of preparation. Participants felt practicing teachers needed in order to teach biotechnology. A select few examples are as follows: "We need collaboration with my peers (biology teachers, agriculture science teachers, etc) for teaching biotechnology. It will be a great chance of the preparation for teaching biotechnology," "Biotechnology topics could be handled with my colleagues (science educators) in that particular area along with them help teach biological components in my TE classes" and "TE teachers need collaborations to prepare for my biotechnology class with scientist or science teachers to bridge the gap or facilitate the discussion between what a scientist actually does and how this can be done in a classroom setting"

This section themes revealed through the analysis of open-ended responses to Sub-Question #2 was "desired results" for in-service PD, with the following three distinct types indicated: practical issues related to biotechnology teaching, introduction to biotechnology and its instruction, and technical content/knowledge.

The most frequently mentioned type of desired result from PD was to emphasize ***practical issues*** ($f = 25$) for teaching biotechnology content in the secondary school level technology education. Examples typical of the 25 responses captured in the following statements: "We need a preparation not for technical content but for practical approach for teaching biotechnology" and "Surely TE teachers should know how to incorporate biotechnology content into the lesson plan and develop/practice the lesson plan"

The second most frequently mentioned desired results that TE teachers wanted from biotechnology PD was an emphasis on the acquisition of ***introductory perspective*** ($f = 13$) toward teaching biotechnology. These perspectives related to the development of a greater awareness of what biotechnology encompasses and to what level of literacy should teachers be preparing their students about this content area. Examples typical of the 13 responses are captured in the following statements.

> Technology education teachers need to be aware of what biotechnology is and the wide variety of topics it covers. It is very important because technology education teachers did not know the biotechnology area compared to other technological areas in the technology education program.
>
> TE teachers would need an introductory guideline for teaching biotechnology. Therefore, the PD in biotechnology area should be implemented with the following questions. What is biotechnology? Why do we need biotechnologically literate students? Is it valuable or significant for TE?

Being personally more ***knowledgeable about biotechnology content*** (f = 13) was the final desired result of the professional development. Technology education teachers participating in this study believe that the technical content or biotechnological knowledge should be obtained through appropriate professional development for teaching biotechnology. The following select statements from the 13 open-ended responses are typical examples reflecting this desired outcome: “I might feel that a foundation in biology would be valuable,” “Teachers need to be aware of the biotechnology content and literate in biotechnology area,” and “TE teachers should obtain a variety of technical/biological topics (hydroponics, alternative energy production, and prosthetics, etc) from specific classes."

Open-ended question #4 was also correlated with Sub-Question #2 and asked, "What role should professional development (pre-service and/or in-service workshops/college courses) play in preparing technology education teachers to help students become more technologically literate about biotechnology?" This open-ended question was asked specifically to further probe teachers' perspectives regarding their role in assisting students to become more biotechnologically literate. Of the 395 survey participants, 222 (56.20%) responded to the open ended question # 4, although only 210 (53.16%) responses were usable for theme analysis. The results of theme analysis (Table 36 and Figure 14) revealed the following four emergent themes regarding the role of PD in preparing TE teachers to assist students in becoming more biotechnologically literate: preparatory, knowledgeable, resources, and motivated. The four themes regarding the role of the PD for teaching biotechnology were the follows: 1) preparing for teaching biotechnology, 2) being knowledgeable about biotechnology content, 3) getting motivated for biotechnology and its instruction, and 4) being resources for teaching biotechnology.

Table 36

Key Themes of the Role in PD for Teaching Biotechnology

Emergent Themes	Explanation of the Emergent Themes	*F*
Preparatory	***Preparatory*** role for teaching biotechnology in their classrooms	88
Knowledgeable	Became ***knowledgeable*** toward biotechnology content.	35
Resource	Provided a variety of ***Resources*** including the idea, lesson plan, curriculum for biotechnology instruction	24
Motivated	Became ***comfortable (interested)*** or ***competent*** with biotechnology content and its teaching	22

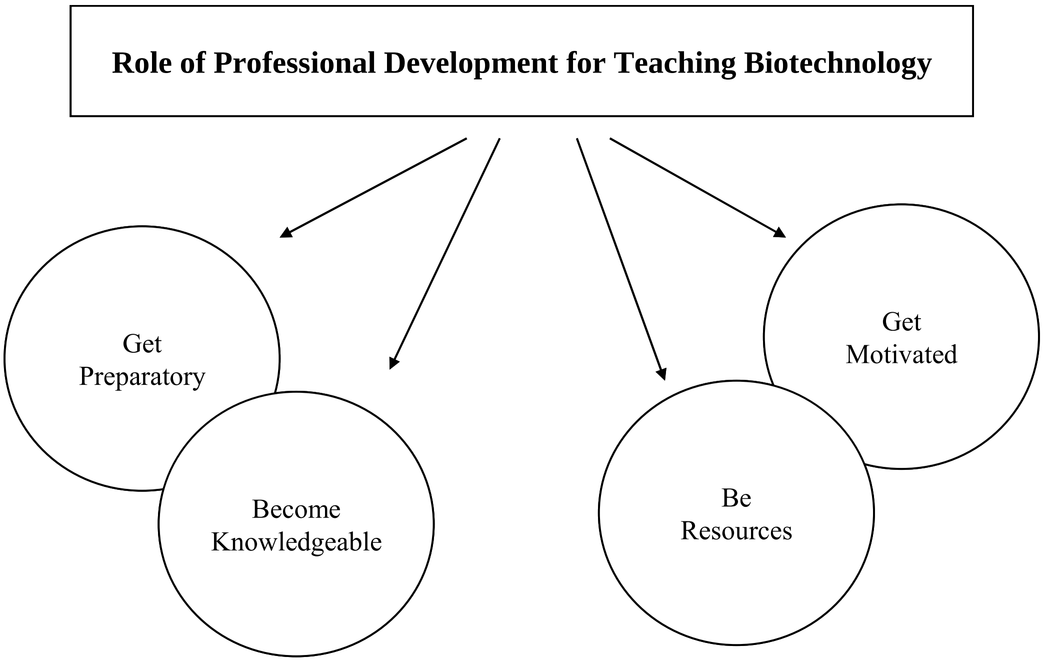

Figure 14. Four themes in the role of the PD for teaching biotechnology

The first role of PD or teaching biotechnology was to prepare for teaching biotechnology (*f* = 88). Typical examples selected from the 88 responses are as follow: “To prepare for teaching biotechnology, training should begin at the teacher college level,” “PD time is essential to prepare for biotechnology instruction in TE classrooms,” and “more in-service workshops on biotechnology would be beneficial for TE teachers to prepare their biotechnology classes.”

Being knowledgeable toward biotechnology content (*f* = 35) was the second role of PD to teach biotechnology. The following select examples are typical responses that reflect participants’ perspectives regarding the role of PD: “I would think that the emphasis would be on training the current teachers that are not knowledgeable in biotechnology,” “Such developments should assist in defining and introducing the terms or concepts related to biotechnology content,” and “If teachers do not have a science interest or knowledge, they need some training in the technical area.”

The third theme was resource (*f* = 24). Respondents in this study indicate PD provides a good resource or information related to teaching biotechnology. Typical examples of these type responses are as follow: “Through in-service workshop, I got a nice instructional material and information for teaching biotechnology” and “In my previous two-week workshop, the instructor provided a variety of resources for biotechnology content and its teaching”

Teachers’ motivation (*f* = 22) was the final theme. A select few examples are as follow:

“In-service trainings would help familiarize or motivate TE teachers to teach biotechnology,” “I’m interested in incorporating genetic studies, human genome, etc in my TE programs adding meaningful learning activities because I have had pre-service courses and in-service training,” and “Biotechnology instruction will not happen without teachers’ motivation. Therefore, TE teachers need PD to have more comfortable feeling toward teaching biotechnology.”

Summary

Technology education teachers’ preparation was investigated as one of the key factors affecting the implementation of biotechnology instruction. Data regarding participants’ PD (independent variable) collected through the *TTBTTB* and teachers’ attitudes toward teaching biotechnology (dependent variable) were analyzed to answer Research Sub-Question 2. Independent *t*-tests and theme analyses were conducted to investigate the impact of the PD on the implementation of biotechnology instruction. Analysis of the data indicated that technology education teachers who took course(s) relevant to teaching biotechnology in the pre-service teacher preparation program and/or participated in in-service PD had greater ***external*** concerns than those who did not. Furthermore, thematic analysis of open ended questions #2 and #4 revealed that technology education teachers in this study perceived the need for practical PD sessions related to biotechnology teaching. Technology education teachers’ motivations and PD were key factors for affecting the implementation of biotechnology instruction. However, even for those who were motivated and prepared for teaching biotechnology, they could not implement biotechnology instruction due to infrastructure issues. An investigation into such infrastructure issues at the school, state, and national level as factors influencing the implementation of biotechnology instruction was a designed as part of this study and is presented in the following section.

Research Sub-Question 3

Research Sub-Question 3 of this study asks: How does the infrastructure (local, state, and national level) supporting technology education programs affect technology education teachers' implementation of biotechnology instruction in their secondary technology education classrooms? Open ended question #5 was written to correlate with Research Sub-Question 3 and is concerned with further investigating the impact of infrastructure issues related to the implementation of biotechnology instruction. A theme analysis for open ended question # 5 was conducted on participants' responses in order to identify emerging themes and examine their frequencies.

Of the 395 survey participants, 215 (54.43%) technology teachers responded to open ended question # 5, although only 198 (50.01%) of these responses were usable. The majority of the 198 respondents (f = 147, 74.24%) indicated that they did not have any support from school, district, and state infrastructure for teaching biotechnology while 51 (25.75%) respondents indicated some level of supports from school, district, and state infrastructure In addition, participants pointed out the significance of the infrastructure issues affecting the implementation of biotechnology instruction. The results of a theme analysis (Table 37 and Figure 15) revealed the four emergent themes: collaboration, circumstance, resources, and standards.

Table 37

Key Themes for the Infrastructure to Implement Biotechnology Instruction

Emergent Themes	Explanation of the Emergent Themes	*F*
Circumstance	School environment/***circumstance*** (class time, funding, facility, class required, etc)	24
Collaboration	***Collaboration*** with other colleagues (biology, agriculture, technology education teachers, etc), supervisor, expert, etc for teaching biotechnology	20
Standards	State level policy or standards and ITEA ***standards***	12
Resources	Local ***resources*** (university, research center, educational institute, library, industry, museum, etc)	10

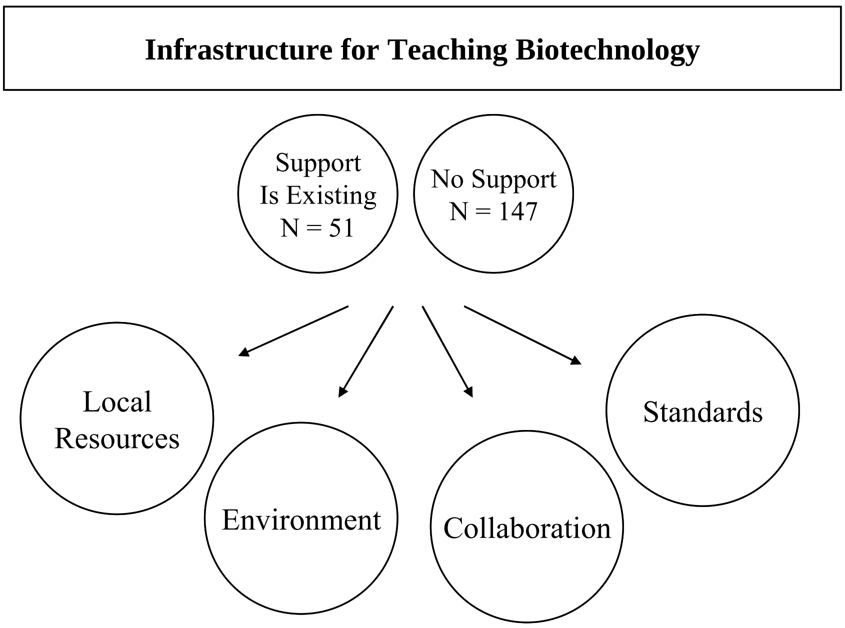

Figure 15. Key Themes for the infrastructure to implement biotechnology instruction

The first infrastructure factor for the implementation of biotechnology instruction was the school ***circumstance/environment*** factor (*f* = 24). Participants felt that sufficient support in fund, time, and facility could be helpful for implementing biotechnology instruction. For example, “For teaching biotechnology content, we have poor funding and large classes. So, it is not possible to implement.” Also, they expressed positive impact of school facility and funding to biotechnology teaching by replying “We have a greenhouse and a consumable budget to provide for the technology education class which includes biotechnology.”

Collaboration with colleagues (*f* = 20) was the second most frequently mentioned infrastructure issue for implementing or preparing for biotechnology instruction. The following select examples are typical examples that reflect collaboration with colleagues: “I sent out an email to our school asking if anyone taught anything related to biotechnology so I could partner up with a science class… but none responded,” “Due to the fact we integrated multiple subjects, my administration was supportive. And I can teach biotechnology with the collaboration,” and “County, state, and national agriculture teachers are eager to share their strategies. So, I had several collaborations with them for teaching biotechnology.”

The third infrastructure issue was ***standards*** (*f* = 12) for teaching biotechnology content. A select few examples are as follows:

Because it is part of state standard course of study for Introduction to Technology, it is

> supported by the school and administration. We are required to teach the standards (state TE standard and ITEA.STL). Our technology education program currently teaches biotechnology.
>
> Biotechnology would only be implemented by the removal of another Technology course. Therefore, we need more strong required standards or responsibilities for teaching biotechnology content in TE classrooms. We are expected to further address the ITEA standards for teaching biotechnology.

Finally, technology education teachers in this study (*f* = 10) emphasized that local resources such as university, institute, and industry were a support for teaching biotechnology. Even though they indicated that there was no support from the district, they emphasized they needed help from the local resources. A typical example follows: "I think it is a shame that local university no longer teaches undergraduate technology education. We need experts or teachers' educators for biotechnology content around our schools."

Summary

The analysis of data collected from the composite on-line survey developed for this study was presented in Chapter IV to answer one main Research Question and three Sub-Questions. The analyses of the pilot study provided instrument reliability and validity using *Cronbach's Alpha* and a factor analysis. Having established credibility of the instrument used in this study, both quantitative and qualitative data (demographics, *ATTB*, *BTTB*, and open ended questions) were collected and analyzed through mean comparison tests (independent *t*-test & ANOVA), correlations, multiple regressions, and theme analyses. Technology education teachers' motivation, Professional Development, and infrastructure issues were investigated as the key factors affecting the implementation of biotechnology, in an effort to answer one main research question, "What predictive values do identified key factors have for affecting the implementation of biotechnology instruction in secondary school level technology education classroom?" Conclusions, implications, and recommendations drawn from these analyses will be discussed in the next chapter.

CHAPTER FIVE: CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Discussed in this chapter are conclusions, implications, and recommendations for future research. Conclusions in this study are based on interpretation of significant findings from the analyses presented in Chapter IV and focused on answering the three sub-questions that collectively provide the answer to the main research question. Implications derived from those conclusions are then presented, followed finally by recommendations for future research and practice.

Conclusions

The purpose of the study was to investigate the key factors (motivation, professional development, and infrastructure) affecting the implementation of biotechnology instruction in secondary level Technology Education programs and establish predictive values for the identified factors. This study was directed by the following main research question: "What predictive values do the identified factors have that affect the implementation of biotechnology instruction in secondary school level technology education classrooms?" Data necessary to answer the main research question was collected through three research sub-questions. Both quantitative (demographics, *ATTB*, and *BTTB*) and qualitative data (open-ended data) were collected to answer the following three research sub-questions: 1) "How do motivational constructs of technology education teachers affect the implementation of biotechnology instruction in their secondary level technology education classrooms?" 2) How does the preparation (pre-service and in-service professional development) of technology education teachers affect their decision to implement biotechnology instruction in their secondary level technology education classrooms? 3) How does the infrastructure (local, state, and national level) supporting technology education programs affect technology education teachers' implementation of biotechnology instruction in their secondary technology education classrooms?

Data collected from the on-line composite survey (*TTBTTB*) were analyzed to answer the one main research question and the three sub-questions through statistical and thematic analysis as discussed in Chapter IV. A total of 395 technology education teachers across the five selected states (Virginia, New York, Connecticut, New Jersey, and Pennsylvania) participated in this study, responding to the *TTBTTB* survey. Of the 395 technology education teachers, 316 (80%) had no experience teaching biotechnology in their classrooms, 328 (83%) had never participated in formal coursework relevant to the teaching of biotechnology in their pre-service teacher programs, and 314 (79.5%) had no in-service professional development (PD) related to the teaching of biotechnology. These results (insufficient implementation and preparation toward teaching biotechnology) are consistent with the low level of implementation of biotechnology instruction in technology education programs revealed through prior studies (Brown et al., 1998;

Sanders, 2001).

From these findings and those prior research studies, we can conclude technology education teachers' implementation and preparation for teaching biotechnology are not sufficient. What would motivate these technology education teachers do so was the purpose of Research Sub-Question 1.

Research Sub-Question 1

The first research sub-question, "How do motivational constructs of technology education teachers affect the implementation of biotechnology instruction in their secondary level technology education classrooms?" was examined through analyzing data (*ATTB*, *BTTB*, and open-ended) collected from the *TTBTTB* survey. Analyses of the data were performed in the following order: an exploratory factor analysis, mean comparison tests, correlations, multiple regressions, and thematic analyses.

Teaching Experience: The results of the independent *t*-test for biotechnology teaching experience collected from the demographic part of the *TTBTTB* presented clear differences for technology education teachers' motivational constructs. The differences indicate that experienced technology education teachers had a greater probability for successful implementation of biotechnology instruction and a higher perceived value toward the teaching of biotechnology. In contrast, the non-experienced group indicated that the personal cost (high score) of implementing biotechnology instruction negatively affected their decision to teach biotechnology.

Teachers' Concerns: Two correlational analyses between motivational constructs and concerns (internal and external concerns) were conducted for two multiple regression analyses. Expectancy (r = -.246, $p < 0.001$) and cost (r = .265, $p < 0.001$) were found to be significantly correlated to internal concerns (implying non-implementation of biotechnology instruction). In addition, expectancy, value, and cost were found to be significantly correlated to external concerns (implying implementation of biotechnology instruction). The findings of the data analysis indicated that technology education teachers' expectancy and value were positively correlated to the implementation of biotechnology instruction but their cost was negatively correlated to the implementation of biotechnology instruction. Mean comparison tests and correlational analyses were enough to identify the relationship between technology education teachers' motivational constructs (expectancy, value, and cost) and the implementation of biotechnology instruction. However, the findings could not prove the impact of the motivational factors associated with the implementation of biotechnology instruction. Therefore, two multiple regressions were conducted to investigate the extent to which the three motivational constructs (predictors) contributed to the implementation of biotechnology instruction

Motivational Predictors: Based on findings of Pearson Correlational Coefficients, the hierarchical multiple regressions indicated that three independent variables (expectancy, value, and cost) successfully predicted technology teachers' concerns (internal and external concerns). Of these three constructs the best predictor of external concerns was "expectancy" which accounted for 26.6% of the total variance. To a lesser extent the "value" and "cost" constructs were also predictors, having accounted for 16.5% and 2.4% respectively. Based on the findings of this model, it can be concluded that a technology education teacher's: 1) expectation (self-belief) of their ability to successfully teach biotechnology has a significant positive effect on their propensity to implement biotechnology instruction in their secondary school level classrooms, 2) perception of the educational benefits for teaching biotechnology affects positively the implementation of biotechnology instruction, 3) perceived loss of time and the efforts required for the teaching of biotechnology has a negative effect on the implementation of biotechnology instruction.

Thematic analyses for open-ended questions #1 regarding students' benefits for being biotechnological literate and #3 regarding teachers' competency for teaching biotechnology were conducted to identify emergent themes and examine the frequencies of those themes. The 193 usable responses for open-ended question #1 revealed four clear themes: technological world (f = 48), students' job/career (f = 48), hands-on experience (f = 24), and integration (f = 19). From this theme analysis, we can conclude that technology education teachers reasonably recognized the value of students' learning biotechnology. Contrary to this belief, 62.96% of the responses to open-ended question #3 expressed negative feelings about their competency toward teaching biotechnology. Furthermore, theme analysis of open-ended question #3 revealed five emergent themes: training (f = 32), support (f = 14), experience (f = 11), information (f = 10), and interest (f = 7), determining why technology teachers did or did not consider themselves competent to teach biotechnology. Analyses of the data led to the conclusion that it is important for technology teachers to have a variety of opportunities (training, experience, and information) and external supports related to biotechnology teaching for being positively competent toward teaching biotechnology

Research Sub-Question 2

The second research sub-question, "How does the preparation (pre-service and in-service professional development) of technology education teachers affect their decision to implement biotechnology instruction in their secondary level technology classroom?" was examined using mean comparison tests (independent *t*-test) of the technology education teachers' attitudes toward teaching biotechnology (*ATTB*) for the technology education teachers' preparation data collected from demographic data of the *TTBTTB* survey.

Analysis of the quantitative data (demographics & *ATTB*) led to two conclusions: First, technology education teachers' preparations toward teaching biotechnology were insufficient. Specifically, of the 395 respondents 328 (83.03%) never took course(s) for teaching biotechnology and 314 (79.5%) never participated in in-service professional development related to biotechnology teaching. This problem (insufficient preparation for teaching biotechnology) is consistent with findings from prior research studies (Brown et al., 1998; Rogers, 1996; Russell, 2003). Second, stages of concern data showed that technology education teachers who had pre-service course(s) and/or in-service Professional Development (PD) associated with biotechnology teaching had significantly greater external concerns toward teaching biotechnology than those who had not. These findings can be interpreted that the technology education teachers' preparation (pre-service course(s) or in-service PD) is a strong predictor for the implementation of biotechnology instruction.

Analysis of the qualitative data collected from open-ended questions #2 and #4 led to in-depth conclusions regarding the need and role of PD related to biotechnology teaching. Of the 183 usable responses for the open-ended question, 161 (87.97%) expressed a perceived need for PD. The technology education teachers perceived that more opportunities related to the teaching of biotechnology are needed.

Research Sub-Question 3

The third research sub-question, "How does the infrastructure (local, state, and national level) supporting technology education programs affect technology education teachers' implementation of biotechnology instruction in their secondary technology education classrooms?" was examined by analyzing the open ended question #5. Of the 198 usable respondents, 147 (74.24%) indicated that they did not have any support from school, district, and state infrastructure for teaching biotechnology. Previous studies (Brown et al., 1998; Haynie & Greenberg, 2001) also indicated similar findings that technology education teachers experienced insufficient support for teaching biotechnology in their classrooms.

Analyses of the data led to a conclusion that infrastructure can be a significant factor that affects the implementation of biotechnology instruction. As the technology education teachers pointed out, insufficient support at the school, district, and state level for teaching biotechnology was a significant obstacle hindering biotechnology teaching in secondary school level technology education classrooms. It is clear that without any support, technology teachers face hardships for implementing biotechnology instruction. Related to the infrastructure issue, analysis of the data from open-ended data #5 revealed four themes: circumstance, collaboration, standards, and resources. Specifically, physical environments (class hours, funding, facility, etc) technology education teachers face, collaboration with other colleagues, standards (state level and ITEA standards), and local resources are significant factors that affect the teaching of biotechnology.

Main Research Question

The overarching research question guiding this study is "What predictive values do the identified factors have that affect the implementation of biotechnology instruction in secondary school level technology education classrooms?" and was answered through synthesis of results from three research sub-questions. The following ten conclusions were drawn:

- Technology education teachers' expectation (self-belief) of their ability to successfully teach biotechnology has a significant positive affect on their propensity to implement biotechnology instruction.
- Technology education teachers' perception of the educational benefits for teaching biotechnology affects positively the implementation of biotechnology instruction.
- Technology education teachers' perceived loss of time and the efforts required for the teaching of biotechnology has a negative affect on the implementation of biotechnology instruction
- It is necessary for the technology education teachers to have a variety of opportunities for developing their self-belief toward teaching biotechnology and experiencing the usefulness and importance of teaching biotechnology in their secondary school level classrooms.
- Technology education teachers' preparation (pre-service courses and/or in-service professional development) related to the teaching of biotechnology can be a strong predictor for the implementation of biotechnology instruction.

- Pre-service course(s) relevant to the teaching of biotechnology should be provided in technology education teacher preparation programs.
- In-service professional development for the teaching of biotechnology should be recognized and conducted by profession of technology education.
- Insufficient support at the local, state, and national level is a significant obstacle for hindering biotechnology teaching in secondary school level technology education classrooms.
- To overcome the obstacle, improved physical environments (class hours, funding, facility, etc) and active collaboration with other colleagues and/or local resources are needed.
- State/ITEA Standards related to the teaching of biotechnology should be emphasized as a guideline for teaching biotechnology content in secondary school level technology education classrooms.

Implications

A reflection on the findings and conclusions drawn from the data analysis provided several implications. These implications will be discussed in the following order: technology education teachers' motivations, teacher preparation, and infrastructure.

A clear implication regarding technology education teachers' motivation is that it is necessary for technology education teachers to have a variety of opportunities for developing their self-belief to successfully teach biotechnology and recognizing the educational benefits of the teaching of biotechnology. A second implication relative to the issue of teacher preparation is that there is a need for pre-service teacher preparation programs to provide course(s) relevant to biotechnology content and its instruction. Furthermore, pre-service preparation programs for technology education teachers should provide in-service professional development opportunities related to the content and teaching of biotechnology.

A third implication drawn from infrastructure issues revealed through data analysis is that for successful implementation of biotechnology content in secondary school level technology education classrooms, a variety of support must be provided. Specifically, school environments (class hours, funding, laboratory, etc) should be improved for teaching biotechnology, and collaboration with the colleagues and local resources (university, research center, and industry) should be encouraged.

Limitations and Recommendations

Participants in this study were limited to secondary school level technology education teachers practicing in five eastern seaboard states. The distribution of those technology education teachers in the states was disproportionate. Even though this study attempted to obtain a reasonable sample to address this problem, it would not be appropriate to generalize the results or conclusions to other states or regions. For a more generalizable study, additional studies that would include technology education teachers from other countries or states should be conducted.

This study investigated technology education teachers' belief toward teaching biotechnology. However, biotechnology instruction has been implemented in other subject areas such as science education and agricultural science education. Therefore, it is recommended to perform further studies for science teachers and agricultural science teachers and compare it with the findings and conclusions drawn in this study.

Furthermore, recommendations for future research include several statistical issues related to factor analysis. The exploratory factor analysis used to confirm the sub-factors (expectancy, value, and cost) of the *BTTB* provided three sub-factors. However, the expectancy construct was measured by only two items while other constructs were measure by a minimum of three items. For this type of analysis it is necessary to have a minimum of three items for measuring expectancy as a factor. Therefore, any future research that attempts to replicate this part of the study should use at least three items for measuring expectancy as a factor. As well, to confirm the sub-factors of an instrument or the intended sub-factors drawn from a theoretical background, a confirmatory factor analysis is necessary (Brown, 2006). The sub-factors (expectancy, value, and cost) of the *BTTB* should be verified by such a confirmatory factor analysis, and it is therefore recommended that confirmatory factor analysis be performed in any future research.

The conclusions and implications drawn in this study reflect a significant need for pre- and in-service preparation for the teaching of biotechnology in the field of technology education. It is highly recommended that pre-service preparation institutions for technology education teachers should take efforts to deliver pre-service course(s) relevant to learning both content and teaching strategies for biotechnology and provide similar opportunities for in-service professional development of practicing technology education teachers.

References

American Association for the Advancement of Science. (1989). *Project 2061: Technology.* Washington, DC.

American Association for the Advancement of Science. (1993). *Benchmarks for Scientific Literacy*, New York: Oxford University Press.

Abrami, P. C., Poulsen, C., & Chambers, B. (2004). Teacher motivation to implement an educational innovation: Factors differentiating users from non-users of cooperative learning. *Educational Psychology, 24*, 201-216.

Atkinson, J. W. (Ed.). (1958). *Motives in fantasy action and society.* Princeton, NJ: D. Van Nostrand.

Biosens (2000). *Technology Education Biotechnology Curriculum.* Blacksburg, VA.

Bogdan, R. C. & Biklen, S. K. (1998). *Qualitative research for education: An introduction to theory and methods.* Allyn & Bacon, Boston.

Brown, A. D. (1995). *An examination of the status of secondary school level biotechnology instruction within technology education programs in the United States.* Unpublished doctoral dissertation, East Texas State University.

Brown, D., Kemp, M., & Hall, J. (1998). On teaching biotechnology in Kentucky. *Journal of Industrial Teacher Education, 35*(4), 44-60.

Brown, T. A. (2006). *Confirmatory factor analysis for applied research*, New York, NY: Guilford.

Christou, C., Eliophotou-menon, M., & Phillippou, G. (2004). Teachers' concerns regarding the adoption of a new mathematics curriculum: An application of CBAM. *Educational Studies in Mathematics, 57*, 157-176.

Corner, L. (2008). *The significance of an approach to the teaching of societal issues related to biotechnology.* Paper presented at annual meeting of the American Educational Research Association, New Orleans, LA.

Crampton, F. E., Thomson, D. C., & Vesely, R. S. (2004). The forgotten side of school finance equity: The role of infrastructure funding in student success. *NASSP Bulletin, 88*(640), 29-52.

Creswell, J. W. (2003). *Research Design: Qualitative, quantitative, and mixed methods approaches* (2nd ed.). Thousand Oaks, CA: Sage.

Daugherty, M. K. (2005). A changing role for technology teacher education. *Journal of Industrial Teacher Education, 42*(1), 41-58.

Dawson, V. (2007). An exploration of high school (12-17 year old) students' understanding of and attitudes toward biotechnology process. *Research in Science Education, 37*(1), 59-73.

DeVore, P. W. (1966). *Technology – an intellectual discipline*. Washington, D.C.: American Industrial Arts Association.

Dunham, T., & Wells, J., & White, K. (2002). Biotechnology education: A multiple instructional strategies. *Journal of Technology Education. 14*(1), 65-81.

Dunn, K. E. (2008). *The implementation of learner-centered principles: an analysis of pre-service teacher beliefs and concerns.* Unpublished doctoral dissertation, The University of Memphis.

Eccles & Wigfield (1995). In the mind of the actor: The structure of adolescents' achievement task values and expectancy-related beliefs. *Personality and Social Psychology Bulletin, 21*(3), 215-225

Eccles, J. S. (2005). Subjective task value and the Eccles et al. model of achievement-related choices In A. J. Elliot, & C. S Dweck (Eds), *Handbook of competence and motivation* (pp. 105-121) New York: The Guildford Press.

Ellsworth, J. B. (2000). Surviving change: A survey of education change models (Report No. IR 020334). Washington, DC: Office of Education Research and Improvement. (ERIC Document Reproduction Services No. ED443417)

Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), Committee on Life, Sciences and Health. (1992). *Biotechnology for the 21st century: Realizing the promise.* Washington DC: Author.

Federal Coordinating Council for of Science, Engineering, and Technology (FCCSET), Committee on Life, Sciences and Health. (1993). *Biotechnology for the 21st century: Realizing the promise.* Washington DC: Author.

France, B. (2000). Biotechnology teaching models: What is their role in technology education? *International Journal of Science Education, 22*(9), 1027-1039.

George, A. A., Hall, G. E., & Stiegelbauer, S. M. (2006). *Measuring implementation in schools: The Stages of Concern Questionnaire.* Austin, TX: Southwest Education Development Laboratory.

Graham, S., & Taylor, A. Z. (2002). Ethnicity, gender, and the development of achievement values. In A. Wigfield, & J. S. Eccles (Eds.), *Development of achievement motivation* (pp. 121-146). San Diego, CA: Academic Press.

Gray, D. G., & Bryce, T. (2006). Socio-scientific issues in science education: Implications for the professional development of teachers. *Cambridge Journal of Education, 36*(2), 171-192

Green, S. K. (2002). Using an expectancy-value approach to examine teachers' motivational strategies, *Teaching and Teacher Education, 18*, 989-1005.

Hall, G. E., George, A. A., & Rutherford, W. L. (1977). *Measuring the stages of concern about an innovation: A manual for use of the stages of concern questionnaire.* Austin: Research and Development Center for Teacher Education, The University of Texas.

Hancock, D. R. (1996). Enhancing faculty motivation to advise students: An application of expectancy theory. *.NACADA Journal, 16,* 11-15.

Haynie, W. J., & Greenberg, D. (2001). Genetic disorders: An integrated curriculum project. *The Technology Teacher, 60*(6), 10-13.

Howell, D. C. (2007). *Statistical methods for psychology (6th ed.)*. Belmont, CA: Duxbury Press.

International Technology Education Association (ITEA) (1996). *Technology for all Americans: A rationale and structure for the study of technology.* Reston VA: Author.

International Technology Education Association (ITEA) (2000). *Standards for technological literacy: Content for the study of technology.* Reston, VA: Author.

International Technology Education Association (ITEA) (2003). *Advancing excellence in technological literacy: Students assessment, professional development, program standards*. Reston, VA: Author

International Technology Education Association (ITEA) (2006). *Technological literacy for all: A rationale and structure for the study of technology.* Reston, VA: Author.

Kay, D. (2006). *The influence of early childhood education teachers' beliefs on curriculum implementation and classroom practice.* Unpublished doctoral dissertation, The University of Missouri-Columbia.

Lemani, C. N. (2004). *Effectiveness of Trek-21 model of professional development on changes in teacher practices with respect to instructional technology integration.* Unpublished doctoral dissertation, West Virginia University.

Leslie, G., & Schibeci, R. (2006). Teaching about designer babies & genetically modified foods: Encouraging the teaching of biotechnology in secondary schools. *American Biology Teacher, 68*(7), 98-103.

Liu, Y., & Huang, C. (2005). Concerns of teachers about technology integration in the USA. *European Journal of Teacher Education, 28*(1), 35-47.

McMillan, J. H. (2004). Educational research: Fundamentals for the consumer. Allyn & Bacon, Boston.

Office of Technological Assessment (OTA) of the Congress of the United States. (1984). *Commercial Biotechnology: An International Analysis.* Washington, DC: US Congress.

Office of Technological Assessment (OTA) of the Congress of the United States. (1988). *US Investment in Biotechnology – Special Report.* Bolder, CO: West View Press.

Office of Technological Assessment (OTA) of the Congress of the United States. (1991) *Biotechnology in a Global Economy.* Government Printing Office, Washington, DC.

Patton, M. Q. (2002). *Qualitative research & evaluation methods (3rd edition)*. Thousand Oaks, CA: Sage.

Perkins, R., & McKnight, M. L. (2005). Teachers' attitudes toward WebQuests as a method of teaching. *Computers in the Schools, 22*(1/2), 123-133.

Reeve, J. (2005). *Understanding motivation and emotion*. Hoboken, NJ: Wiley.

Rogers, E. M. (2003). *Diffusion of innovations*, 5th edition. New York: Free Press.

Rogers, G. E. (1996). The technical content of industrial/technology teacher education. *Journal of Technology Education, 8*(1), 40-49.

Russell, J. (2003). The assessment of student learning is a pivotal component of effective teaching and learning. *The Technology Teacher, 63*(2), 28-32.

Saez, M. J., Nino, A. G., & Carretero, A. (2008). Matching society values: Students' views of biotechnology. *International Journal of Science Education, 30*(2), 167-183.

Sahin, I. (2006). Detailed review of Rogers' diffusion of innovations theory and educational technology-related studies based on Rogers' theory. *The Turkish Online Journal of Educational Technology, 5*(2).

Sahin, I., & Thompson, A. (2006). Using Rogers' s theory to interpret instructional computer use by COE faculty. *Journal of Research on Technology in Education, 39*(1), 81-104.

Sanders, M. (2001). New paradigm or old wine? The status of technology education practice in the United States, *Journal of Technology Education, 12*(2), 35-55.

Savage, E. & Sterry, L. (Eds.). (1990). *A conceptual framework for technology education*. Reston, VA: International Technology Education Association.

Schroll, D. (2007). *Examining what influences a teacher's choice to adopt technology and* *constructivist principles in the classroom learning environment.* Unpublished doctoral dissertation, Walden University.

Scott, D., Washer, B., & Wright, M. (2006) A Delphi study to identify recommended biotechnology competencies for first-year/initially certified technology education teachers. *Journal of Technology Education, 17*(2), 44-56.

Snyder, J. & Hales, J. (1981). *Jackson's Mill Industrial Arts Curriculum Theory.* Charleston, WV: West Virginia Department of Education.

Solomon, J. (2001). Teaching for scientific literacy: What could it mean. *School Science Review, 82*(300), 93-96.

Steele, F., & Aubusson, P. (2004). The challenge in teaching biotechnology. *Research in Science Education, 3*4(4), 365-387.

Stotter, D. E. (2004). *Assessment of the learning and attitude motivation of technology education students who complete an instructional unit on Agriculture and Biotechnology.* Unpublished doctoral dissertation, North Carolina State University. Raleigh.

Strauss, A. (1987). *Qualitative analysis for social scientists.* Cambridge, England: Cambridge University Press.

Tolman, E. C. (1932). *Purposive behavior in animals and men*. New York: Century.

Towers, E. R., Lux, D., & Ray, W. (1966). *A rationale and structure for industrial arts subject* *matter.* Columbus. OH: The Ohio State University.

Vroom, V. H. (1964). *Work and motivation.* New York: John Wiley & Sons.

Warner, W. E. (1947). *A curriculum to reflect technology*. Columbus, OH: Industrial Arts Center.

Wells, J. G. (1992). *Establishment of a taxonometric structure for the study of biotechnology as a secondary school component of technology education.* Unpublished doctoral dissertation, Virginia Polytechnic Institute and State University

Wells, J. G. (1994). Establishing a taxonometric structure for the study of biotechnology in secondary school technology education. *Journal of Technology Education, 6*(1), 58-75.

Wells, J. G. (1995). Defining biotechnology. *The Technology Teacher, 54*(7), 11-14.

Wells, J. G. (1999a). *Technology Education Biotechnology Curriculum*. Paper presented at the Technology Education Leadership Program, University of Maryland, Eastern Shores.

Wells, J. G. (1999b). Biotechnology content organizers. *Journal of Industrial Technology Education. 36*(4), 70-76.

Wells, J. G. (1999c). *The Effects of the Technology Education Biotechnology Curriculum Seminar and Prior Biotechnology Experience on Technology Education Teachers' Attitudes Toward Biotechnology Integration.* Unpublished research manuscript from the TEBC Project, West Virginia University, Morgantown, WV.

Wells, J. G. (2000). Effects of an on-line computer-mediated communication course, prior computer experience and internet knowledge, and learning style on students' internet attitudes computer-mediated technologies and new educational challenges. *Journal of Industrial Teacher Education, 37*(3), 22-53.

Wells, J. G. (2007). *Biotechnology Literacy*. Paper presented at the *Engineers of the Future Summer Institute*. Buffalo State University, Buffalo, NY

Wells, J. G. (2008). *Biotechnology Literacy: PBL in the Classroom.* Paper presented to the Virginia Tech Integrative STEM Education graduate students, Virginia Tech

Wells, J., & Anderson, D. (1997). Learners in a telecommunications course: Adoption, diffusion, and stages of concern, *Journal of Research on Computing in Education, 30*(1), 83-105.

Wells, J. G., & Kwon, H. (2008). Inclusion of biotechnology in US Standards for Technological Literacy: Influence on South Korean Technology Education Curriculum. *Proceedings of the 19th Pupil's Attitude Toward Technology Conference,* 315-333.

Wells, Pinder & Smith (1992). Algae, electronics, and ginger beer: Exploration in biotechnology at the Governor's school. *TIES Magazine*, March/April, Drexel University, PA.

Wilson, E., Kirby, B., & Flower, J. (2002). Factors influencing the intent of North Carolina agricultural biotechnology curriculum. *Journal of Agricultural Education, 43*(1), 69-81.

Wigfield, A., Tonks, S., & Eccles, J. S. (2004). Expectancy-value theory in cross-cultural perspective. In D. M. Mclnerney and S. Van Etten (Eds). *Big theories revisited: Research* *on sociocultural influences on motivation and learning* (pp. 165-198). Greenwich, CT: Information Age Publishing.

Wozney, L., Venkatesh, V., & Abrami, P. (2006). Implementing computer technologies: Teachers' perceptions and practices. *Journal of Technology and Teacher Education, 14*, 173-207.

Wright, R T. (1995). Technology education curriculum effort. In E. M. Martin (Ed.), *Foundation of Technology Education* (pp. 247-285). Peoria, IL: GLENCOE/McGraw-Hill.

Yates, B. L. (2001, May). Applying diffusion theory: Adoption of media literacy programs in schools. (Report No. CS510578). Washington, DC: Paper presented in the Annual Meeting of the International Communication Association. (ERIC Reproduction Document ED453564).

Yin, R. K. (2003). *Case study research: Design and methods third edition.* Thousand Oaks, CA: SAGE Publications.

Appendix A

Technology Teachers' Beliefs To Teach Biotechnology (TTBTTB) Instrument

Technology Teachers' Beliefs Toward Teaching Biotechnology

1. Technology Teachers' Belief To Teach Biotechnology

Dear Technology Educator:

My name is Hyuksoo Kwon, and I am a doctoral student in the Technology Education program at Virginia Tech working with my advisor Dr. John Wells. I am currently conducting my dissertation research on the teaching of biotechnology in the Technology Education classroom. As a Technology Education teacher you are the critical factor in this research, and I hope you will accept my invitation to participate in this important study.

In 2000 biotechnology was presented as an established content organizer within the national Standards for Technological Literacy (ITEA, 2000). However, nearly a decade later broad implementation of biotechnology instruction in Technology Education classrooms has not been realized. This is an issue of concern to the profession and I am conducting this study to investigate why the teaching of biotechnology in secondary school level Technology Education classrooms is not more widespread. Your participation can help the profession to better understand the issue.

To participate in this study I am asking you to complete this survey that takes 15-20 minutes to complete. The data collected from this study will only be used to fulfill my dissertation requirements, and will not be distributed in any way beyond scholarly publications and presentations. All participants will remain anonymous and any data provided will be safeguarded to maintain that anonymity. If you wish to participate in this important research study, please click the NEXT button below.

I cannot stress enough how important your input is to this research and I would be most appreciative of your taking [illegible]urvey. If you h[illegible]lease do not hesitate to contact me (540-808-7756; kwon06@vt.edu) or my advisor (540-231-8471; jgwells@vt.edu). Thank you for taking the time to participate and for contributing to this valuable study.

Sincerely,

Hyuksoo Kwon

Technology Teachers' Beliefs Toward Teaching Biotechnology

2. PART I: DEMOGRAPHIC DATA

1. Please indicate your gender

- ◯ Male
- ◯ Female

2. What grade level(s) of Technology Education do you currently teach?

- ◯ Middle School
- ◯ High School
- ◯ Middle School & High School

3. What is the highest degree that you currently hold?

- ◯ Bachelor's
- ◯ EdS
- ◯ PhD
- ◯ Master's
- ◯ EdD

4. In which of the following stubject areas are you licensed to teach?

- ◯ Technology Education
- ◯ Career and Technical Education
- ◯ Science

Other (Please specify)

5. How many total years have you been teaching secondary school (middle and/or high school) level Technology Education?

Number of Years at Middel School

Number of Years at High School

Number of Years at Middle School/High School

6. Do you teach biotechnology in your Technology Education classrooms?

- ◯ No
- ◯ Yes

7. If you marked "Yes" in Question 6 above, indicate how many years at any/all of the following levels:

Number of Years teaching biotechnology at Middle School

Number of Years teaching biotechnology at High School

Number of Years teaching biotechnology at Middle/High School

8. In your pre-service teacher preparation program, how many courses did you take to prepare you to teach biotechnology?

- ◯ None
- ◯ 2 courses
- ◯ 4 courses
- ◯ 1 course
- ◯ 3 courses
- ◯ 5 or more

Technology Teachers' Beliefs Toward Teaching Biotechnology

9. Have you participated in any in-service professional development for teaching biotechnology?

- ◯ No
- ◯ Yes

10. If you marked "Yes" in Question 9 above, indicate below the types and length of time spent in each:

1-Day Biotechnology Workshops (Indicate how many - give a number) ______

2-Day Biotechnology Workshops (Indicate how many - give a number) ______

1-Week Biotechnology Workshops (Indicate how many - give a number) ______

2-Week Biotechnology Workshops (Indicate how many - give a number) ______

Course (College/University/Graduate School) (Indicate how many - give number) ______

Other Professional Development (Briefly describe and give a number) ______

11. How would you describe the type of community within which your school is located?

- ◯ Rural
- ◯ Urban
- ◯ Suburban
- ◯ Town
- ◯ Small City
- ◯ Medium city
- ◯ Large city

12. The average number of students in my Technology Education classes is:

- ◯ 1-10
- ◯ 11-20
- ◯ 21-30
- ◯ 31-40
- ◯ More than 41

Technology Teachers' Beliefs Toward Teaching Biotechnology

3. PART II: Attitude Toward Teaching Biotechnology (ATTB)

DIRECTIONS: Answer as completely and truthfully as you possibly can when thinking how each of the following statements applies to your PRESENT attitude toward teaching biotechnology. Click the number that best reflects your present attitude. The higher the number, the better the statement reflects your present attitude.

1. Please check the number that best reflects your present attitude.

	Not true of me now (0)	(1)	(2)	(3)	(4)	(5)	(6)	Very true of me now (7)
1. I am concerned about students' attitudes toward biotechnology.	◯	◯	◯	◯	◯	◯	◯	◯
2. I now know of several approaches for how I might go about teaching biotechnology.	◯	◯	◯	◯	◯	◯	◯	◯
3. I don't even know what biotechnology is.	◯	◯	◯	◯	◯	◯	◯	◯
4. I am concerned about not having enough time to learn about biotechnology so that I can teach it effectively.	◯	◯	◯	◯	◯	◯	◯	◯
5. I would like to help other faculty teach biotechnology.	◯	◯	◯	◯	◯	◯	◯	◯
6. I have very limited knowledge about biotechnology.	◯	◯	◯	◯	◯	◯	◯	◯
7. I would like to know how the integration of biotechnology concepts might affect me when I am trying to teach.	◯	◯	◯	◯	◯	◯	◯	◯
8. I am concerned about what my employer(s) might expect me to know about teaching biotechnology and how those expectations might be in conflict with what I like to do.	◯	◯	◯	◯	◯	◯	◯	◯
9. I am concerned about improving what I presently know about teaching biotechnology.	◯	◯	◯	◯	◯	◯	◯	◯
10. I would like to work with present fellow workers and others who are teaching biotechnology.	◯	◯	◯	◯	◯	◯	◯	◯
11. I am concerned about how my teaching biotechnology might affect my students.	◯	◯	◯	◯	◯	◯	◯	◯
12. I am not concerned about teaching biotechnology.	◯	◯	◯	◯	◯	◯	◯	◯
13. I would like to know who will make decisions about my teaching biotechnology.	◯	◯	◯	◯	◯	◯	◯	◯
14. I would like to discuss the possibility of teaching biotechnology.	◯	◯	◯	◯	◯	◯	◯	◯
15. I would like to know the resources available if teaching biotechnology is to be integrated into my job.	◯	◯	◯	◯	◯	◯	◯	◯
16. I am concerned about my inability to learn all there is to know about teaching biotechnology effectively.	◯	◯	◯	◯	◯	◯	◯	◯
17. I would like to know how my teaching is supposed to change because of integrating biotechnology.	◯	◯	◯	◯	◯	◯	◯	◯
18. I would like to familiarize my fellow workers and my employers about biotechnology instruction as I learn about it and work with it more.	◯	◯	◯	◯	◯	◯	◯	◯
19. I am concerned about evaluating my impact on students.	◯	◯	◯	◯	◯	◯	◯	◯
20. I would like to change how biotechnology content might be used as I learn more about it.	◯	◯	◯	◯	◯	◯	◯	◯
21. I do not care much about teaching biotechnology; my schedule prevents me from caring too much.	◯	◯	◯	◯	◯	◯	◯	◯
22. I would like to modify the integration of biotechnology in my job based on students' experiences.	◯	◯	◯	◯	◯	◯	◯	◯
23. Although I don't care much about teaching biotechnology, I am concerned about it.	◯	◯	◯	◯	◯	◯	◯	◯

Technology Teachers' Beliefs Toward Teaching Biotechnology

4. PART II: Attitude Toward Teaching Biotechnology (ATTB) -CONTINUED

DIRECTIONS: Answer as completely and truthfully as you possibly can when thinking how each of the following statements applies to your PRESENT attitude toward teaching biotechnology. Click the number that best reflects your present attitude. The higher the number, the better the statement reflects your present attitude.

1. Please check the number that best reflects your present attitude.

	Not true of me now (0)	(1)	(2)	(3)	(4)	(5)	(6)	Very true of me now (7)
24. I would like to excite my students or clients about teaching biotechnology concepts.	○	○	○	○	○	○	○	○
25. I am concerned about the time needed to learn about teaching biotechnology that will keep me away from doing what I am supposed to be doing as part of my job.	○	○	○	○	○	○	○	○
26. I would like to know what teaching biotechnology will require in the immediate future.	○	○	○	○	○	○	○	○
27. I would like to coordinate my efforts in learning about biotechnology instruction with fellow workers.	○	○	○	○	○	○	○	○
28. I would like to have more information on the time required to learn about biotechnology.	○	○	○	○	○	○	○	○
29. I would like to know what other people are doing in relation to teaching biotechnology.	○	○	○	○	○	○	○	○
30. At this time, I am not interested in learning about teaching biotechnology concepts.	○	○	○	○	○	○	○	○
31. I would like to determine how to supplement and enhance biotechnology instruction.	○	○	○	○	○	○	○	○
32. I would like to use feedback from my students to change how I teach biotechnology.	○	○	○	○	○	○	○	○
33. I would like to know how my job will change when I begin teaching biotechnology.	○	○	○	○	○	○	○	○
34. My present schedule is preventing me from learning too much about integrating biotechnology instruction.	○	○	○	○	○	○	○	○
35. I would like to know how the integration of biotechnology instruction is better than the methods I presently use or plan to employ when I do my job.	○	○	○	○	○	○	○	○

Technology Teachers' Beliefs Toward Teaching Biotechnology

5. PART III: Belief Toward Teach Biotechnology (BTTB)

[DIRECTION] The following statements ask you how you feel about TEACHING biotechnology. There are no right or wrong answers. We are only interested in your honest opinion. Please check the one number for each statement that shows how you feel. Thank you for your honest opinion.

1. Compared to other teachers, how well do you expect to do at teaching biotechnology in your classrooms this year?

	Much worse (1)	2	3	4	5	6	Much better (7)
1 (Much worse) 7 (Much better)	◯	◯	◯	◯	◯	◯	◯

2. Personally, how well do you think you will do at teaching biotechnology this year?

	Very poorly (1)	2	3	4	5	6	Very well (7)
1 (Very poorly) 7 (Very well)	◯	◯	◯	◯	◯	◯	◯

3. In general, I find teaching biotechnology content very interesting

	Very boring (1)	2	3	4	5	6	Very interesting (7)
1 (Very boring) 7 (Very interesting)	◯	◯	◯	◯	◯	◯	◯

4. How much do you like teaching biotechnology content?

	Not very much (1)	2	3	4	5	6	Very much (7)
1 (Not very much) 7 (Very much)	◯	◯	◯	◯	◯	◯	◯

5. Is the amount of effort it will take to teach biotechnology content well worthwhile to you

	Not very worthwhile (1)	2	3	4	5	6	Very worthwhile (7)
1 (Not vey worthwhile) 7 (Very worthwhile)	◯	◯	◯	◯	◯	◯	◯

6. I feel that, to me, being good at teaching biotechnology is very important.

	Not at alll important (1)	2	3	4	5	6	Very important (7)
1 (Not at all important) 7 (Very important)	◯	◯	◯	◯	◯	◯	◯

7. How important is it to you to teach biotechnology in your Technology Education courses?

	Not at all important (1)	2	3	4	5	6	Very important (7)
1 (Not at all important) 7 (Very important)	◯	◯	◯	◯	◯	◯	◯

Technology Teachers' Beliefs Toward Teaching Biotechnology

8. How useful is learning biotechnology for helping your students become more technologically literate after they graduate?

	Not very useful (1)	2	3	4	5	6	Very useful (7)
1 (Not very useful) 7 (Very useful)	○	○	○	○	○	○	○

9. How useful is what your students learn in biotechnology courses for their' daily lives outside school?

	Not very useful (1)	2	3	4	5	6	Very useful (7)
1 (Not very useful) 7 (Very useful)	○	○	○	○	○	○	○

10. Teaching biotechnology takes too much preparation time.

	Strongly disagree (1)	2	3	4	5	6	Strongly agree (7)
1 (Strongly disagree) 7 (Strongly agree)	○	○	○	○	○	○	○

11. Teaching biotechnology in my Technology Education courses requires a great deal of effort.

	Strongly disagree (1)	2	3	4	5	6	Strongly agree (7)
1 (Strongly disagree) 7 (Strongly agree)	○	○	○	○	○	○	○

12. Teaching biotechnology in my Technology Education courses requires specialized materials and equipment.

	Strongly disagree (1)	2	3	4	5	6	Strongly agree (7)
1 (Strongly disagree) 7 (Strongly agree)	○	○	○	○	○	○	○

Technology Teachers' Beliefs Toward Teaching Biotechnology

6. PART IV: Open Ended Questions

1. Standard 15 of the ITEA Standards for Technological Literacy includes biotechnology as a content area that should be taught by technology education teachers to develop students with some level of biotechnology literacy. What benefits are there for developing students who are more biotechnologically literate specifically through technology education programs?

2. What level of preparation do you feel technology education teachers need in order to prepare their students to be more technologically literate about biotechnology?

3. How competent do you feel you are to teach about biotechnology literacy in your classroom?

4. What role should professional development (pre-service programs and/or in-service workshops/college courses) play in preparing technology education teachers to help students become more technologically literate about biotechnology?

5. In what way(s) does your administration, school, or other colleagues support or encourage teaching about biotechnology in your technology education program?

Appendix B

Expressed Permission for Using the Children's Self and Task Perception

(Motivational Instrument) from One of the Authors

Delete | Reply | Reply All | Forward | Redirect | View Source | Move

Date: Mon, 30 Mar 2009 10:11:18 -0400
From: Jacque Eccles [redacted]
To: Hyuksoo KWON [redacted]
Subject: **RE: Dr Eccles, Need your help**

You have my permission to use our scales. Please let me know what you find out.

Jacque Eccles

McKeachie Collegiate Professor of Psychology, Women's Studies, and Education

University of Michigan

426 Thompson Street
PO Box 1248

Ann Arbor, Michigan 48106-1248

Phone: [redacted]

Fax: [redacted]

Note: If you do not receive a reply from me I'm probably out of town. If you need to reach me immediately please contact my assistant Deanna Maida at dmigut@umich.edu or by phone at 734-647-0624. If you need to schedule an appointment please contact my assistant Lori Rudy at lrudy@umich.edu or by phone 734 647-5282.

Appendix C

IRB Approval Letter

VirginiaTech

Office of Research Compliance
Carmen T. Green, IRB Administrator
2000 Kraft Drive, Suite 2000 (0497)
Blacksburg, Virginia 24061
540/231-4358 Fax 540/231-0959
e-mail ctgreen@vt.edu
www.irb.vt.edu
FWA00000572(expires 1/20/2010)
IRB # is IRB00000667

DATE: February 19, 2009

MEMORANDUM

TO: John Wells
Hyuksoo Kwon

FROM: [redacted]

SUBJECT: **IRB Exempt Approval:** "Key Factors Affecting the Implementation of Biotechnology Instruction in Secondary School Level Technology Education Classrooms" , IRB # 09-173

I have reviewed your request to the IRB for exemption for the above referenced project. The research falls within the exempt status. Approval is granted effective as of February 19, 2009.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in the research protocol. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.

2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

cc: File

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Appendix D

Request Letter Asking Technology Education Teachers' Listservs

February 2009

Individual Full Name:

My name is Hyuksoo Kwon and I am an international Ph.D. student in the Technology Education program at Virginia Tech working with my advisor Dr. John Wells. I am currently conducting dissertation research on “Technology teachers’ beliefs toward the teaching of biotechnology” and am at the data collection stage. My data will be collected using a composite on-line survey delivered to technology education teachers in secondary schools within a select few eastern seaboard states. My plan is to collect data near the end of February or first part of March.

Crucial to my research is being able to ask practicing technology educators if they would participate in my research by completing a short online survey. An efficient way to make this request is by sending an email invitation to key technology education listservs in the targeted states. My email would ask that those technology educators willing to participate follow a hyperlink and complete a short online survey (anonymity ensured). This is where I need your help. As the state supervisor you will know what technology education listservs exist in your state and who I should contact about having my email request posted through those listservs.

If you are willing to lend me your help, I would ask that you please give me the contact information (name, phone number or email) for the individual(s) in your state who manages the technology education listserv(s). If you do not have this information, perhaps you could direct me to the person who might.

I would be most grateful for any help you may provide in my efforts to conduct this important research for our field. If you can assist me in this endeavor, please simply reply to this e-mail. Should you have any questions or concerns, please do not hesitate to contact me ([redacted] or [redacted]) or my advisor ([redacted] or [redacted]). Thank you for your consideration of my request. I look forward to hearing from you.

Sincerely,
Hyuksoo Kwon

Appendix E.

Invitation E-mail for the TTBTTB Survey

Dear Technology Educator:

My name is Hyuksoo Kwon, and I am a Ph.D. student in the Technology Education program at Virginia Tech working with my advisor Dr. John Wells. I am currently conducting my dissertation research on "technology teachers' beliefs toward the teaching of biotechnology". You are receiving this invitation e-mail because you teach Technology Education.

Biotechnology content is an established content organizer within the national Standards for Technological Literacy (ITEA, 2000). However, the actual delivery of biotechnology instruction in Technology Education classrooms has not realized broad implementation. Previous studies have recognized that there is a need to identify those key factors affecting the implementation of biotechnology instruction in secondary school level Technology Education classrooms. The purpose of the study is to investigate technology teachers' belief toward the teaching of biotechnology in secondary school level Technology Education classrooms.

The information derived from the survey will be used to investigate technology teachers' belief regarding the teaching of biotechnology in secondary level school Technology Education. The data collected from this study will only be used to fulfill my dissertation requirements, and not distributed in any way beyond scholarly publications and presentations. Your participation will be anonymous and any data provided will be safeguarded to maintain that anonymity. Instructions for participating and completing the survey are provided for when you access the web page. It will take 15-20 minutes to complete this linked survey. I would very appreciate if you could take the time to complete the survey linked below. If you wish to participate in this important research study, please click the SURVEY LINK below.

http://www.surveymonkey.com/s.aspx?sm=6f5yCi0_2fEaAB1J7uBI5rAQ_3d_3d

If you have any questions or concerns, please do not hesitate to contact me ([redacted] or [redacted]) or my advisor ([redacted] or [redacted]). I appreciate your taking time for volunteering to participate in this study.

Sincerely,
Hyuksoo Kwon