Importance of selected science and technology topics in the instructional programs to Iowa high school agricultural educators

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by

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A thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Agricultural Education

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Ames, Iowa

2012

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ACKNOWLEDGMENTS

I would like to express my sincere appreciation to my major professor Dr. Robert A. Martin for his constant support and guidance throughout this program. His suggestions for this research were invaluable. I am grateful to him for explaining his views patiently and also respecting my views. He was very considerate of my needs as a graduate student and supported me with an assistantship and professional development duties.

I would also like to express my sincere thanks to my other committee members, Dr. Gregory S. Miller and Dr. David G. Acker, for their input to this research work. They were always there for me whenever I needed any help. Their ideas gave me inspiration for the design of this research. Special thanks to Dr. Gregory S. Miller for his time and suggestions toward the development of the questionnaire in this survey. Special thanks to Dr. Gaylan Scifield for conducting the process of the whole data collection in this research.

I am grateful to my family members for their support and affection. Because of their financial support, I had a chance to study abroad and finished my master study. My sincere thanks are due to all my dear friends here at Iowa State and others from China for their good wishes and attention.

This section would be incomplete without expressing my heart-felt profound gratitude to all teachers during my schooling. They made me realize the real value of education. I am grateful to them for their causeless and unceasing love.

ABSTRACT

Literature suggests that the integration of science and technology knowledge is necessary for the agricultural industry to succeed. Many science and technology advances have changed agriculture significantly. Therefore, teaching science and technology assumes importance for the success of agricultural education. There are many nonformal and formal agricultural education institutions in the United States with the high school agricultural education being the most common one for youth development.

The purpose of this study was to determine the level of importance of selected science and technology topics as perceived by high school agricultural educators in Iowa when integrating these topics into their instructional programs and to identify teachers' needs for professional development in these topics.

Data were collected from high school agricultural teachers in Iowa by using an expert panel-reviewed and reliability-tested electronic questionnaire. Two hundred and twenty teachers served as the target population for this census study. The findings were based on 69 usable questionnaires out of the 71 that were returned.

It was found that a typical Iowa high school agricultural teacher was a middle-aged man with substantial years of work experience in a variety of discipline areas and held a bachelor's degree. Teachers perceived most of the selected science and technology topics to be important and were in need of inservice education on a majority of these topics. It was further found that the perceptions of high school agricultural teachers toward the selected science topics have changed during the past twenty years. Equipment, funding, and curriculum resources availability were cited as the main limitations when integrating science and technology topics into their instructional programs. One-way ANOVA analysis and Cramer's V indicated that demographics including the years of work, the highest degree held, owning or operating a farm and involvement in organizations influenced high school agricultural teachers' attitudes toward some topics and barriers.

Ultimately, the findings from this study brought greater understanding of the current situation of Iowa high school agricultural teachers' perceptions and needs toward the integration of science and technology into their curricula. Agricultural education professionals can benefit from addressing the results and the recommendations of this study in order to improve the integrated agricultural science curriculum in Iowa.

CHAPTER 1. INTRODUCTION

Background information, situation, and the problem statement

Agriculture can never be isolated from science and technology. Throughout the history of agricultural development, the application of scientific and technological advances has greatly influenced the agriculture industry. The passage of the Hatch Act of 1887 is considered to be a result of the scientific revolution in American agriculture that occurred in the late 1800s when farmers required more scientific research (Hillison, 1996). American experiment stations supported by the Hatch Act take the responsibility "to conduct original research or verify experiments . . . bearing directly on the agricultural industry of the United States" (Marcus, 1985). Because of these strategies, American agriculture remains in a leading position regarding the international competition for productivity and quality.

The formal agricultural education program started in America after the passage of the Smith-Hughes Act of 1917. From that point the vocational agriculture curriculum went into a stage of "spreading knowledge throughout the farming regions about how and when to use agricultural innovations" (National Research Council, Board on Agriculture, Committee on Agricultural Education in Secondary Schools, 1988, p. 56). This responsibility highlights the importance of science and technology in agriculture once again. Research has shown the positive actions made by agricultural educators in response to this challenge. Dormody (1992) pointed out that a majority of the agriculture and science departments have long been sharing resources. Whent (1994) found one example of the sharing of resources in her research. The AgriScience Institute and Outreach Program increased cooperation and resource sharing between agriculture and science teacher participants.

High school agricultural education programs, as an essential aspect of agricultural education, can provide students the necessary knowledge and skills needed for further education and development. Thus, the role of agriscience in the high school curriculum has been a significant national issue in agricultural education. It is claimed that science combined with agriculture will be delivered more effectively (National Research Council, Board on Agriculture, Committee on Agricultural Education in Secondary Schools, 1988). In fact, as the essential component of the agricultural education curriculum, science related competency areas/knowledge bases had already been put to use (Binkley & Tulloch, 1981; Hughes et al., 2001). Concepts and principles in many disciplines, such as chemistry, biology, genetics, physiology, and zoology, are readily applied to plant and animal studies (Moss, 1985). Illinois high school science teachers felt that agriculture programs should become more science based (Osborne & Dyer, 1998). The teachers believe that integrating science assisted students to better understand science concepts and their application to agriculture (Balschweid, Thompson, & Cole, 2000).

Today, the issue of teaching science and technology in high school agricultural programs still remains and is even more serious and complex than before. Agriscience, bioscience, and ag-technology have become prevalent and confirm the truth of the issues related to the infusing of science and technology in the agricultural education curriculum (National Council on Vocational Education, 1990).

Various national reports ensure the impact of biotechnology and genetic engineering on the agricultural industry and consumers of agriculture (National Council on Vocational Education, 1990). However, the National Council on Vocational Education also declared that “the subject matter about agriculture and in agriculture must be broadened” (Kirby, 1990, p. 71). When agriculture goes beyond the farm, agricultural education, as a discipline closely associated with agriculture, should also be enlarged.

It can be deduced from the forgoing discussion that high school agricultural educators are the right persons to teach science and technology in their instructional programs comprehensively. But Martin, Rajasekaran and Vold (1989) declared that, “ although sciences pertinent to agriculture are being taught, we do not know to what extent they are being taught nor do we know what is being taught and what more should be taught related to the sciences of agriculture” (p. 244). This means, although many science and technologies are already applied to agriculture in more ways than most of us suspect (Smith, 1989), there is still a need to figure out the current attitude high school agricultural educators hold toward selected science and technology topics in their instructional programs.

Several research studies on curriculum issues in agricultural education (Whent, 1994; Wilson, Kirby, & Flowers, 2002; Thompson & Balschweid, 1999; Newman & Johnson, 1993; Norris & Briers, 1989; Layfield, Minor, & Waldvogel, 2001; Balschweid & Thompson, 2002; Thompson & Schumacher, 1998) have provided much information on the attitudes, the perceived needs and barriers of integrating science and technology into the study of agriculture. With the efforts of these researchers, the agricultural curriculum is perhaps on the way to improve programs. However, agricultural educators still are faced with the challenge of teaching in-depth science and technology topics in class, which requires them to have a comprehensive preparation. What's more, in this rapidly changing society, attitudes will be changed, previous barriers will be overcome, and new problems will arise. And even though educators have taught science and technology, what is the current extent to which teachers believe science and technology is important in the existing curriculum? Given the future of agricultural education, it is necessary to examine the degree of importance of selected science and technology topics in the instructional programs to high school agricultural educators.

A thorough review of the literature indicates that there is a need to examine the current extent to which selected science and technology topics in the instructional programs are important to high school agricultural educators. In order to understand the attitude of high school agricultural educators on this issue of integration of science and technology, it is essential to know the answers to the following questions:

1. To what extent are selected science and technology topics important for integrating into the instructional programs in agriculture according to high school agricultural educators?
2. To what extent should professional development be provided to teachers in order to overcome the obstacles when adding these selected topics into their

instructional curriculum?

3. What are the barriers to integrate science and technology into the agriculture curriculum?

Need for the study

It is a well documented fact that adding suitable science and technology topics into the instructional curriculum is necessary for agricultural education in high school and for students' development. In this context it becomes essential that we should have a clear understanding of current high school agricultural educators and what they believed to be important so that we can help them to enlarge the effectiveness of teaching selected science and technology topics in their classes. This study could provide information toward accomplishing this purpose.

The review of literature indicates the previous perceptions and some barriers of integrating science and technology. We still need to find out the current situation of Iowa high school agricultural educators. There have been some studies that worked on the perceptions of high school agricultural educators toward the importance of science and technology, but there is no known study that associates the related professional development. This study was aimed at contributing information that could be used for the successful education of high school students regarding the science and technology related competency areas/knowledge bases in agriculture and also for designing in-service educational programs for high school agricultural educators.

Purposes & objectives

The purpose of this descriptive study was to determine the degree to which the selected science and technology topics are important in Iowa high school agricultural educators' instructional programs. A secondary purpose was to determine the need for professional development regarding the topics.

The specific objectives of the study were to determine:

1. The degree to which the selected science and technology topics are important in their instructional programs.
2. The need for the professional development on teaching the selected science and technology topics.
3. The barriers of teaching the selected science and technology topics in their curriculum.
4. Identify selected demographic information.

Significance of the study

The significance of this study is four-fold:

1. Analyzing the degree of the importance of selected science and technology topics in their curriculum would help us understand the perception of high school educators toward this issue, which could provide us useful information to know the current situation, and to modify high school courses in agriculture.
2. Identifying the needs of high school educators toward the selected science and technology topics could be used in planning in-service workshops to enhance teachers' performance in delivering the selected science and technology topics.
3. Identifying the barriers of high school educators to adding selected science and

technology topics into their curricula could provide information to the state supervisor of agricultural education and teacher educators in order to improve the infusion of selected science and technology in the agricultural education curriculum.

4. Comparing and contrasting the demographics information could be useful in indentifying any statistically significant differences that may be related to adding selected science and technology into the curriculum effectively.

Definition of selected terms

1. Education: "Bringing about desirable changes in knowledge (things known), attitudes (things felt) and skills (things done), either in all, or one or more of them." (Reddy, 1993, p.7).
2. High school education: Educational courses given in high school in order to prepare students for college and work.
3. Iowa high school agricultural educators: Teachers hold full-time teaching positions in high school agricultural programs in Iowa.
4. Science: Science is a body of knowledge that covers general truths of the operation of general laws, and a process that can be used to obtain and test knowledge through the scientific method. In this study, we mainly focus on the natural science, which means the study of the natural world, such as Plant Science, Genetics, Animal Science, Soil Science, Microbiology, and Food Science.
5. Technology: Technology is the usage of tools, machines, techniques or methods in order to solve a problem or improve performance. The technology combined with

agriculture aims to use the agricultural resources and natural resources efficiently in the chain of production, processing and marketing. In this study, we focus on 1) the on-the-farm technology, which works on improving the productivity, such as biotechnology, automation technology, and power technology; 2) the agribusiness technology, which depends on strategic decision making, management, marketing, and processing systems.

6. Importance: The mean score on a set of selected science and technology topics on a five-point Likert type scale on the importance of these topics in the instructional programs to high school agricultural educators.
7. Professional development: Skills and knowledge attained for both personal development and career advancement.
8. Need: The mean score on a set of selected science and technology topics on a five-point Likert type scale on the need of the professional development high school agricultural educators would like to have on these topics.
9. Barrier: Factors that block or impede high school agricultural educators to teach the selected science and technology topics in their instructional programs.

Limitation of the study

This study was limited to Iowa high school agricultural educators employed during the 2011-2012 school year. The science and technology topics in the study did not include all the existing topics. They were selected based on a previous national study (Martin et al., 1989).

Summary

This chapter was organized under the sections: background information and problem statement, need for the study, purpose and objective, significance of the study, definitions of the selected terms, and limitation of the study. Science and technology related competency areas/knowledge have been identified as an essential part in high school agricultural education. It has been reported that adding suitable science and technology topics into the instructional curriculum will improve students' performance for further education and self development. Added to this, national research council pointed out that many programs fell behind the rapidly changing science and technologies. In this context, teaching science and technology topics in high school agricultural education programs assumes significance.

High school educators are positioned uniquely to add science and technology topics instructional programs. Such programs have been taught in high school, but many studies suggest that there is not sufficient evidence to show the extent of the infusing of science and technology. Hence, it becomes essential to know: what degree of importance of selected science and technology topics in the instructional programs is demonstrated by high school agricultural educators; what extent should professional development be provided to teachers in order to overcome the obstacles when adding these selected topics into their instructional curriculum.

There have been some studies on this issue, but the rapidly changing society must continually investigate perceptions and barriers, and then generate idea to address current problems. This study was to determine the current level of importance and barriers for high school agricultural educators toward the selected science and technology topics, in order to provide useful information on course offerings, teacher workshops and in-services, and agricultural education curriculum.

CHAPTER 2. REVIEW OF LITERATURE

Integrating appropriate science and technology knowledge into agricultural education is essential for the future development of agriculture in the United States. Therefore, research about the current curriculum situation in agricultural education is important so agricultural educators can adopt suitable science and technology topics in their instructional programs. Although agricultural education is being offered by educators in a variety of settings, high school educators are uniquely positioned to educate our contemporary young people through agricultural educational programs integrated with science and technology topics. There is little known research available on the current perceptions of high school agricultural educators toward the selected science and technology topics. To ascertain the status, and improve the existing agricultural educational programs, it is essential to analyze the level of importance of the selected science and technology topics for integrating into the instructional programs in agriculture according to high school agricultural educators; the needed level of the professional development to be provided to teachers in order to overcome the obstacles when adding these selected topics; and identify the barriers to integration of selected science and technology topics into the agriculture curriculum.

This chapter focuses on five sections. A brief review of the origins of science and technology in agricultural education is provided in section one. The changes in agricultural education associated with science and technology are described in section two. The role of science and technology in high school agriculture educational programs is presented in section three. Section four briefly describes the need for the professional development and inservice education. Finally, section five presents research findings from related studies.

Agricultural education ties to science and technology

Agricultural science and associated technology became well-accepted terms for several decades after the Hatch Act first used agricultural science in its preface. It stated:

> … in order to aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture, and to promote scientific investigation and experiment respecting the principles and applications of agricultural science, there shall be established, under direction of the college or colleges or agricultural department of colleges in each State or Territory a department known and designated as an “experiment station". (Hatch Act, 1887, p. 1)

This advanced idea offered substantial help, such an act funded research, in order to implement the distribution of research findings to famers. Two years after the passage of the Hatch Act, Chamber’s Encyclopedia (1889) gave a definition of agricultural education:

> Agricultural Education, as at present understood, is a comprehensive term, including instruction in chemistry, geology, botany, zoology, mechanics embracing, in short the science as well as the practice of agriculture. (p. 61)

This definition was mainly built on the science-based and academic-oriented aspects of agricultural education at that time. Thus, early agricultural education was considered as an academic and scientific course of study.

Twenty-eight years after the Chamber's Encyclopedia definition was published, one important law, the Smith-Hughes Act, first stressed the vocational role of agricultural education:

> …such education shall be that which is under public supervision or control; that the controlling purposes of such education shall be to fit for useful employment; that such education shall be of less than college grade and be designed to meet the needs of persons over fourteen years of age who have entered upon or who are preparing to enter upon the work of the farm or of the farm home. (Smith-Hughes Act, 1917)

However, this "vocational" portion in agricultural education are criticized later by the National Research Council (1988). It believed that avoiding the "vocational" label would "help attract students with diverse interests, including the college bound and those aspiring to professional and scientific careers in agriculture" (National Research Council, 1988, p. 35). In other words, the "vocational" label narrows down the diversity of student population, which is important for the future development of agricultural education. The National Research Council Committee (1988) also asked for more revisions to prevent agricultural education from becoming just job preparation.

Although the Smith-Hughes Act introduced the vocational-based requirement into agricultural education, "the basic science base for the agricultural education programs has not changed" (Hillison, 1996, p.12). Haye (1980) states, "If instruction in agriculture is to take its rightful place in curriculum, it should be regarded as a science and not as a vocational subject for students who cannot cope with the sciences" (p. 20).

With a deep and clear understanding of science in agriculture education, agricultural educators have also promoted technologies in relevant curricula. Through the Vocational Education Act of 1984, the United States Congress appropriated funds to help vocational students learn about new technologies. Biotechnology is a good example for integrating technology. As Smith (1989) stated, biotechnology is already applied to agriculture in more ways than most of us suspect. Hardy believed that "biotechnology with all its inherent complexities, mysteries, problems, and challenges, promises to revolutionize farming and agriculture" (Cited in Martin, 1989, p. 243).

In conclusion, the history of science and technology in agriculture clearly indicates the close relationship among them. A review of the changes about the role of science and technology in agriculture education in the formal or informal institutions is presented in the next section.

Changes in agricultural education toward science and technology

Changes have occurred constantly in many dimensions of society, including agriculture and education (National Research Council, 1988; Adams & Hamm, 1994). As American agricultural industry becomes more scientific and technological, more science knowledge and skills are demanded. Because of this phenomenon, one significant change is the increased emphasis on the role of science in agricultural education (Camp, 1994). Enderlin and Osborne (1992) believed this change could stimulate students' abilities in not only the inquiry skills, but also the understanding of the agriculture-related science principles.

Buriak (1989, p.4) once defined agriscience as, an "instruction in agriculture emphasizing the principles, concepts, and laws of science and their mathematical relationships supporting, describing, and explaining agriculture." Based on this definition, Lee (1994) clarified "the principles of science that undergird agriculture" (p.2) as the core of the emphasis. He also stated that, "Agriscience and technology require [instructional] approaches that are different from traditional agricultural education." (Lee, 1994, p. l-2) Furthermore, he pointed out that a hands-on and application-oriented science educational idea should be built in order to create these new approaches (Lee, 1994). Osborne (1993) applied the hands-on activities to reinforce student learning of science principles. Such activities are consistent with the constructivist approaches in science education, which accentuates the necessity of concrete physical experiences in learning science concepts and principles (Brooks & Brooks, 1993; Fensham, 1992).

Science has always been a basic tenet of agricultural instruction in the United States (True, 1929). As the curriculum of secondary agricultural education developed over the years, the content of the instruction emphasized more on the "how" of agricultural production practices, rather than the "why" (Williams, 1990). Changes in the content reflected changes in the technology of production agriculture, e.g., new, and more efficient ways of showing "how."

From that moment in which we aware of the significant influence of science and technology in agriculture, ongoing efforts have been made to expand the scientific and technical content in agricultural education. However, we must realize that the principal reason for all these changes in agricultural education is to meet the needs of contemporary agricultural development. We must clearly understand that agriculture can never be regarded as producing food only. The definition of agriculture should be related to economic, sociological, political, and environmental and behavior functions (Commission on Education in Agriculture and Natural Resources, 1971). Duval (1988) pointed out:

> Agriculture, the nation's largest industry, is changing. It is changing from an industry that is by tradition production oriented to one that requires more professionals in marketing, management, science, education, and communication. Today's agriculturalists are seeking new and better methods of achieving higher agricultural production, while striving to meet consumer demands of what is produced, as well as how it is managed, processed, and marketed. (p.18)

Since agricultural education is a discipline closely associated with agriculture, it must make an appropriate response to these changes and challenges effectively. Otherwise, agricultural education will lose its essence. Fortunately, our agricultural educators have taken action. Because of their efforts, science and technology in today's agricultural education play a critical role in many aspects.

In summary, from the first time we applied science and technology to solve agricultural problems to now, we try to integrate science and technology systematically in agriculture education and many changes have happened. So, high school agricultural education needs to respond to the further development of agricultural education. A review of some of the important changes is provided in the next section.

Science and technology in high school agricultural education

The formal secondary agricultural education program in the United States was driven by the Smith-Hughes Act of 1917. Because of this act, more and more relevant departments in the United States were mobilized to promote and future develop programs of vocational education in agriculture, trades, industries and homemaking (Phipps & Osborne, 1988). The National Research Council committee (1988) stated that “vocational agriculture programs must be upgraded to prepare students more effectively for the study of agriculture in post-secondary schools and colleges and for current and future career opportunities in agricultural sciences, agribusinesses, marketing, management, and food production and processing” (p. 1). This statement outlined the different types of knowledge required by agricultural education programs, which are based on science and technology, students’ future development, and agricultural needs.

However, the evolution of agriculture programs must continue if the programs are to meet the needs of students in the 21st century (Krueger & Mundt, 1991). This evolution process is significant, but difficult. Should we completely abandon the past, and then start from sketch? Osborne (1993) described this behavior as "a drastic mistake" (p.3). He indicated that although we need to redefine the place and role of agricultural education in the secondary schools, it does not mean we must throw away everything from the past. What we should do is to teach these conventional topics by linking the practices of agriculture with the science. He believed this agriscience instruction will make the agriculture program stronger, while making a unique contribution to the scientific literacy of students in the school.

Over the years, high school agriculture educators have devoted a lot of time searching for a suitable program model to conduct a comprehensive curriculum, which combines classroom and laboratory instruction, supervised experience, and FFA activities together, in order to serve the needs of students better not only in developing student personal skills, but also in preparing abilities needed in agricultural employment. A traditional agricultural education program contains three circled elements: classroom instruction, FFA and supervised agricultural experience (SAE). However, Hughes and Barrick (1993) provided an accurate analysis for this traditional model:

1. This model overlapped some high-related activities.
2. Activities of FFA and SAE were not related to classroom and laboratory instruction.
3. The context of school and community for the total agricultural education program was not apparent.

Considering the changes and challenges in the agricultural industry, student population, society, education system, and the work place, they further pointed out that a new model should be established to reflect the needs of students, agricultural education and society accurately within the context of the current educational environment (Hughes & Barrick, 1993). Advances in the field of biotechnology in agriculture, as well as the increasingly technical nature of agricultural careers have led many leaders in agricultural education to propose an emphasis on science and technology in high school agriculture programs.

In short, the above cited literature suggests that educators have been working on creating a suitable model that can integrate science and technology effectively in high school education. In addition to establishing a proper model, high school teachers should be competent in the educational processes required in conducting successful instructional programs. Professional development and inservice education provided in next section can improve their teaching performance.

Professional development and inservice education

Professional development and inservice education for novice and experienced teachers are designed to improve the quality of classroom instruction; enable them to grow professionally; introduce the practical applications of research-validated strategies; and so on. These activities aim to help teachers achieve a higher effectiveness of the educational process, which includes conducting a needs assessment, the understanding of the learning styles, the determination of the delivery system, and the evaluation systems.

It was reported by Husen, Saha and Noonon that teacher education can make a difference – qualifications, experience and levels of education and knowledge were all positively associated with student achievement (cited in Psacharopoulos and Woodhall, 1985). On the other hand, to respond to the demands for curriculum development, teachers are becoming increasingly involved in seeking opportunities to improve their professional skills and teaching effectiveness (Craft, 1996). Thus, professional development programs are crucial in bringing about change in teachers' classroom practices, their attitudes and beliefs, as well as students' learning outcomes (Guskey, 2002).

Many researchers (Tuthill, Seidel, & McClure, 1987; Hall, 1986; Weil, 1985) believe that research-based inservice education can bring significant teaching improvement upon a sound theoretical soil. Using the theory of the nature of adult learning and developmental stages as a basis, inservice education shifts from a deficit model of staff development, which emphasizes remediation, to a developmental model, which emphasizes growth (Hall, 1986). For example, the Wake County Program uses Joyce's training model as its theoretical backing (McNair, McGee, Timberlake, Hines, & Reiman, 1987).

Inservice education can also encourage teachers to examine and assess their own practice, as a basis for future personal and professional growth. As Levine (1988) described, professional development schools could provide teachers a place to develop, test and disseminate new kinds of institutional structures, which are inquiring, reflective, and knowledge based. An example is the National Education

Association's Mastery-in-Learning Project (MILP). This project offers teachers skills and resources to promote their schools into "self-renewing centers of inquiry" (Tuthill et al., 1987).

Many schools have successfully carried out some activities related with the professional development and inservice education. The University of Montevallo Regional In-Service Education Center (University of Montevallo, 2012) provides sustained, comprehensive, and effective professional development programs according to the research based information that addresses the critical issues facing educators in today's world. Through transferring knowledge and skills that support school focused needs, the Center’s ultimate goal is to promote student achievement. Professional development in Florida (Florida Department of Education, 2012) is closely related to students’ needs. Principals are required to identify the development plans that are based on the needs of students. Thus, inservice activities are selected and scheduled locally to correspond to specific schools student needs.

It is evident from the above successful practice that high school teachers are in need of professional development and inservice education for achieving a higher effectiveness of educational programs.

Previous related studies

Analyzing the perceptions of high school teachers involved with agriculture when integrating science and technology into their instructional programs and the barriers during this process is important to making decisions. This is reflected in the number of research studies that have been conducted locally (Thompson &

Balschweid, 1999; Newman & Johnson, 1993; Norris & Briers, 1989; Layfield, Minor, & Waldvogel, 2001; Peasley & Henderson, 1992), nationally (Whent, 1994; Thompson & Schumacher, 1998) and globally (Balschweid & Thompson, 2002) in many aspects related to the quality of teaching performance like the role of teachers, the attitude of teachers, the resources and the barriers of integrating science and technology. A brief summary of research findings from some of these studies is given below.

Whent (1994) analyzed the barriers between agriculture and science teachers regarding the resource sharing process in the agriscience program. Through selecting ten agriculture/science teacher teams nationally, she found that lacking of awareness of both the resources available and similarities in curriculum is a serious factor inhibiting the cooperation process. In order to improve the integration process, opportunities for direct communication should be provided to teachers as a way to realize the differences between the culture of agricultural education and science education that block integration. Whent further pointed out that without the involvement and support of administrators, the integration process cannot take place successfully. She believed that students would benefit from the integration between science and agriculture.

Peasley and Henderson (1992) identified Ohio high school agriculture teachers' utilization, attitudes, and knowledge toward an agriscience curriculum. However, their findings did not correspond to previous findings (Rogers, 1971; Christiansen & Taylor, 1966). These previous authors pointed out that attitudes should be significantly related with the level of teaching of a curricular change, as well as the knowledge and educational level. But, Peasley and Henderson found that factors like attitudes and knowledge level, showed low or negligible influence on the level of agriscience curriculum being taught. Another important conclusion from this study was that the desire of Ohio high school agriculture teachers to develop the agriscience curriculum materials was strong and they also required leadership from the state Agricultural Education Service on agriscience curriculum development. Thus, Peasley and Henderson believed that leaders of agricultural education in Ohio should take the responsibility to further develop, conceptualize, and implement an agriscience core curriculum.

Warnick and Thompson (2007) studied the perceptions, attitudes and barriers of high school science teachers and agriculture teachers toward integrating science into the agricultural education curriculum. They clearly indicated that the majority of science and agriculture teachers held positive attitudes toward integrating science into the agricultural education curriculum. But barriers, like the lack of enough background information, and the lack of funding and equipment, agreed by over half of the science and agriculture teachers, did inhibit the integration process. This finding indicated the same items as barriers to integrating science in the previous studies (Balschweid & Thompson, 2002; Layfield et al, 2001; Thompson & Balschweid, 1999; Thompson, 2001).

It can be seen from the above cited research studies that agricultural education teachers' attitudes, knowledge and understanding of science and technology were analyzed in making important decisions for improving the effectiveness of the instructional programs. Also, the existence of barriers during the process of integrating science and technology can be reasonably deduced from these research findings.

Summary

This chapter was organized under the sections: agricultural education ties to science and technology, changes in agricultural education toward science and technology, science and technology in high school agricultural education, professional development and inservice education, and research findings from related past studies.

The history of science and technology in agricultural education indicated a strong correlation among them. Although the definition of agricultural education is influenced by the political, economic and cultural situation at different times, the core of science and technology has never changed. Changes only take place in the role, the weight and the selection of appropriate science and technology into the instructional programs. The literature presented some important changes in our history in order to illustrate the necessity of science and technology in agriculture education.

This study was confined to high school agriculture teachers' perceptions, their needs for professional development and inservice education, and the barriers toward the integration of science and technology in their instructional programs. High school education is a significant phase during students' growth process. A review of history, importance and innovation of high school agricultural education was provided to give context to the study and justify the selection of high school agriculture teachers as research subjects for this study.

High school agriculture teachers have to do a lot of ground work before conducting their educational programs. The quality of their preparations for whole educational process will finally determine the ultimate integration effect. So, professional development and inservice education relative to the integration process is very necessary. Thus, a review of the significance of professional development and inservice education was given.

Finally, a review of research studies that have been conducted on analyzing the perceptions of high school agriculture teachers toward integrating science and technology into the agricultural education curriculum and the barriers during this process. This section encompassed research studies from multiple perspectives indicating the importance and applicability of this study.

In conclusion, this chapter has provided a rationale for this study and provides the foundation for answering the following research questions:

1. To what extent are selected science and technology topics important for integrating into the instructional programs in agriculture according to high school agricultural educators?
2. To what extent should professional development be provided to teachers in order to overcome the obstacles when adding these selected topics into their instructional curriculum?

3. What are the barriers to integrate science and technology into the agriculture curriculum?

CHAPTER 3. METHODS

The purpose of this study was to determine the degree to which the selected science and technology topics are important in Iowa high school agricultural educators' instructional programs. A secondary purpose was to determine the need for professional development regarding the topics. The following four specific objectives served to accomplish the study's purposes:

1. The degree to which the selected science and technology topics are important in their instructional programs.
2. The need for the professional development on teaching the selected science and technology topics.
3. The barriers of teaching the selected science and technology topics in their curriculum.
4. Identify selected demographic information and compare.

This chapter provides a description of the research methods and procedures used towards accomplishing the purposes of the study, with the following the sections: research design, data source, instrumentation, data collection, data analysis, assumptions made by the researcher and limitations of the study.

Research design

A descriptive census survey was used for this study. This research design was deemed appropriate for this study because descriptive research answers questions about the status of a defined population and involves describing but not manipulating variables (Ary, Jacobs, & Sorensen, 2010). This study was predominantly exploratory and descriptive through gathering information from a well defined population with appropriate contact information. According to Groves et al. (2009), a census is a systematic effort to cover an entire population. They also pointed out that conducting a census study with a reliable sampling from could help eliminate any coverage errors, like undercoverage, ineligible units (or overcoverage), duplication, and clustering.

Because of the characteristics of a survey, some internal validity threats are inherent and inevitable. A suitable, reliable and valid questionnaire could address and control some internal validity threats. Stating the questions clearly without any ambiguity and giving short and simple instructions for each section could reduce the measurement error. The external validity threats, such as sampling error, selection error, and frame error, were addressed and controlled through indentifying the latest and representative data source free of duplications. As non-response error is a significant threat to external validity of this study, proper statistical measures and suitable follow-up efforts were adopted to account for this problem. Overall, the research design selected for this study was believed to be appropriate to achieve the purposes of the study.

Data source

The target population for this study consisted of 240 agricultural teachers who conduct agricultural education programs in high schools in Iowa during the 2011-2012 school year. The population frame was established from the 2011-2012 Iowa high school agriculture teachers directory procured by the department of

Agriculture Education & Studies at Iowa State University. This directory was estimated for frame error, or mistakes or errors in the list of the population (Groves, Fowler, Couper, Lepkowski, Singer & Tourangeau, 2009). The frame was also double checked for accuracy with the list of high school agriculture teachers procured by the IAAE (Iowa Association of Agricultural Educators) in order to avoid any possible duplication. This procedure ensured that there were no selection and frame errors.

Instrumentation

The Institutional Review Board at the Iowa State University approved this study. The data collection instrument for this study was an electronic questionnaire developed using Survey Monkey® with the cooperation of the Director of the Brenton Center for Agricultural Instruction & Technology Transfer, College of Agriculture and Life Sciences at the Iowa State University. The questionnaire was modeled after related research: Martin et al. (1989), Rajasekaran (1989), Kirby (1990), Peasley and Henderson (1992), National agriculture, food and natural resources (AFNR) career cluster content standards (2009), and Wilson et al. (2002). The questionnaire included three sections. Section I and II used five point Likert-type scales, and Section III used close-ended and open-ended questions. A five point continuum was used for the Likert-type scales with a view of giving provision for high school teachers to take a neutral stance, if they wished.

Section I focused on selected 15 science and 15 technology topics, and had two parts. For measuring the level of importance of these selected topics (Part 1), the scale used was from 1 = Not Important (NI) to 5 = Highly Important (HI). For measuring the need for professional development associated with these selected topics (Part 2), the scale used was from 1 = None (N) to 5 = Very High Need (VHN). There were 16 items of the general barriers in Section II. For measuring teachers' perceptions about these barriers (section II), the scale used was from 1 = Strongly Disagree (SD) to 5 = Strongly Agree (SA). Section III consisted of ten close-ended and open-ended questions in order to obtain the demographic data and the background information.

The validity and reliability of the questionnaire was certified by an expert panel-review and a reliability-test. A panel of experts reviewed the face, content and construct validity of the questionnaire. Professors from the Departments of Agricultural Education and Studies made up this expert panel. These experts evaluated the questionnaire on the following aspects: (1) the appropriateness of the framing of the questions, (2) the relevance to the study in order to ensure the questions measure what the investigator purported to measure, and (3) the clarity of statements that could elicit proper responses. All of the suggestions made by the panel were used to revise the questionnaire.

A pilot-test with 20 randomly selected high school agricultural teachers was conducted to receive feedback from teachers and the data were used to establish the reliability of the questionnaire. Considering the major flaws in the questionnaire, a sample size of 20 for a pilot-test is appropriate (Sudman, 1976). High school agricultural teachers who participated in the pilot-test were excluded from the formal study. The feedback was used to improve the face and content validity. The reliability of the questionnaire (Cronbach's coefficient, α) was computed from the data collected in the pilot-test, and used to examine the internal reliability of the items in the questionnaire. Values of 0.813, 0.812, 0.926, 0.901, and 0.783 were reported for the importance level of the selected science topics (Section I), the need for professional development associated with these science topics (Section I), the importance level of the selected technology topics (Section I), the need for professional development associated with these technology topics (Section I), and the perceptions about the general barriers (Section II), respectively. George and Mallery (2003) gave the following rule of thumb when interpreting the values: > 0.9 – excellent, > 0.8 – good, > 0.7 – acceptable, > 0.6 – questionable, > 0.5 – poor, and < 0.5 – unacceptable. So, the questionnaire used for this study was considered reliable.

Data collection

A prior email notification about the survey was sent to high school agricultural teachers who were eligible for this study. This notification sought the teachers' cooperation, and informed them clearly that participation was completely voluntary and they could withdraw at any time. It was also ensured that any changes in the study's objectives would be shared with them. After that, the questionnaire was emailed to them with a total of four follow-ups (Dillman, 2007) conducted at suitable time intervals. The legitimate consent of teachers for the study was assumed if they filled out this questionnaire. This study did not offer any monetary incentive for participation. In order to ensure the credibility of this study, a log of important events was maintained all through the research process. In order to reach a higher response rate, several follow-up reminders were sent over the course of the research study period. Dillman, Smyth, and Christian (2009) suggested that varying the stimulus during the email follow-ups could avoid the messages getting sorted out by spam filters. And the time interval between the different follow-ups is situation based (Dillman et al., 2009). As Dillman (2007) mentioned, the final contact should be made differently in order to attract research participants.

The electronic mail survey has many advantages, such as prompt returns, lower item nonresponse, and more complete answers to open-ended questions (Dillman, 2007), when compared to mail survey, telephone interviews or face-to-face interviews. Data can be collected and sorted by computer easily after receiving as many responses as possible. Additionally, respondents will perform more accurately and honestly when they self-administer a survey, as opposed to answering questions over a phone or in person (Tourangeau, Rips, & Rasinkski, 2000).

Data analysis

The Statistical Package for Social Science (SPSS®19.0) was applied in the data analysis. All the data collected via Survey Monkey® were deleted once analysis was done and the results were published. It was confirmed that only the researcher had access to the data. The demographic data and the background information were used only as group percentages in order to ensure the anonymity and confidentiality of the research participants.

Descriptive statistical parameters, such as frequencies (f), sample mean (M), standard deviation (SD), percentages ($\%$), were used to analyze the level of importance, the need for professional development, the perceptions toward the general barriers, and the demographic information. Inferential statistical tools, like independent two-sample t-test, one-way analysis of variance ($ANOVA$), Cramer's V were used to test for any significant relationships between key demographic information and teachers' choices.

Assumptions made by the investigator

The following assumptions were made by the researcher before starting this study:

1. The high school agricultural teachers provided accurate information, and not give just socially desirable answers.
2. The high school agricultural teachers did not interact with each other while filling out the questionnaire.
3. The high school agricultural teachers understood the questions in the questionnaire the way the investigator intended.
4. There was no response bias while answering the Likert-type items.
5. The directory of high school agricultural teachers available in the department of Agriculture Education & Studies at the Iowa State University was up-to-date.

Limitations of the study

1. The population frame was developed based upon the staff directories in the Department of Agriculture Education & Studies at the Iowa State University.

High school agricultural teachers not listed in these directories were not represented in this study.

2. The results from the perceptions component of this study cannot be generalized over a longer period of time as perceptions tend to change with time. Therefore, the findings are applicable only to the period when the data were collected. However, they provide important insights for improving the integration process and for designing professional development workshops for teachers.
3. The response rate of this study was 31.36%. As Lindner, Murphy and Briers (2001) stated that any response rate of less than 85% could result in significant differences between early and late respondents, thus affecting the external validity of the study. Non-response error was examined by comparing late respondents to early respondents (Dooley & Lindner, 2003; Miller & Smith, 1983). Overall, there were no statistically significant differences at the 0.05 level of significance suggesting that the results could be generalized to non-respondents and the total population. So, this limitation was reasonably considered as not being a threat to external validity.
4. The study population was limited to high school agricultural teachers in Iowa. Therefore, the results may not be generalized to the entire country.

CHAPTER 4. FINDINGS

The purpose of this study was to determine the degree to which selected science and technology topics are important in Iowa high school agricultural educators' instructional programs. A secondary purpose was to determine the need for professional development regarding the topics. The following four specific objectives served to accomplish the study's purposes:

1. Identify the degree to which the selected science and technology topics are important in their instructional programs.
2. Identify the need for the professional development on teaching the selected science and technology topics.
3. Identify the barriers of teaching the selected science and technology topics in their curriculum.
4. Identify selected demographic information and determine comparison based on the data.

The results from this study were presented under the following sections: demographic information, findings for each objective, and additional comments provided by the respondents for improving the integration process.

Seventy-one of the 220 high school agricultural teachers contacted (32.27%), responded to the questionnaire. However, only 69 questionnaires were usable, yielding a response rate of 31.36%. An independent samples t-test was used to test for any statistically significant differences between early and late respondents (Dooley & Lindner, 2003; Miller & Smith, 1983). Early and late respondents were compared on the mean scores for all the items in Section I (Part1: level of importance of these selected science and technology topics, and Part 2: need for professional development associated with these selected topics), Section II (teachers' perceptions toward the barriers), and demographics like age and work experience. The t-test results revealed that there were no statistically significant differences between the two groups at the .05 level on all items. The data were analyzed using SPSS version 19.0, and the findings are presented accordingly.

Demographic information

The respondents had a mean work experience of 18.85 years, with a standard deviation of 11.73. Their work experience ranged from 1-40 years. The mean age of the respondents was 42.65 years with a standard deviation of 11.66 (Table 1). The respondents ranged from 21-62 years of age. Since outliers were detected in the age category, a median was calculated to account for the skewed distribution. The median age of the respondents was 46 years, indicating that the age distribution was negatively skewed. In order to conduct further analysis, the respondents were divided into four categories based on their work experience (Figure 1).

Table 1

Mean and standard deviation scores of high school agricultural teachers based on their work experience and age

Demographic characteristic	*M*	*SD*	n
Work Experience	18.85	11.73	66
Age	42.65	11.66	65

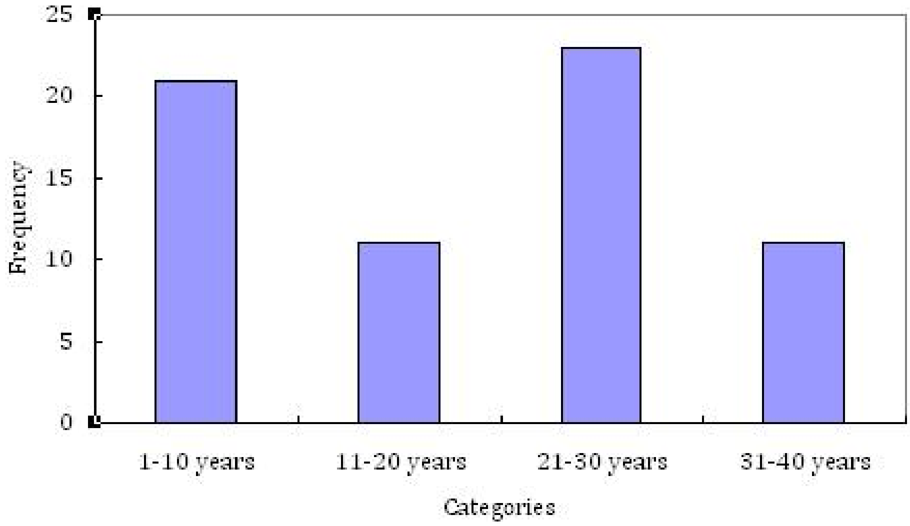

Figure 1

Frequency distribution of high school agricultural teachers based on working experience (n= 68)

A majority (75.36%) (Figure 2) of the respondents were male. When asked about their highest academic degrees, 36 (52.17%) respondents held a bachelor's degree, 31 (44.93%) respondents held a master's degree, none of them held a PhD, and two of them (2.90%) held other degrees (Figure 3). According to the responses of high school agricultural teachers, animal science (95.65%), plant science (89.86%), and horticulture (82.61%) were the top three courses they taught (Table 2). Among the respondents, 28 (40.58%) owned or operated a farm, and 59 (85.51%) were members of agricultural education organizations (Table 3), such as IAAE, NAAE, ACTE, IACTE, and NACTE.

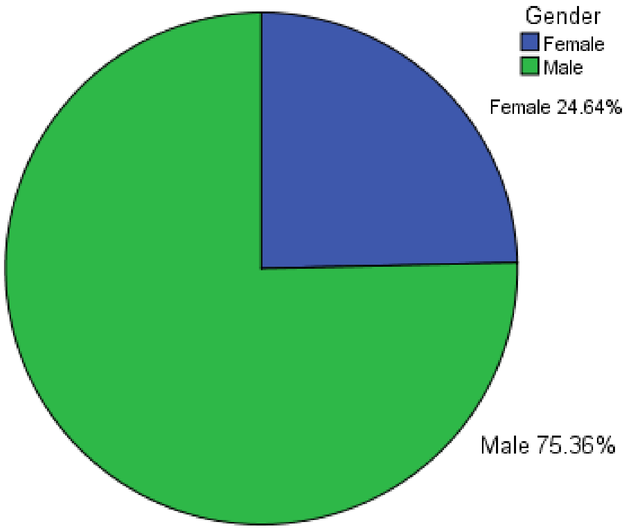

Figure 2

Frequency distribution of high school agricultural teachers based on their gender (n= 69)

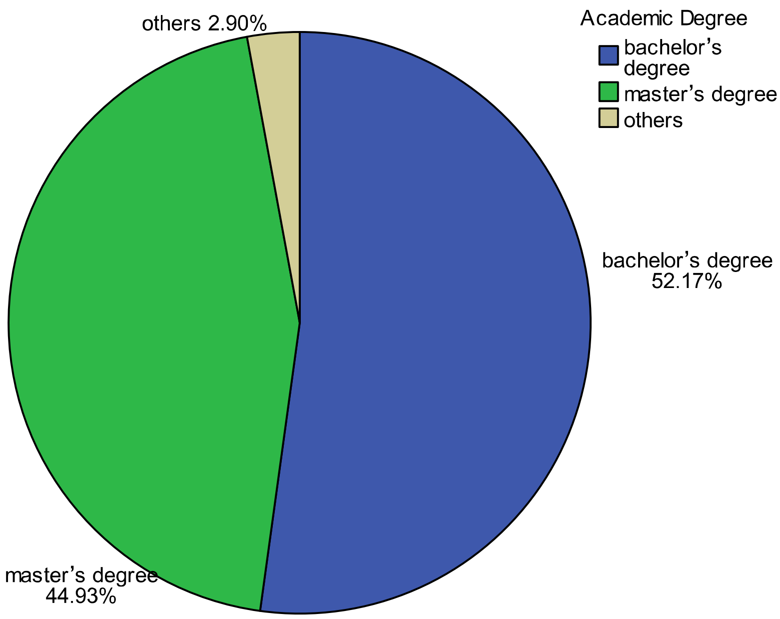

Figure 3

Frequency distribution of high school agricultural teachers based on their academic degree (n= 69)

Table 2

Frequency distribution of high school agricultural teachers based on major courses or units they teach (n=69)

Major courses or units	*f*	%
Plant science	62	89.86
Animal science	66	95.65
Environmental science	30	43.48
Food science	15	21.74
Agribusiness	56	81.59
Agricultural Machinery	36	52.17
Horticulture	57	82.61
Natural resource	41	59.42
Others	9	13.04

Table 3

Frequency distribution of high school agricultural teachers based on farm owned and organizations involvement (n=69)

Variable	*f*	%
Own or operate a farm		
Yes	28	40.58
No	41	59.42
Member of agricultural education organizations		
Yes	59	85.51
No	10	14.49

Objective 1: Identify the level of importance of the selected science topics

Mean and standard deviation scores for the level of importance of the selected science topics are presented in Table 4.

Table 4

Mean and standard deviation scores for the level of importance of the selected science topics

Selected science topics	M	SD	n
The knowledge of hydroponics	3.10	0.81	68
The effect of growth hormones on the rate of vegetatively propagated plants	3.15	0.99	67
Identification of plant growth regulators	3.16	0.86	67
The differences between traditional plant breeding methods and gene splicing	3.63	0.78	67
Mutation in plants	3.12	0.86	67
Explanation on how cycling time can be increased in animal production	3.48	0.93	67
The principles of sex linkage in animals	3.32	0.83	66
The function of endocrines in animals	3.11	0.95	65
The environmental factors contributing to soil erosion	4.18	0.75	65
The biological properties of soil	3.91	0.65	65
The structure of a selected fungus in agriculture	2.72	0.98	65
The natural selection in plants	3.22	0.86	65
Water holding capacity of soil	3.63	0.91	65
The process of milk formation in cattle	3.38	0.91	65
The way to use vinegar in the manufacture of canned vegetables	2.35	0.96	65

1 = Not Important to 5 = Highly Important

The mean scores indicated that high school agricultural teachers perceived the majority of the selected science topics to be “Somewhat Important” to “Important”. Only “the environmental factors contributing to soil erosion” fell under “Important” to “Highly Important” categories. Two topics, “the structure of a selected fungus in agriculture” and “the way to use vinegar in the manufacture of canned vegetables”, fell under “Of little Importance” to “Somewhat Important” categories. An interesting finding was that none of teachers chose “Not Important” for “the environmental factors contributing to soil erosion" and "the biological properties of soil".

Since the selected science topics were based on a previous national study (Martin et al., 1989), an independent sample t-test was computed to analyze for any statistically significant differences in the mean scores of the level of importance of the same science topics in these two studies (Table 5). The significance level (α) was set a priori at 0.05. The results from this test revealed that the level of importance of six topics had statistically significant differences between the previous national study and this study. Among them, only "the differences between traditional plant breeding methods and gene splicing" obtained a significantly higher mean score of the level of importance in this study, and others obtained significantly higher mean scores of the level of importance in the previous national study.

Table 5

Independent two-sample t-test between the previous national study and this study on the level of importance of the selected science topics

Selected science topics		Mean	SD	*t*	df	P
The knowledge of hydroponics	Previous	3.78	0.92	5.51*	303	0.001
	Current	3.10	0.81			
The effect of growth hormones on the rate of vegetatively propagated plants	Previous	3.77	1.05	4.32*	302	0.001
	Current	3.15	0.99			
Identification of plant growth regulators	Previous	3.70	0.99	4.05*	302	0.001
	Current	3.16	0.86			
The differences between traditional plant breeding methods and gene splicing	Previous	3.09	1.15	-3.61*	302	0.001
	Current	3.63	0.78			
Mutation in plants	Previous	2.91	1.12	-1.42	302	0.157
	Current	3.12	0.86			

* = significant at the .05 level

Table 5 (continued)

Selected science topics		Mean	SD	*t*	df	P
Explanation on how cycling time can be increased in animal production	Previous Current	3.54 3.48	1.03 0.93	0.43	302	0.668
The principles of sex linkage in animals	Previous Current	3.12 3.32	0.96 0.83	-1.54	301	0.125
The function of endocrines in animals	Previous Current	3.06 3.11	1.14 0.95	-0.32	300	0.750
The environmental factors contributing to soil erosion	Previous Current	4.14 4.18	0.81 0.75	-0.36	300	0.720
The biological properties of soil	Previous Current	4.13 3.91	0.86 0.65	1.92	300	0.056
The structure of a selected fungus in agriculture	Previous Current	2.87 2.72	1.26 0.98	0.89	300	0.374
The natural selection in plants	Previous Current	3.06 3.22	1.04 0.86	-1.14	300	0.255
Water holding capacity of soil	Previous Current	4.08 3.63	0.85 0.91	3.72*	300	0.001
The process of milk formation in cattle	Previous Current	3.52 3.38	1.10 0.91	0.94	300	0.348
The way to use vinegar in the manufacture of canned vegetables	Previous Current	3.59 2.35	1.11 0.96	8.20*	300	0.000

A one-way analysis of variance (*ANOVA*) was applied to test for any statistically significant differences in the mean scores of the level of importance of the selected science topics (Table 6) among high school agricultural teachers in four groups based on the years of work experience (Figure 1). It was found that there were no statistically significant differences in the mean scores of all the selected science topics, except “identification of plant growth regulators”, among these four groups at the .05 level. The differences existed between the respondents who had 11-20 years work experience with a higher mean score and those who had 21-30 years work experience, and between the respondents who had 21-30 years work experience and those who had 31-40 years work experience with a higher mean score.

Table 6

One-way ANOVA among four groups of high school teachers based on the level of importance of the selected science topics

The knowledge of hydroponics	df	SS	MSS	F	P
Between groups	3	0.155	0.052	0.073	0.974
Within groups	59	42.067	0.713		
The effect of growth hormones on the rate of vegetatively propagated plants					
Between groups	3	5.920	1.973	2.114	0.108
Within groups	59	55.064	0.933		
Identification of plant growth regulators					
Between groups	3	8.435	2.812	4.450*	0.007
Within groups	59	37.279	0.632		
The differences between traditional plant breeding methods and gene splicing					
Between groups	3	2.259	0.753	1.223	0.310
Within groups	59	36.344	0.616		
Mutation in plants					
Between groups	3	1.897	0.632	0.877	0.458
Within groups	59	42.516	0.721		
Explanation on how cycling time can be increased in animal production					
Between groups	3	2.867	0.956	1.066	0.370
Within groups	59	52.879	0.896		
The principles of sex linkage in animals					
Between groups	3	2.215	0.738	1.046	0.3793
Within groups	58	40.962	0.706		
The function of endocrines in animals					
Between groups	3	3.156	1.052	1.124	0.347
Within groups	58	54.263	0.936		

* = significant at the .05 level

Table 6 (continued)

The environmental factors contributing to soil erosion	df	SS	MSS	F	P
Between groups	3	1.186	0.395	0.665	0.577
Within groups	58	34.492	0.595		
The biological properties of soil					
Between groups	3	0.666	0.222	0.520	0.670
Within groups	58	24.753	0.427		
The structure of a selected fungus in agriculture					
Between groups	3	5.514	1.838	2.002	0.124
Within groups	58	53.260	0.918		
The natural selection in plants					
Between groups	3	2.677	0.892	1.204	0.317
Within groups	58	43.000	0.741		
Water holding capacity of soil					
Between groups	3	4.792	1.597	2.017	0.121
Within groups	58	45.918	0.792		
The process of milk formation in cattle					
Between groups	3	2.234	0.745	0.856	0.469
Within groups	58	50.476	0.870		
The way to use vinegar in the manufacture of canned vegetables					
Between groups	3	5.409	1.803	1.981	0.127
Within groups	58	52.785	0.910		

In order to find whether the level of importance of the selected science topics reported by teachers was correlated with the key demographic areas of degree held, owning or operating a farm, and organizations involvement, the strength of association (Cramer's V) was provided in Table 7. Davis (1971) gave the following rule of thumb when describing the magnitude of relationship between variables: > 0.7 – very strong, 0.5 to 0.69 – substantial, 0.30 to 0.49 – moderate, 0.10 to 0.29 – low, and 0.01 to 0.09 – negligible.

Table 7

Relationship between key demographic areas and the level of importance of the selected science topics

Selected science topics	Degree held	Own or operate farm	Organizations involvement
The knowledge of hydroponics	0.18	0.24	0.15
The effect of growth hormones on the rate of vegetatively propagated plants	0.18	0.36	0.26
Identification of plant growth regulators	0.18	0.38	0.17
The differences between traditional plant breeding methods and gene splicing	0.27	0.33	0.33
Mutation in plants	0.13	0.28	0.21
Explanation on how cycling time can be increased in animal production	0.31	0.32	0.44*
The principles of sex linkage in animals	0.23	0.16	0.20
The function of endocrines in animals	0.13	0.36	0.15
The environmental factors contributing to soil erosion	0.25	0.32	0.15
The biological properties of soil	0.27	0.32	0.26
The structure of a selected fungus in agriculture	0.18	0.31	0.22
The natural selection in plants	0.32	0.39	0.28
Water holding capacity of soil	0.19	0.46*	0.21
The process of milk formation in cattle	0.32	0.30	0.47*
The way to use vinegar in the manufacture of canned vegetables	0.19	0.32	0.27

* = significant at the .05 level

As indicated in Table 7, there were low relationships between the highest academic degree held and the majority of the selected science topics. Although three topics, “explanation on how cycling time can be increased in animal production”, “the natural selection in plants”, and “the process of milk formation in cattle” showed moderate relationship with the degree held, none of the selected topics was significant at the .05 level. However, the relationships between owning or operating a farm and the selected science topics were stronger. Ten of the selected science topics fell under the “moderate” category. Among them, “water holding capacity of soil” was significant at the .05 level. Although the relationships between involvement in organizations and the majority of the selected science topics were low, there were three topics belonging to the “moderate” category. Two topics, “explanation on how cycling time can be increased in animal production”, and “the process of milk formation in cattle” were significant at the .05 level.

In addition to the selected science topics related to high school agricultural education, the respondents were given an option to provide any additional science topics they believed to be important. The topic, “understanding the relationships of long term soil quality to agricultural production practices”, was proposed by a teacher. One of the respondents argued that there were many agriculture illiterate teachers teaching high school agriculture. Thus, it was needed to put more effort into teaching the basics of agriculture.

Objective 2: Identify the level of importance of the selected technology topics

Mean and standard deviation scores for the level of importance of the selected technology topics are presented in Table 8.

Table 8

Mean and standard deviation scores for the level of importance of the selected technology topics

Selected technology topics	**M**	**SD**	**n**
Animal assessment methods	3.52	0.90	65
Record tools used on the observation of a plant development	2.89	0.90	65
Techniques used in genetic manipulations	3.33	1.04	64
Processes used to produce animal hormones from transgenic organisms	3.03	1.00	65
Wastewater treatment	2.98	1.02	65
Recycling methods	3.11	1.14	64
Operation advanced laboratory equipments	2.97	1.19	64
Food preservation methods	3.22	0.98	64
Quality-assurance tests on food products	3.48	0.80	64
Methods of reducing the effects of animal agriculture on the environment	3.66	0.84	64
Approaches to effective customer relationships	3.84	0.88	64
A variety of strategies to evaluate goals	3.58	1.11	64
Communication skills	4.22	1.00	64
Problem-solving models	4.05	1.09	64
Appropriate statistical techniques	2.97	1.01	62

1 = Not Important to 5 = Highly Important

The mean scores indicated that high school agricultural teachers perceived the majority of the selected technology topics to be “Somewhat Important” to “Important”. Although four topics, “record tools used on the observation of a plant development”, “wastewater treatment”, “operation advanced laboratory equipments”, and “appropriate statistical techniques” fell under “Of little Importance” to “Somewhat Important”, they were all closed to “Somewhat Important” category. Two topics, “communication skills” and “problem-solving models” were in the “Important” to “Highly Important” categories. It was interesting to find that none of the respondents chose "Not Important" for "quality-assurance tests on food products" and "approaches to effective customer relationships".

Since these 15 items of the selected technology topics can be divided into two groups: 1) the on-the-farm technologies, which work on improving the productivity (including item1, 2, 3, 4, and 7); and 2) the off-the-farm technologies, which depend on strategic decision making, management, marketing, and processing systems (including item 5, 6, 8, 9, 10, 11, 12, 13, 14, and 15), a comparison of the summated mean scores between two groups are shown in Figure 4. A dependent sample t-test was further computed to analyze for any statistically significant differences in the summated mean scores of the two groups (Table 9). The significance level (α) was set a priori at 0.05. It was found that there were statistically significant differences toward the summated mean scores between the level of importance of the on-the-farm technology topics and that of the off-the-farm technology topics, which obtained a significantly higher mean score.

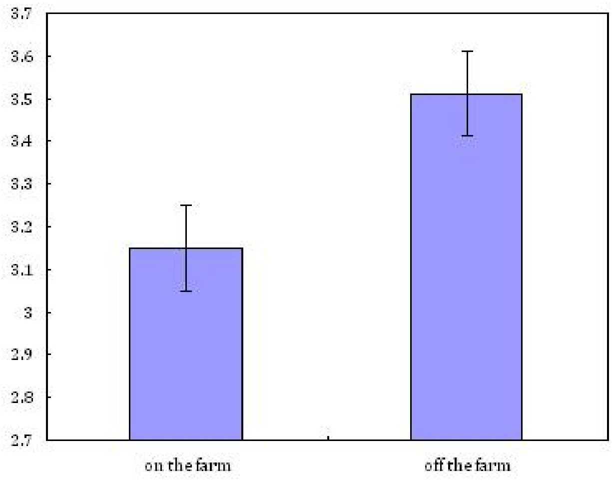

Figure 4

Comparison of the mean scores of two groups based on different technology types

Table 9

Dependent two-sample t-test between the on-the-farm technology topics and the off-the-farm technology topics on the level of importance

Two technology groups	Mean	SD	*t*	df	P
On- the-farm technology	3.15	1.03	-4.99*	960	0.001
Off-the-farm technology	3.51	1.07			

* = significant at the .05 level

A one-way analysis of variance (*ANOVA*) was computed to test for any statistically significant differences in the mean scores of the level of importance of the selected technology topics (Table 10) among high school agricultural teachers in four groups basing on the years of working experience (Figure 1). It was found that only four items had statistically significant differences in the mean scores of the level of importance among these four groups at the .05 level. What's more, these four topics were all classified as the off-the-farm technology. An interesting finding was that the differences all existed between the respondents who had 1-10 years working experience and those who were in other groups.

Table 10

One-way ANOVA among four groups of high school teachers based on the level of importance of the selected technology topics

Animal assessment methods	df	SS	MSS	F	P
Between groups	3	3.707	1.236	1.501	0.224
Within groups	58	47.729	0.823		
Wastewater treatment					
Between groups	3	3.652	1.217	1.133	0.343
Within groups	58	62.284	1.074		
Techniques used in genetic manipulations					
Between groups	3	2.964	0.988	0.901	0.446
Within groups	57	62.479	1.096		

* = significant at the .05 level

Table 10 (continued)

Processes used to produce animal hormones from transgenic organisms	df	SS	MSS	F	P
Between groups	3	3.711	1.237	1.253	0.299
Within groups	58	57.273	0.987		
Record tools used on the observation of a plant development					
Between groups	3	0.574	0.191	0.220	0.882
Within groups	58	50.393	0.869		
Recycling methods					
Between groups	3	1.807	0.602	0.454	0.715
Within groups	57	75.602	1.326		
Operation advanced laboratory equipments					
Between groups	3	7.713	2.571	1.803	0.157
Within groups	57	81.271	1.426		
Food preservation methods					
Between groups	3	7.029	2.343	2.484	0.070
Within groups	57	53.758	0.943		
Quality-assurance tests on food products					
Between groups	3	2.702	0.901	1.406	0.250
Within groups	57	36.511	0.641		
Methods of reducing the effects of animal agriculture on the environment					
Between groups	3	4.809	1.603	2.345	0.082
Within groups	57	38.961	0.684		
Approaches to effective customer relationships					
Between groups	3	6.301	2.100	2.945*	0.041
Within groups	57	40.649	0.713		
A variety of strategies to evaluate goals					
Between groups	3	13.194	4.398	4.388*	0.008
Within groups	57	57.134	1.002		
Communication skills					
Between groups	3	10.249	3.416	4.815*	0.005
Within groups	57	40.439	0.709		
Problem-solving models					
Between groups	3	9.034	3.011	3.112*	0.033
Within groups	57	55.163	0.968		

Table 10 (continued)

Appropriate statistical techniques	df	SS	MSS	F	P
Between groups	3	5.224	1.741	1.815	0.155
Within groups	55	52.776	0.960		

The strength of association (Cramer's V) in Table 11 indicated whether the level of importance of the selected technology topics reported by teachers was correlated with the key demographic areas of degree held, owning or operating a farm, and originations involved. Overall, there were no statistically significant relationships between the selected technology topics and the key demographic areas. Based on the results of the relationship between the topics and the degree held, only the strength of association of two topics were moderate and there was even a negligible relationship between "processes used to produce animal hormones from transgenic organisms" and the degree teachers held. In the case of the relationships between the selected topics and owning or operating a farm, there were six topics falling under the "moderate" category, but only one topic was the on-the-farm technology. The majority of the relationships between topics and involvement in organizations was low, and two topics showed moderate association.

Table 11

Relationship between key demographic areas and the level of importance of the selected technology topics

Selected technology topics	Degree held	Own or operate farm	Organizations involvement
Animal assessment methods	0.23	0.20	0.26
Record tools used on the observation of a plant development	0.21	0.29	0.14

Table 11 (continued)

Selected technology topics	Degree held	Own or operate farm	Organizations involvement
Techniques used in genetic manipulations	0.22	0.29	0.22
Processes used to produce animal hormones from transgenic organisms	0.07	0.13	0.25
Wastewater treatment	0.15	0.23	0.34
Recycling methods	0.26	0.37	0.27
Operation advanced laboratory equipments	0.17	0.30	0.24
Food preservation methods	0.29	0.16	0.20
Quality-assurance tests on food products	0.15	0.20	0.22
Methods of reducing the effects of animal agriculture on the environment	0.15	0.36	0.17
Approaches to effective customer relationships	0.13	0.26	0.11
A variety of strategies to evaluate goals	0.26	0.39	0.38
Communication skills	0.32	0.34	0.24
Problem-solving models	0.25	0.28	0.18
Appropriate statistical techniques	0.35	0.32	0.26

In addition to the selected technology topics related to high school agricultural education, the respondents were given an option to provide any additional technology topics they believed to be important. Two areas were identified by teachers: (1) computer based learning systems and web based teaching programs, which can be more suitable for today's low budget educational systems; (2) use of appropriate GPS/GIS technology.

Objective 3: Identify the need for professional development of the selected science topics

Mean and standard deviation scores for the need for professional development of the selected science topics are presented in Table 12.

Table 12

Mean and standard deviation scores for the need for professional development of the selected science topics

Selected science topics	M	SD	n
The knowledge of hydroponics	3.07	0.99	67
The effect of growth hormones on the rate of vegetatively propagated plants	2.91	0.92	66
Identification of plant growth regulators	2.98	0.97	66
The differences between traditional plant breeding methods and gene splicing	3.47	0.92	66
Mutation in plants	2.86	0.83	65
Explanation on how cycling time can be increased in animal production	3.08	0.87	65
The principles of sex linkage in animals	3.02	0.80	65
The function of endocrines in animals	2.91	0.86	65
The environmental factors contributing to soil erosion	2.95	0.87	65
The biological properties of soil	2.97	0.87	65
The structure of a selected fungus in agriculture	2.60	0.93	65
The natural selection in plants	2.75	0.75	65
Water holding capacity of soil	2.61	0.90	65
The process of milk formation in cattle	2.88	0.82	65
The way to use vinegar in the manufacture of canned vegetables	2.16	0.88	64

1 = None to 5 = Very high need

The mean scores revealed that the need for professional development of the selected science topics reported by high school agricultural teachers were mainly to be “Low need” to “Some need”. Although four items, “the knowledge of hydroponics”, “the principles of sex linkage in animals”, “explanation on how cycling time can be increased in animal production”, and “the differences between traditional plant breeding methods and gene splicing", fell under "Some need" to "High need" categories, the first three topics were very close to "Some need". An interesting finding was that none of the respondents chose "Very high need" for two items, "the natural selection in plants" and "the way to use vinegar in the manufacture of canned vegetables".

A one-way analysis of variance (*ANOVA*) was computed to test for any statistically significant differences in the mean scores of the need for professional development of the selected science topics (Table 13) among high school agricultural teachers in four groups based on the years of work experience (Figure 1). Analysis of variance indicated that there were no statistically significant differences in the mean scores of the majority of the items. The need for professional development of "the differences between traditional plant breeding methods and gene splicing" showed a statistically significant difference between the respondents who had 1-10 years work experience and those who had 11-20 years work experience with a higher mean score at the .05 level. Compared with other groups, respondents who had 31-40 years work experience with a higher mean score illustrated a statistically significant difference of the need for professional development of "the natural selection in plants" at the .01 level.

Table 13

One-way ANOVA among four groups of high school teachers based on the need for professional development of the selected science topics

The knowledge of hydroponics	df	SS	MSS	F	P
Between groups	3	1.334	0.445	0.528	0.665
Within groups	58	48.876	0.843		
The effect of growth hormones on the rate of vegetatively propagated plants					
Between groups	3	2.746	0.915	1.158	0.334
Within groups	58	45.851	0.791		
Identification of plant growth regulators					
Between groups	3	2.617	0.872	0.966	0.415
Within groups	58	51.367	0.903		
The differences between traditional plant breeding methods and gene splicing					
Between groups	3	6.631	2.210	3.137*	0.032
Within groups	58	40.869	0.705		
Mutation in plants					
Between groups	3	0.870	0.290	0.412	0.745
Within groups	58	40.824	0.704		
Explanation on how cycling time can be increased in animal production					
Between groups	3	2.080	0.693	0.864	0.465
Within groups	38	46.517	0.802		
The principles of sex linkage in animals					
Between groups	3	1.061	0.354	0.527	0.666
Within groups	58	38.939	0.671		
The function of endocrines in animals					
Between groups	3	1.527	0.509	0.673	0.572
Within groups	58	43.892	0.757		
The environmental factors contributing to soil erosion					
Between groups	3	1.400	0.467	0.570	0.637
Within groups	58	47.455	0.818		
The biological properties of soil					
Between groups	3	2.624	0.875	1.20	0.349
Within groups	58	45.311	0.781		

* = significant at the .05 level

** = significant at the .01 level

Table 13 (continued)

The structure of a selected fungus in agriculture	df	SS	MSS	F	P
Between groups	3	4.203	1.401	1.728	0.171
Within groups	58	47.039	0.811		
The natural selection in plants					
Between groups	3	8.512	2.837	6.372**	0.001
Within groups	58	25.826	0.445		
Water holding capacity of soil					
Between groups	3	3.940	1.313	1.621	0.194
Within groups	58	46.980	0.810		
The process of milk formation in cattle					
Between groups	3	0.771	0.257	0.371	0.774
Within groups	58	40.196	0.693		
The way to use vinegar in the manufacture of canned vegetables					
Between groups	3	3.081	1.027	1.313	0.279
Within groups	57	44.592	0.782		

The need for professional development of the selected science topics reported by teachers was correlated with the key demographic areas. Table 14 displays the strength of association (Cramer's V) between the need for professional development and the demographic areas of degree held, owning or operating a farm, and involvement in originations.

Table 14

Relationship between key demographic areas and the need for professional development of the selected science topics

Selected science topics	Degree held	Own or operate farm	Organizations involvement
The knowledge of hydroponics	0.29	0.36	0.20
The effect of growth hormones on the rate of vegetatively propagated plants	0.08	0.27	0.15
Identification of plant growth regulators	0.21	0.45*	0.32

* = significant at the .05 level

Table 14 (continued)

Selected science topics	Degree held	Own or operate farm	Organizations involvement
The differences between traditional plant breeding methods and gene splicing	0.31	0.33	0.15
Mutation in plants	0.22	0.20	0.19
Explanation on how cycling time can be increased in animal production	0.20	0.25	0.21
The principles of sex linkage in animals	0.27	0.33	0.17
The function of endocrines in animals	0.28	0.35	0.14
The environmental factors contributing to soil erosion	0.13	0.26	0.23
The biological properties of soil	0.24	0.30	0.25
The structure of a selected fungus in agriculture	0.11	0.30	0.17
The natural selection in plants	0.17	0.16	0.24
Water holding capacity of soil	0.30	0.25	0.08
The process of milk formation in cattle	0.41*	0.34	0.43*
The way to use vinegar in the manufacture of canned vegetables	0.11	0.14	0.19

The relationships between the highest academic degree held and the majority of the need for professional development of the selected science topics were low, and “the effect of growth hormones on the rate of vegetatively propagated plants” even fell under the “negligible” category. Among three topics that were in the “moderate” category, the relationship between the degree held and the need for professional development of “the process of milk formation in cattle” was significant at the .05 level. What’s more, the same trend was observed for the relationships between the involvement in organizations and the need for professional development of the topics. However, the relationships between owning or operating a farm and the need for professional development of the selected science topics were classified as "low" and "moderate" categories equally. Only one topic, "identification of plant growth regulators" showed a significant relationship between owning or operating a farm and the need for professional development at the .05 level.

A correlation test was applied to find whether the level of importance and the need for professional development of every selected science topic was related to each other. The value of the correlation coefficient (Pearson's r) and the coefficient of determination (r^2) are demonstrated in Table 15. The following general categories are used to interpret a calculated r value: 0.0 to 0.2 - very weak to negligible correlation, 0.2 to 0.4 - weak and low correlation, 0.4 to 0.7 - moderate correlation, 0.7 to 0.9 – strong and high correlation, and 0.9 to 1.0 - very strong correlation. First, all the correlations were positive, which implied as the level of importance increased, the need for professional development also tended to increase. Second, according to the rule above, the majority of the selected science topics indicated a moderate correlation between the level of importance and the need for professional development. Two topics fell in to the "weak and low correlation" level, and only one topic, "the way to use vinegar in the manufacture of canned vegetables", performed a strong and high correlation. An interesting finding was that all the correlations between the level of importance and the need for professional development, but "the environmental factors contributing to soil erosion", was significant at the .01 level.

Table 15

Correlation between the level of importance and the need for professional development of every selected science topics

Selected science topics	Pearson's r	r^2
The knowledge of hydroponics	0.53**	0.28
The effect of growth hormones on the rate of vegetatively propagated plants	0.64**	0.41
Identification of plant growth regulators	0.55**	0.30
The differences between traditional plant breeding methods and gene splicing	0.58**	0.34
Mutation in plants	0.51**	0.26
Explanation on how cycling time can be increased in animal production	0.70**	0.49
The principles of sex linkage in animals	0.58**	0.34
The function of endocrines in animals	0.60**	0.36
The environmental factors contributing to soil erosion	0.23	0.05
The biological properties of soil	0.33**	0.11
The structure of a selected fungus in agriculture	0.60**	0.36
The natural selection in plants	0.45**	0.20
Water holding capacity of soil	0.51**	0.26
The process of milk formation in cattle	0.59**	0.35
The way to use vinegar in the manufacture of canned vegetables	0.82**	0.67

** = significant at the .01 level

Furthermore, it was observed that the mean scores of the level of importance (Table 4) of all the items were more than the corresponding need for professional development items (Table 12). Hence, a paired t-test was computed to test for any statistically significant differences between their mean scores (Table 16). It was found that there were statistically significant differences between the level of importance and the need for professional development on ten out of fifteen topics with the level of importance having significantly higher mean scores. Among them, one item was significant at the .05 level, and others were significant at the .01 level.

This result indicated that high school agricultural teachers had less need for professional development on the selected science topics though they perceived them to be important.

Table 16

Paired samples t-test between the level of importance and the need for professional development of the selected science topics

Selected science topics	Paired differences		*t*	df	P
	M	SD			
The knowledge of hydroponics	0.30	0.89	0.28	67	0.784
The effect of growth hormones on the rate of vegetatively propagated plants	0.23	0.82	2.25*	65	0.028
Identification of plant growth regulators	0.17	0.87	1.56	65	0.124
The differences between traditional plant breeding methods and gene splicing	0.15	0.79	1.56	65	0.124
Mutation in plants	0.29	0.82	2.86**	64	0.006
Explanation on how cycling time can be increased in animal production	0.42	0.70	4.75**	64	0.000
The principles of sex linkage in animals	0.31	0.75	3.31**	64	0.001
The function of endocrines in animals	0.20	0.81	1.98	64	0.051
The environmental factors contributing to soil erosion	1.23	1.01	9.81**	64	0.000
The biological properties of soil	0.94	0.90	8.41**	64	0.000
The structure of a selected fungus in agriculture	0.12	0.86	1.16	64	0.251
The natural selection in plants	0.46	0.85	4.38**	64	0.000
Water holding capacity of soil	1.02	0.89	9.17**	64	0.000
The process of milk formation in cattle	0..51	0.79	5.16**	64	0.000
The way to use vinegar in the manufacture of canned vegetables	0.19	0.56	2.68**	63	0.009

* = significant at the .05 level

** = significant at the .01 level

In addition to the selected science topics identified by the researcher in the survey questionnaire, the respondents were given an option to provide any additional science topics they required more professional development. The topic, "biotechnoloy and food manufacturing", was suggested by a teacher.

Objective 4: Identify the need for professional development of the selected technology topics

Mean and standard deviation scores for the need for professional development of the selected technology topics are presented in Table 17.

Table 17

Mean and standard deviation scores for the need for professional development of the selected technology topics

Selected technology topics	**M**	**SD**	**n**
Animal assessment methods	3.20	0.99	64
Record tools used on the observation of a plant development	2.89	0.91	64
Techniques used in genetic manipulations	3.33	1.08	63
Processes used to produce animal hormones from transgenic organisms	3.17	1.02	64
Wastewater treatment	2.72	1.02	64
Recycling methods	2.69	0.89	64
Operation advanced laboratory equipments	2.95	1.23	64
Food preservation methods	3.11	1.04	64
Quality-assurance tests on food products	3.28	0.79	64
Methods of reducing the effects of animal agriculture on the environment	3.22	0.84	64
Approaches to effective customer relationships	3.25	0.87	64
A variety of strategies to evaluate goals	2.91	1.06	64
Communication skills	3.14	0.97	64
Problem-solving models	3.31	1.14	64
Appropriate statistical techniques	2.79	0.98	62

1 = None to 5 = Very high need

The need for professional development of the selected technology topics reported by high school agricultural teachers was measured by the mean scores. Six of fifteen items belonged to "Low need" to "Some need", and others fell under "Some need" to "High need" categories. An interesting finding was that none of the respondents chose "Very high need" for "recycling methods", and no one regarded "quality-assurance tests on food products" and "approaches to effective customer relationships" to be "None" category. However, items grouped in the off-the-farm technology took a larger proportion than items grouped in the on-the farm technology in "Some need" to "High need" categories. Thus, a comparison between two technology groups (Figure 5) was indicated and an independent two-sample t-test was further computed to analyze for any statistically significant differences in the mean scores of the two groups (Table 18). The significance level (α) was set a priori at 0.05. It was found that there were no statistically significant differences between the need for professional development of the on-the-farm technology topics and that of the off-the-farm technology topics.

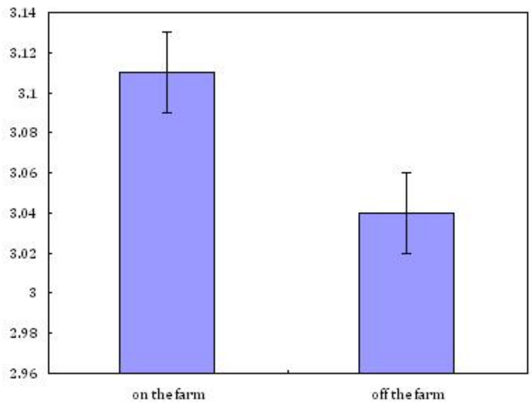

Figure 5

Comparison of the mean scores of two groups based on different technology types

Table 18

Independent two-sample t-test between the on-the-farm technology topics and the off-the-farm technology topics on the need for professional development

Two technology groups	Mean	SD	*t*	df	P
On- the-farm technology	3.11	1.06	1.01	955	0.313
Off-the-farm technology	3.04	0.99			

A one-way analysis of variance (*ANOVA*) was computed to test for any statistically significant differences in the mean scores of the need for professional development of the selected technology topics (Table 19) among high school agricultural teachers in four groups basing on the years of working experience (Figure 1). It was found that there were no statistically significant differences on the mean scores of the need for professional development of the selected technology topics, expect “a variety of strategies to evaluate goals” and “communication skills”, among four groups at the .05 level. It was interesting to find that the statistically significant differences for both topics were between the respondents who had 1-10 years working experience and those who had 11-20 years working experience.

Table 19

One-way ANOVA among four groups of high school teachers based on the need for professional development of the selected technology topics

Animal assessment methods	df	SS	MSS	F	P
Between groups	3	0.911	0.304	0.295	0.829
Within groups	57	58.728	1.030		
Record tools used on the observation of a plant development					
Between groups	3	1.545	0.515	0.594	0.621
Within groups	57	49.405	0.867		

* = significant at the .05 level

Table 19 (continued)

Techniques used in genetic manipulations	df	SS	MSS	F	P
Between groups	3	5.164	1.721	1.502	0.224
Within groups	56	64.169	1.146		
Processes used to produce animal hormones from transgenic organisms					
Between groups	3	3.824	1.275	1.241	0.303
Within groups	57	58.537	1.027		
Wastewater treatment					
Between groups	3	2.348	0.783	0.735	0.536
Within groups	57	60.734	1.066		
Recycling methods					
Between groups	3	0.127	0.042	0.051	0.985
Within groups	57	47.316	0.830		
Operation advanced laboratory equipments					
Between groups	3	9.802	3.267	2.214	0.096
Within groups	57	84.133	1.476		
Food preservation methods					
Between groups	3	0.728	0.243	0.207	0.891
Within groups	57	66.682	1.170		
Quality-assurance tests on food products					
Between groups	3	4.600	1.533	2.596	0.061
Within groups	57	33.662	0.591		
Methods of reducing the effects of animal agriculture on the environment					
Between groups	3	4.505	1.502	2.187	0.099
Within groups	57	39.134	0.687		
Approaches to effective customer relationships					
Between groups	3	3.881	1.294	1.740	0.169
Within groups	57	42.382	0.744		
A variety of strategies to evaluate goals					
Between groups	3	9.441	3.150	2.933*	0.041
Within groups	57	61.149	1.073		
Communication skills					
Between groups	3	8.514	2.838	3.335*	0.026
Within groups	57	48.503	0.851		

Table 19 (continued)

Problem-solving models	df	SS	MSS	F	P
Between groups	3	10.027	3.342	2.732	0.052
Within groups	57	69.743	1.224		
Appropriate statistical techniques					
Between groups	3	3.826	1.275	1.320	0.277
Within groups	55	53.123	0.966		

The strength of association (Cramer's V) between the need for professional development of the selected technology topics reported by teachers and the key demographic areas of degree held, owning or operating a farm, and involvement in originations is displayed in Table 20. Overall, the relationship between the need for professional development of "quality-assurance tests on food products" and the owning or operating a farm was the only item that was statistically significant at the .05 level. The strength of association among the degree held, the involvement in organizations, and the need for professional development of the selected topics was low. Although the relationships between owning or operating a farm and the technology items were stronger, they were still moderate.

Table 20

Relationship between key demographic areas and the need for professional development of the selected technology topics

Selected technology topics	Degree held	Own or operate farm	Organizations involvement
Animal assessment methods	0.20	0.21	0.19
Record tools used on the observation of a plant development	0.26	0.19	0.19
Techniques used in genetic manipulations	0.25	0.18	0.28

* = significant at the .05 level

Table 20 (continued)

Selected technology topics	Degree held	Own or operate farm	Organizations involvement
Processes used to produce animal hormones from transgenic organisms	0.27	0.20	0.17
Wastewater treatment	0.28	0.26	0.21
Recycling methods	0.17	0.31	0.22
Operation advanced laboratory equipments	0.16	0.28	0.17
Food preservation methods	0.33	0.38	0.28
Quality-assurance tests on food products	0.22	0.37*	0.27
Methods of reducing the effects of animal agriculture on the environment	0.22	0.35	0.14
Approaches to effective customer relationships	0.27	0.24	0.26
A variety of strategies to evaluate goals	0.36	0.26	0.30
Communication skills	0.23	0.36	0.25
Problem-solving models	0.16	0.36	0.27
Appropriate statistical techniques	0.33	0.25	0.32

A correlation test was applied to find whether the level of importance and the need for professional development of the selected technology topics were related to each other. The value of the correlation coefficient (Pearson's r) and the coefficient of determination (r^2) were demonstrated in Table 21. Overall, all the correlations were positive at the .01 level, which meant as the level of importance increased, the need for professional development also tended to increase. The values of the correlation coefficient of the selected technology topics fell under the "moderate" and "strong and high" categories equally.

Table 21

Correlation between the level of importance and the need for professional development of every selected technology topics

Selected technology topics	Pearson's r	r^2
Animal assessment methods	0.62**	0.38
Record tools used on the observation of a plant development	0.81**	0.66
Techniques used in genetic manipulations	0.76**	0.58
Processes used to produce animal hormones from transgenic organisms	0.79**	0.62
Wastewater treatment	0.80**	0.64
Recycling methods	0.66**	0.44
Operation advanced laboratory equipments	0.87**	0.76
Food preservation methods	0.74**	0.55
Quality-assurance tests on food products	0.67**	0.45
Methods of reducing the effects of animal agriculture on the environment	0.53**	0.28
Approaches to effective customer relationships	0.55**	0.30
A variety of strategies to evaluate goals	0.61**	0.37
Communication skills	0.47**	0.22
Problem-solving models	0.70**	0.49
Appropriate statistical techniques	0.86**	0.74

** = significant at the .01 level

In addition, it was observed that the mean scores of the level of importance (Table 8) of all the items, but "processes used to produce animal hormones from transgenic organisms" were not less than the corresponding need for professional development items (Table 17). Hence, a paired t-test was computed to test for any statistically significant differences between their mean scores (Table 22). It was found that there were statistically significant differences between the level of importance and the need for professional development on ten out of the fifteen topics with the level of importance having significantly higher mean scores. Among them, two items were significant at the .05 level, and others were significant at the .01 level.

This result indicated that high school agricultural teachers had less need for professional development on these technology topics though they perceived them to be important.

Table 22

Paired samples t-test between the level of importance and the need for professional development of the selected technology topics

Selected science topics	Paired differences M	Paired differences SD	*t*	df	P
Animal assessment methods	0.33	0.84	3.14**	63	0.003
Record tools used on the observation of a plant development	0.00	0.56	0.00	63	1.000
Techniques used in genetic manipulations	0.00	0.74	0.00	62	1.000
Processes used to produce animal hormones from transgenic organisms	-0.14	0.66	-1.70	63	0.095
Wastewater treatment	0.27	0.65	3.28**	63	0.001
Recycling methods	0.42	0.87	3.88**	63	0.000
Operation advanced laboratory equipments	0.02	0.63	0.20	63	0.843
Food preservation methods	0.11	0.74	1.19	63	0.240
Quality-assurance tests on food products	0.20	0.65	2.51*	63	0.015
Methods of reducing the effects of animal agriculture on the environment	0.44	0.81	4.30**	63	0.000
Approaches to effective customer relationships	0.59	0.83	5.72**	63	0.000
A variety of strategies to evaluate goals	0.67	0.96	5.60**	63	0.000
Communication skills	1.08	1.01	8.52**	63	0.000
Problem-solving models	0.73	0.86	6.84**	63	0.000
Appropriate statistical techniques	0.18	0.53	2.64*	61	0.010

* = significant at the .05 level
** = significant at the .01 level

In addition to the selected technology topics identified by the researcher in the survey questionnaire, the respondents were given an option to provide any additional technology topics in which they required more professional development. One of the respondents argued that the lack of tools or labs to perform the techniques for genetic manipulations or advanced techniques made it difficult to simulate those topic areas.

Objective 5: Identify the general barriers

Mean and standard deviation scores for the agreement of the general barriers reported by high school agricultural teachers when integrating science and technology into their instructional programs are presented in Table 23. It was defined operationally such that a score of ≤ 2.00 would be considered as a low or negative perception, a score of 2.01 – 4.00 as neutral, and ≥ 4.01 as high or positive perception about the selected general barriers on the five-point Likert-type scale that ranged from 1 – 5.

Table 23

Mean and standard deviation scores for teachers' perceptions about the general barriers

General barriers	M	SD	n
The limited knowledge of the science topics	3.08	1.04	64
The limited knowledge of the technology	3.31	1.04	64
The limited skill on how to teach science and technology in the curriculum	3.30	1.03	64
The lack of training on choosing the appropriate science topics	3.44	0.95	63
The lack of training on choosing the appropriate technology topics	3.45	0.99	64

1 = Strongly Disagree, 2 = Disagree, 3 = Uncertain, 4 = Agree, 5 = Strongly Agree

Table 23 (continued)

General barriers	M	SD	n
The lack of equipment	4.58	0.75	64
The low student academic ability	2.78	1.08	64
The lack of classroom/lab space	3.92	1.01	64
The lack of the curriculum resources	4.00	1.02	64
The lack of knowledge on how to apply the science topics	3.30	1.09	64
The lack of knowledge on how to apply the technology topics	3.36	1.06	64
The lack of time to teach the selected topics	3.66	1.12	64
The lack of the support from school administrators	2.66	1.17	62
The lack of funding	4.23	1.11	62

The mean scores of teachers' agreement about the general barriers mainly ranged from 2.01 to 4.00, which indicated that the respondents had neutral perceptions of these barriers. Only two barriers, "the lack of equipment" and "the lack of funding", had the mean scores that fell under "Agree" to "Strongly agree". It meant that the respondents had strong perceptions of these two barriers. Overall, the top three barriers in this study were: "the lack of equipment" (M = 4.58), "the lack of funding" (M = 4.23), and "the lack of the curriculum resources" (M = 4.00).

On further analysis, the frequency distribution of the barrier statements (Table 24) gave a detailed review of teachers' perceptions. It showed that no one chose "Strongly disagree" for "the lack of time to teach the selected topics" and no one chose "Disagree" for "the lack of equipment". Four out of the fourteen statements: "the limited knowledge of the technology", "the lack of training on choosing the appropriate science topics", "the lack of training on choosing the appropriate technology topics", and "the lack of classroom/lab space" had a majority (≥ 50%) of the respondents on one extreme (Agree) of the scale. As the top two barriers, "the lack of equipment" and "the lack of funding", also had a majority (> 50%) of the respondents on one extreme (Strongly Agree) of the scale. This means that they are major concerns when it comes to integration because these barriers keep teachers from quality instruction.

Table 24

Frequency distribution of teachers' perceptions about the general barriers

General barriers	Strongly Disagree		Disagree		Uncertain		Agree		Strongly Agree	
	f	%	*f*	%	*f*	%	*f*	%	*f*	%
The limited knowledge of the science topics	4	6.25	18	28.13	13	20.31	27	42.19	2	3.13
The limited knowledge of the technology	3	4.69	14	21.88	11	17.19	32	50.0	4	6.25
The limited skill on how to teach science and technology in the curriculum	1	1.56	19	29.69	9	14.06	30	46.88	5	7.81
The lack of training on choosing the appropriate science topics	1	1.59	12	19.05	13	20.63	32	50.79	5	7.94
The lack of training on choosing the appropriate technology topics	2	3.13	12	18.75	10	15.63	35	54.69	5	7.81
The lack of equipment	1	1.56	0	0	4	6.25	15	23.44	44	68.75

1 = Strongly Disagree, 2 = Disagree, 3 = Uncertain, 4 = Agree, 5 = Strongly Agree

Table 24 (continued)

General barriers	Strongly Disagree		Disagree		Uncertain		Agree		Strongly Agree	
	f	%	*f*	%	*f*	%	*f*	%	*f*	%
The low student academic ability	5	7.81	27	42.19	12	18.75	17	26.56	3	4.69
The lack of classroom/lab space	2	3.13	6	9.38	5	7.81	33	51.56	18	28.13
The lack of the curriculum resources	1	1.56	7	10.94	6	9.38	27	42.19	23	35.94
The lack of knowledge on how to apply the science topics	2	3.13	17	26.56	13	20.31	24	37.50	8	12.50
The lack of knowledge on how to apply the technology topics	2	3.13	15	23.44	12	18.75	28	43.75	7	10.94
The lack of time to teach the selected topics	0	0	16	25.00	6	9.38	26	40.63	16	25.00
The lack of the support from school administrators	12	19.35	17	27.42	18	29.03	11	17.74	4	6.45
The lack of funding	2	3.23	4	6.45	8	12.90	12	19.35	36	58.06

A one-way analysis of variance (*ANOVA*) was computed to test for any statistically significant differences in the mean scores of the perceptions about the general barriers (Table 25) among high school agricultural teachers in four groups based on the years of work experience (Figure 1). It was found that there were no statistically significant differences on the mean scores of all the statements, but “the low student academic ability”, among four groups at the .05 level. The statistically significant difference for that barrier was between the respondents who had 11-20 years work experience and those who had 31-40 years work experience.

Table 25

One-way ANOVA among four groups of high school teachers based on their perceptions about the general barriers

The limited knowledge of the science topics	df	SS	MSS	F	P
Between groups	3	2.350	0.783	0.727	0.540
Within groups	58	62.505	1.078		
The limited knowledge of the technology					
Between groups	3	4.657	1.552	1.440	0.240
Within groups	58	62.520	1.078		
The limited skill on how to teach science and technology in the curriculum					
Between groups	3	3.541	1.180	1.111	0.352
Within groups	58	61.636	1.063		
The lack of training on choosing the appropriate science topics					
Between groups	3	1.546	0.515	0.569	0.638
Within groups	57	51.602	0.905		
The lack of training on choosing the appropriate technology topics					
Between groups	3	2.976	0.992	1.019	0.391
Within groups	58	56.460	0.973		
The lack of equipment					
Between groups	3	0.510	0.170	0.287	0.835
Within groups	58	34.409	0.593		
The low student academic ability					
Between groups	3	10.436	3.479	3.263*	0.028
Within groups	58	61.838	1.066		
The lack of classroom/lab space					
Between groups	3	3.918	1.306	1.428	0.244
Within groups	58	53.066	0.915		
The lack of the curriculum resources					
Between groups	3	1.390	0.463	0.443	0.723
Within groups	58	60.545	1.044		

* = significant at the .05 level

Table 25 (continued)

The lack of knowledge on how to apply the science topics	df	SS	MSS	F	P
Between groups	3	3.786	1.262	1.049	0.378
Within groups	58	69.763	1.203		
The lack of knowledge on how to apply the technology topics					
Between groups	3	3.174	1.058	0.936	0.429
Within groups	58	65.535	1.130		
The lack of time to teach the selected topics					
Between groups	3	0.513	0.171	0.132	0.941
Within groups	58	75.035	1.294		
The lack of the support from school administrators					
Between groups	3	5.895	1.966	1.416	0.248
Within groups	56	77.755	1.388		
The lack of funding					
Between groups	3	3.234	1.078	0.844	0.475
Within groups	56	71.499	1.277		

The strength of association (Cramer's V) between teachers' perceptions about the general barriers and the key demographic areas of degree held, owning or operating a farm, and involvement in originations was displayed in Table 26. It was found that the relationships between the key demographic areas and teachers' perceptions about the general barriers mainly classified to be low. However, two items, "the limited knowledge of the technology" and "the lack of knowledge on how to apply the technology topics", showed statistically significant relationships with the degree held at the .05 level. It was interesting to note that "the lack of knowledge on how to apply the technology topics" also indicated a statistically significant relationship with owning or operating a farm at the .01 level. In addition to this barrier, the relationship between "the lack of knowledge on how to apply the science topics" and owning or operating a farm was statistically significant at the .05 level. None of the barriers showed statistically significant relationships with involvement in organizations.

Table 26

Relationship between key demographic areas and teachers' perceptions about the general barriers

General barriers	Degree held	Own or operate farm	Organizations involvement
The limited knowledge of the science topics	0.29	0.20	0.18
The limited knowledge of the technology	0.41*	0.21	0.23
The limited skill on how to teach science and technology in the curriculum	0.21	0.16	0.16
The lack of training on choosing the appropriate science topics	0.27	0.20	0.09
The lack of training on choosing the appropriate technology topics	0.29	0.21	0.23
The lack of equipment	0.21	0.20	0.10
The low student academic ability	0.29	0.14	0.22
The lack of classroom/lab space	0.24	0.29	0.10
The lack of the curriculum resources	0.26	0.29	0.23
The lack of knowledge on how to apply the science topics	0.37	0.43*	0.28
The lack of knowledge on how to apply the technology topics	0.39*	0.51**	0.31
The lack of time to teach the selected topics	0.18	0.06	0.15
The lack of the support from school administrators	0.18	0.26	0.35
The lack of funding	0.30	0.18	0.25

* = significant at the .05 level

In addition to the listed barriers identified in the survey questionnaire, the respondents were given an option to provide any additional barriers they believed to block the integration process. Many respondents regarded the listed barriers as big issues. They argued that the lack of time to plan and change the current curriculum and the lack of time to study and prepare to teach new concepts in the classroom made it hard to implement science and technology into programs. One of the respondents thought that we needed more instructors to learn about and use the CASE curriculum.

Overall comments provided by high school agricultural teachers

Twenty-seven high school agricultural teachers provided pertinent feedback in the form of comments typed in the open-ended question provided in the questionnaire about how to improve the extent of science and technology topics in their agricultural education programs. These comments were analyzed and placed under the following broad areas:

1. A state wide general agricultural curriculum that can match the agricultural education courses with the standards and benchmarks of science and technology is needed. Such curriculum should be built as a unit kit including lessons, activities, and the tools/equipment needed.
2. Many teachers provided a positive appraisal on the CASE curriculum. However, they asked for more access to CASE curriculum — materials, training and equipment.
3. The educational system at the university needs to meet the requirements of teaching in high school. Respondents suggested that the agricultural education

department in ISU should prepare their graduates in building and teaching such an integrated curriculum.

4. High school teachers required more resources, support, and continued training that fit their busy schedules from the dominant institutions, such as IAAE, FFA, and ISU. Professional development should be frequently updated on the major competencies of science and technology.
5. In addition to the knowledge base and curriculum sources, the related facilities that can be used for a variety of activities in classes and the available funding are also essential to implement science and technology concepts.
6. The collaboration between science teachers and agricultural teachers will increase the level of the integration process.
7. Online educational opportunities for students can attract good quality students into their programs.

CHAPTER 5. DISCUSSION

The purpose of this study was to determine the level of importance of the selected science and technology topics as perceived by high school agricultural educators in Iowa when integrating these topics into their instructional programs and to identify their needs for inservice education associated with these selected topics during this process.

This study aimed to seek the answer to two main questions. First, what is the degree of importance of the selected science and technology topics to high school agricultural teachers toward the integration process in Iowa? Based on a previous national study, the fifteen selected science topics included both traditional and advanced aspects in the science field. And the fifteen selected technology topics covered both the on-the-farm technology topics and the off-the-farm technology topics. The secondary purpose of this study sought to determine the need for professional development regarding these topics.

The following four specific objectives served to accomplish the study's purposes:

1. The degree to which the selected science and technology topics are important in their instructional programs.
2. The need for the professional development on teaching the selected science and technology topics.
3. The barriers of teaching the selected science and technology topics in their curriculum.

4. Identify selected demographic information and compare.

In this chapter, the findings obtained from this research study are summarized and analyzed for the purpose of discussion. Appropriate statistical tools as detailed in the findings chapter (chapter 4) were used to investigate data under each of the objectives stated above. A discussion of these findings under each objective in terms of their congruence with similarly structured past studies and contribution to the existing knowledge base are presented in this chapter.

The discussion of the findings in this chapter is presented under the following sections: (1) demographic characteristics of high school agricultural teachers, (2) the level of importance of the selected science topics, (3) the need for professional development of the selected science topics, (4) the level of importance of the selected technology topics, (5) the need for professional development of the selected technology topics, and (6) perceptions of high school agricultural teachers toward the general barriers in the integration process. In addition, the information provided by the respondents as their suggestions to improve the extent of teaching science and technology in their instructional programs were found important to be included as a part of the discussion and therefore are not discussed under a separate heading.

Demographic information of high school agricultural teachers

The target population for this research study was all high school agricultural teachers within the state of Iowa. Of the 220 high school agricultural teachers who served as the study population, 69 (31.36%) of those who responded to the survey had a mean work experience of about 19 years in high school agricultural education programs and were around 43 years of age (Table 1). A majority of them were male (≈ 75%) (Figure 2) and had earned a bachelor's degree (≈ 52%) as their highest academic degree (Figure 3) though a high percentage had attained master's degrees. These findings appeared consistent with the findings of Wilson, Kirby, and Flowers (2002), Warnick and Thompson (2007) regarding the gender distribution; with the findings of Peasley and Henderson (1992) regarding both the gender distribution and educational level; with the findings of Boone, Gartin, Boone, and Hughes (2006) regarding only the educational level. Different from this study, the national study conducted by Martin et al. (1989) indicated that the majority of vocational agriculture instructors held a master's degree. However, all five studies reported here did not show any consistent demographic variables of age and work experience.

The probable reasons for these variabilities could be differences in the target populations, sampling procedures and as well as the geographical locations. Samples for the studies conducted by Wilson, Kirby, and Flowers (2002), Warnick and Thompson (2007), Peasley and Henderson (1992), and Boone, Gartin, Boone, and Hughes (2006) were drawn from different states in America. Since each state organization tends to promote agriculture education in a way best suited to its own needs, the diversity of the demographic variables can be accepted reasonable. This could explain the differences in age and work experience. On the other hand, since the research method in this study was a census that covered an entire population, it can eliminate any coverage errors that may occur in others studies cited above. Also, there are differences in the time periods when these studies were conducted. The studies ranged more than two decades (Martin et al., 1989) to this study, which means there could have been restructuring in terms of hiring policies in high school agricultural education. All of these rational factors could have contributed to the differences in the demographic information of the respondents.

Another reason for inconsistency in educational level could be that in the case of the national study of Martin et al. (1989), they sampled 237 vocational agriculture instructors, who were identified from the Agriculture Teachers Directory for the year of 1987 published by the National Vocational Agriculture Teachers Association of the U.S.A, from all fifty states. Compared to this study (n=69), the national study of Martin et al. included a bigger sample size (n=237). It is true that the higher the sample size, the more likely that the findings of the study have a higher chance of being an accurate description of population parameters (Ary et al., 2010; Agresti & Finlay, 2008). However, it can not be ignored that the long time periods could icrease the risk of the deduction when applying the finding of the national study to a specific state. This reason also can be confirmed by Peasley and Henderson (1992), and Boone, Gartin, Boone, and Hughes (2006), since they also reported a lower percentage of a master's degree held. Certainly, the influence of a small population should also be considered, and therefore it could be reasonably assumed that the findings from this study are limited to the description of the high school agricultural teachers in Iowa.

In addition to the demographic information above, high school agricultural teachers also were asked about the major courses they taught, whether they owned or operated a farm, and whether they were members of any agricultural education organizations. The major courses are animal science (95.65%), plant science (89.86%), and horticulture (82.61%), which fit the core component of agricultural education curriculum recommended by CASE (Curriculum for Agricultural Science Education). In this study, a total of 22 different subject areas were identified as the respondents' major courses of teaching. Such a broad and diverse curriculum indicates that high school agricultural teachers in Iowa represent a broad teaching experience in various areas.

A low percentage (40.58%) of owning or operating a farm leads to less practical experience of agriculture. That is why one of the respondents argued the existence of some agriculture illiterate teachers in high school agricultural education. Therefore, the related institutions need to provide more opportunities for high school agricultural teachers to have a face-to-face contact with the application of agriculture science and technology. A high percentage (85.51%) of the organizations involvement improves the communication of teachers from different high school agricultural education programs. Many agricultural education organizations, like IAAE, NAAE and FFA, also offer the inservice workshops to effective their teaching skills. Thus, high school agricultural teachers in Iowa have available resources to obtain the associated professional development. However, many respondents required more access to the useful resources.

The work experience (M=18.85), age (M=42.65) and educational qualifications (M_0= Bachelor's degree) of high school agricultural teachers indicated that a typical high school agricultural teacher in Iowa as defined operationally for this study was a basic educated middle aged male with substantial years of work experience. Although requirements for agriculture teachers vary, most states require at least a bachelor's degree for those wanting to work at the middle and high school levels. So the findings seem to be in congruence with the policies of the National Association of Agricultural Educators. Overall, the demographic information indicates that high school agricultural teachers in Iowa are well experienced and knowledgeable individuals capable of teaching their programs successfully. However, an effective integration of science and technology depends on not only teachers' demographic characteristics, but also their perceptions toward the necessary components during this process discussed under the following headings.

Level of importance of the selected science topics

Fifteen selected science topics were used on a five point Likert-type scale to measure the high school agricultural teachers' perceived importance that ranged from 1 (not important) to 5 (highly important). The high school agricultural teachers seemed to perceive the selected science topics to be important (M ranged from 3.10-4.18 Table 4) for implementing the integration process, expect two traditional topics, "the way to use vinegar in the manufacture of canned vegetables" (M=2.35) and "the structure of a selected fungus in agriculture" (M=2.72). That means, that high school agricultural teachers had positive perceptions for the majority of the selected science topics. "The environmental factors contributing to soil erosion" was the only topic with a mean score that was greater than 4 (important) and none of respondents regard it as “no important”. Overall, the findings illustrated that high school agricultural teachers perceived the advanced science areas (environment, bioscience, and genomics) more important than the traditional science areas (mycology, plant science, animal physiology).

In order to answer the issue whether these perceptions were consistent from past to present or not, an independent sample t-test was computed to analyze for any statistically significant differences in the mean scores of the level of importance of the same science topics between a previous national study (Martin et al., 1989) and this study. The test results indicated that high school agricultural teachers’ perceptions on the level of importance of six science topics changed during the past three decades. An interesting point that emerged from this test was that as an advanced science topic, “the differences between traditional plant breeding methods and gene splicing” was the only one with a higher mean score in this study. This finding appears to be in line with the conclusion drawn from the comparison of the mean scores above. As many scholars say that agriculture in 21st century is moving into a gene field, these findings support this comment and indicate that high school agricultural teachers’ minds have been well prepared for this new version of agriculture.

The next important question to be analyzed was whether these perceptions about the selected science topics were consistent among high school agricultural teachers with different years of work experience or were there any statistically significant differences. One-way ANOVA was computed toward this purpose, and findings indicated that the perceptions were consistent among the teachers with different years of work experience, expect "identification of plant growth regulators". Specifically, the respondents with 21-30 years work experience scaled a statistically significant lower mean score on this topic. Considered the high mean score of this topic in the national study (Martin et al., 1989), it is reasonable to state that the perceptions of these teachers toward the traditional science areas have significantly changed when comparing with the time they were almost novice teachers. This result matches with the rapid growth trend of the advanced science areas during the past twenty years.

Furthermore, it was not found any substantial relationship (Table 7) among the highest degree held, owning or operating a farm, organizational involvement, and teachers' perceptions toward the selected science topics. Only three moderate relationships were significant at the .05 level. One significant relationship existed between owning or operating a farm and the topic of "water holding capacity of soil". As a topic in soil science, it is a basic knowledge for farm management. Thus, high school agricultural teachers who own or operate a farm tend to teach the science topics that are closely related to their farms. Two topics in animal production indicated a significant relationship with the organizational involvement. This result indicated the focal points of the programs provided by these organizations.

Need for professional development of the selected science topics

The high school agricultural teachers in Iowa were also asked to rate their perceived need for professional development of the same fifteen selected science topics categorized under a Likert-type scale that ranged from 1 (none) to 5 (very high need). The findings of this study revealed that high school agricultural teachers were in need of professional development on all of the identified topics (M ranged from 2.16-3.08 in Table 13). However, none of the respondents reported their need for professional development on two topics, “the natural selection in plants” and “the way to use vinegar in the manufacture of canned vegetables”, as “very high need”. Thus, the findings demonstrated that the need for professional development toward the traditional science areas was a little weak though teachers needed professional development in all these science topics.

Additionally, results from One-way ANOVA revealed that there were statistically significant differences in the mean scores of teachers’ need for professional development of two topics, “the differences between traditional plant breeding methods and gene splicing” at the .05 level and “the natural selection in plants” at the .01 level. To be specific, the novice teachers with 1-10 years work experience required less need on both science topics when comparing with experienced teachers with longer work years. This result corroborated that current new high school agricultural teachers have already accepted basic inservice education on both the traditional science areas and the advanced science areas. The relevant departments should attempt to satisfy the needs of the experienced teachers toward the professional development of the selected science topics. Another point worth noting was that the results of One-way ANOVA on the level of importance and the need for professional development were dissimilar.

In case of the relationship analysis between the demographic areas and teachers' need for professional development of the selected science topics, there were also three moderate relationships were significant at the .05 level. However, only one topic, "the process of milk formation in cattle", existed significant relationships with the organizations involvement toward the need for professional development, as well as the level of importance. This result further confirmed the effectiveness of the inservice education offered by these organizations. As a practical science topic in farm production, "identification of plant growth regulators" was significantly related to the demographic of owning or operating a farm.

Considering the different statistical outcomes of the level of importance and the need for professional development, it was further found that high school agricultural teachers did not need the corresponding professional development to the extent they perceived them to be important, though the level of importance and the need for professional development were significantly correlated. The results from the paired t-test indicated that there were statistically significant differences between the level of importance and the need for professional development on ten out of fifteen topics with the level of importance having significantly higher mean scores (Table 17). The reasons could be many for this finding and need to be found out in future research.

This might suggest that perceptions related to importance were not getting translated into behavior in terms of need for professional development. However, caution needs to be exercised for interpreting this causal relationship mainly for three reasons:

1. This study employed a descriptive survey design which offers no control on extraneous variables that could affect a dependent variable (need for professional development in this case). The research design needs to be causal-comparative or ex-post facto, or higher for inferring a causal relationship between variables (Ary et al., 2010);
2. There might be other better indicators of perceptions other than/in addition to perceived importance that could influence teachers' need for professional development;
3. It can be inferred that the current professional development service has already provided high school agricultural teachers enough knowledge on the selected science topics. On the other hand, it can also be inferred that there could be some inhibitory factors, which reduce their demand for inservice education. As many respondents stated on the open-end questions, their busy schedules led them to lack time to attend workshops that may last for extended periods of time. It could be a probable reason why teachers reported less need for professional development though they perceived the identified science topics to be important.

Level of importance of the selected technology topics

Fifteen selected technology topics were identified, and high school agricultural teachers were asked to rate the perceived importance on Likert-type scales that ranged from 1 (not important) to 5 (highly important). The respondents tended to perceive the selected technology topics to be important (M ranged from 2.89-4.22 Table 8) for implementing the integration process, while the mean scores of several topics were less than, but close to 3 (somewhat important). Also, none of the respondents regarded "quality-assurance tests on food products" and "approaches to effective customer relationships" to be "not important".

Further, the foregoing analysis on the statistically significant differences in the summated mean scores between the on-the-farm technology topics and the off-the-farm technology topics helps identify the perceptions of high school agricultural teachers toward the selected technology topics. The findings illustrated that high school agricultural teachers perceived the off-the-farm technology areas significantly important than the on-the-farm technology areas (Table 9). This result suggested that teachers' perceptions toward the off-the-farm technology did respond to the requirement of the agricultural employees in the future. As McDowell (2001) pointed out in his book, there was a strong predisposition for the on-the-farm issues in the extension service. The extension faculty spent too many resources only on the on-the-farm agricultural production technology and its management. Such services led them to ignore the off-the-farm issues that did affect farm profitability. Thus, McDowell suggested that in order to provide farmers what they need, we should pay attention to the off-the-farm issues. We can say that high school students in today's classroom will be the potential staff of the extension service in the further. Since their agricultural teachers have already realized the importance of the off-the-farm technology, it can be reasonable to assume that high school students will master the necessary knowledge and skills of these technologies if the related resources are supplied effectively. Therefore, the goal of high school education, offering productive youth to our society, can be truly achieved.

One-way ANOVA analysis revealed that there were statistically significant differences among high school agricultural teachers having different years of work experience in the mean scores of the level of importance of four off-the-farm technology topics. An interesting point that emerged from this test was that the differences all existed between the teachers who had 1-10 years work experience with significant higher mean scores and those who were in other groups. This finding appeared to illustrate that the novice high school agricultural teachers regarded the off-the-farm technology more important than the experienced high school agricultural teachers did. In other words, the perceptions of these novice teachers toward the off-the-farm technology were more in line with the development requirements of the agricultural technology in the future.

Regarding the results from the strength of association, there were no statistically significant relationships between the selected technology topics and the key demographic areas at the .05 level, though several relationships were moderate. This result indicated that the demographics of the highest degree held, owning or operating a farm, and organizational involvement did not appear to have considerable influence in making decisions regarding the level of importance of the selected technology topics (Table 12).

Need for professional development of the selected technology topics

The same fifteen selected technology topics were also applied to acquire the data of high school agricultural teachers' perceived need for professional development on a Likert-type scale that ranged from 1 (none) to 5 (very high need). It was found that high school agricultural teachers were in need of professional development on all of the identified topics (M ranged from 2.69-3.33 in Table 18). An interesting point that appeared from studying the frequency of the distribution on the scale was that three off-the-farm technology topics did not get any supporters on the same categories. None of high school agricultural teachers chose "very high need" for "recycling methods", and no one regarded "quality-assurance tests on food products" and "approaches to effective customer relationships" to be "none". Therefore, this data indicated that there was less diversity on the perceptions toward the need for professional development of these three technology topics among teachers. However, different from the statistical analysis on the level of importance between the on-the-farm technology topics and the off-the-farm technology topics, there were no statistically significant differences between the need for professional development of the on-the-farm technology topics and that of the off-the-farm technology topics. Thus, inservice education for both the on-the-farm technology and the off-the-farm technology is necessary for high school agricultural teachers to integrate the selected technology into their instructional programs.

The next central question to be answered was the consistency of teachers' need for professional development toward the selected technology among the respondents with different years of work experience. It was found that the respondents with 1-10 years work experience indicated a statistically significant stronger need for professional development on two topics, “a variety of strategies to evaluate goals” and “communication skills”, than those with 11-20 years work experience at the .05 level. This result was similar to the One-way ANOVA of the level of importance toward the selected technology topics that teachers who had 1-10 years work experience showed significantly higher mean scores on these two topics. Thus, compared to teachers with medium years of work experience, new high school agricultural teachers did need more inservice education to apply these two technology topics that they believed to be important in their educational programs, though they have already mastered the selected science topics. In other words, new teachers’ need for professional development mainly concentrated in the technology fields.

In case of the relationship analysis between the demographic areas and teachers’ need for professional development of the selected technology topics, only one topic, “quality-assurance tests on food products” had a moderate and statistically significant relationship with owning or operating a farm at the .05 level. This off-the-farm technology is necessary for farm management. Thus, teachers who own or operate a farm need less inservice education on this topic, since they have already applied it into their farms in some way and have knowledge about it because of their experience.

Because of the different statistical outcomes of the level of importance and the need for professional development toward the selected technology topics, a paired t-test was computed to find whether the perceptions of these two parts were consistent. The findings indicated that high school agricultural teachers did not need the corresponding professional development toward ten out of fifteen technology topics, including both the on-the-farm and the off-the-farm areas, to the extent they perceived them to be important, though the level of importance and the need for professional development were significantly correlated. There are many possible reasons to explain the result that the level of importance had significantly higher mean scores (Table 23). For detailed analysis please refer to previous section (*Need for Professional Development of the Selected Science Topics*).

Teachers' perceptions toward the general barriers

Fourteen general barriers were identified, and high school agricultural teachers were asked to rate the perceived agreement on Likert-type scales that ranged from 1 (strongly disagree) to 5 (strongly agree). Overall, respondents seemed to hold neutral attitudes toward the majority of the general barriers (M ranged from 2.01 to 4.00 Table 24) that influenced the integration process, though they indicated strong and positive agreement toward three barriers. High school agricultural teachers perceived "the lack of equipment" as most serious barrier for the integration process followed by "the lack of funding" and "the lack of the curriculum resources", whereas "the lack of the support from school administrators" was perceived to be least serious (Table 24). Also, by analyzing the frequency distribution toward the barrier statements (Table 25), the tendency for the extreme on the scale illustrated that teachers' perceptions of these three major barriers were similar.

The findings regarding the extent of agreement on the general barriers appeared to be consistent with past related studies. Warnick and Thompson (2007) found that the lack of funding and equipment did inhibit the integration process. Similarly, in a study of Indiana agriculture teachers conducted by Balschweid and Thompson (2002), a study of agricultural educators in North Carolina conducted by Wilson, Kirby, and Flowers (2002), a study conducted by Thompson (2001) of Oregon principals, a study of South Carolina agricultural teachers conducted by Layfield et al (2001), and a study of Oregon agricultural teachers conducted by Thompson and Balschweid (1999), the respondents all rated the highest scores on the same barriers to integrating science.

Additionally, Peasley and Henderson (1992) studied Ohio high school teachers of agriculture and found that they wanted a state core curriculum in agriscience and leadership from the state Agricultural Education Service on agriscience curriculum development. Their first finding can be explained as "the lack of the curriculum resources" in this study. However, in this study, Iowa high school agricultural teachers did not regard the lack of the support from superiors as a serious block. It further indicated that the related agricultural education institutions in Iowa had provided teachers some resources to integrate science and technology into their instructional programs, although the resources were not enough argued by some respondents.

A meaningful point that emerged from analyzing the perceptions of high school agricultural teachers regarding the general barriers during the integration process was that although the different studies cited above obtained different results on the major barriers, the barriers included not only the knowledge base, but also some resources used in teaching science and technology. So the preparation on the related knowledge domain alone is insufficient for integrating science and technology into their instructional programs successfully. Thus, it is imperative that high school agricultural teachers in Iowa need competence in the related resources in addition to their knowledge background in agricultural education for effectively teaching their students.

One-way ANOVA analysis revealed that there was a statistically significant difference among high school agricultural teachers with different years of work experience in the perceived agreement for only one barrier: the low student academic ability. Specifically, the respondents with 31-40 years work experience performed a statistically significant higher agreement on this topic than the respondents with 11-20 years work experience. This result indicated that the higher the number of year of work, the less satisfaction with student academic ability. In other words, experienced high school agricultural teachers are eager to attract more outstanding students into their programs.

Furthermore, it was found only one substantial and statistically significant relationship between owning or operating a farm and the perceived agreement on “the lack of knowledge on how to apply the technology topics” (Table 27). In addition to this barrier, there also is a moderate and statistically significant relationship between owning or operating a farm and the perceived agreement on "the lack of knowledge on how to apply the science topics". These findings indicated that teachers without experience on the farm regarded the barriers related with application more serious, since they did not have enough opportunity to contact or apply the science and technology. Thus, why is it some respondents believed that involving a farm management was necessary for teaching high school students? Two topics, "the limited knowledge of the technology" and "the lack of knowledge on how to apply the technology topics", showed statistically significant relationships with the degree held. This result indicated that teachers with a master's degree regarded the barriers related with technology more serious.

CHAPTER 6. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Science and technology have always been the basic elements for agricultural production in the United States. As we all know, the definition of agriculture focus on the application of science and technology that covers a wide range of principles of the physical, chemical and biological areas in the agricultural industry. The United States Department of Agriculture confirmed the important role of science and technology by stating that advances in science and technology contributed to increase farm productivity, enhance the nutrient content of foods, and utilize new processing and marketing strategies in global agriculture in the 20th century (U.S. Department of Agriculture, 2003). Therefore, it is significant to educate some appropriate science and technology topics to the youth, since they will be the potential agricultural researchers, producers and staffs in the future. There are many channels in the United States for the youth to gain such information. However, as a fundamental part of agricultural education, high school agricultural education programs take the responsibility to provide their students the necessary knowledge and skills required by the future tendency of agricultural industry. Thus, it is necessary to obtain the current situation of high school agricultural educators toward the science and technology topics when integrating these topics into their instructional programs.

This study sought to analyze the perceptions of the selected science and technology topics by high school agricultural teachers in Iowa, and draw implications for: (1) the understanding of the level of importance of these selected topics; (2) the need for professional development of high school agricultural teachers; and (3) the improvement of the integration process. The following four specific objectives served to accomplish the study's purposes:

To identify and analyze:

1. The degree to which the selected science and technology topics are important in their instructional programs.
2. The need for the professional development on teaching the selected science and technology topics.
3. The barriers of teaching the selected science and technology topics in their curriculum.
4. Identify selected demographic information and compare.

The target population for this descriptive census survey consisted of all high school agricultural teachers within the state of Iowa. Of the two hundred and twenty high school agricultural teachers who served as the accessible population, 69 (31.36%) of them responded to this survey. An electronic questionnaire developed using SurveyMonkey® was used to collect the data. The expert panel-validated questionnaire consisted of three sections. Section I and II used five point Likert-type scales, and Section III used close-ended and open-ended questions. The Cronbach's coefficient (α value) for reliability ranged from 0.783 to 0.926, which were considered reliable according to George and Mallery (2003). Data were analyzed by using Statistical Package for Social Science (SPSS®19.0).

Demographic data revealed that high school agricultural teachers responding to the study had a mean work experience and age of 18.85 and 42.65 years, with standard deviations of 11.73 and 11.66, respectively. A majority of the respondents were male, and had earned a bachelor's degree. Animal science, plant science, and horticulture were the top three courses among 22 different subject areas they taught. Though many teachers (85.51%) took part in different agricultural organizations, less of them (40.58%) owned or operated a farm.

Iowa high school agricultural teachers seemed to perceive the majority of the selected science topics to be important when integrating these topics into their instructional programs. However, the traditional science areas displayed less mean scores on the level of importance than the advanced science areas. Further analysis of the differences between this study and the previous national study (Martin et al., 1989) indicated that the level of the importance toward the traditional science topics decreased during the past two decades. One-way ANOVA conducted for testing any statistically significant differences among teachers with different work years on the perceived importance of the selected science topics revealed that, respondents with 21-30 years work experience regarded "identification of plant growth regulators" to be less important than others. A moderate but significant relationship existed between owning or operating a farm and the topic of "water holding capacity of soil". Teachers with farm experience scaled this topic to be less important. Two topics in animal production also exited moderate but significant relationships with the organizations involvement. Teachers worked as members in any organizations scaled these topics to be less important.

Iowa high school agricultural teachers were in need of professional development on all of the fifteen selected science topics, but the need for professional development toward the traditional science areas was little weak. One-way ANOVA conducted for testing any statistically significant differences among teachers with different work years on the need for professional development of the selected science topics revealed that, the novice teachers with 1-10 years work experience required less inservice education on two topics, “the differences between traditional plant breeding methods and gene splicing” and “the natural selection in plants”. A moderate but significant relationship existed between owning or operating a farm and the topic of “identification of plant growth regulators”. Teachers with farm experience showed less need for professional development on this topic. A moderate but significant relationship also existed between the organizational involvement and “the process of milk formation in cattle”. Teachers worked as members in any organizations required less professional development on this topic.

Further analysis indicated that though the level of importance and the need for professional development of the selected science topics were significantly correlated, these positive perceptions toward the level of importance seemed not to be reflected in the need for professional development, as evidenced by statistically significant higher mean scores for the perceived importance compared to the need for professional development. Overall, the same trend was observed with the perceived importance of ten out of fifteen technology topics vs. their need for professional development of these topics.

Iowa high school agricultural teachers seemed to perceive the majority of the selected technology topics to be important when integrating these topics into their instructional programs. Additional, an in-depth analysis illustrated that high school agricultural teachers perceived the off-the-farm technology areas significantly important than the on-the-farm technology areas. One-way ANOVA conducted for testing any statistically significant differences among teachers with different work years on the perceived importance of the selected technology topics revealed that, respondents with 1-10 years work experience regarded four off-the-farm technology topics to be more important than others. Demographics including the highest degree held, owning or operating a farm, and the organizations involvement did not highly influence high school agricultural teachers' attitude toward the level of importance of the selected technology topics.

Iowa high school agricultural teachers were in need of professional development on all of the fifteen selected technology topics. Though teachers' perceptions were more central toward the off-the-farm technology topics, their needs for professional development of the on-the-farm technology topics and the off-the-farm technology topics were statistically equivalent. One-way ANOVA conducted for testing any statistically significant differences among teachers with different work years on the need for professional development of the selected technology topics revealed that, respondents with 1-10 years work experience indicated a statistically significant stronger need for professional development of two topics, “a variety of strategies to evaluate goals” and “communication skills”. A moderate but significant relationship existed between owning or operating a farm and the topic of “quality-assurance tests on food products”. Teachers with farm experience showed less need for professional development on this topic.

Regarding the general barriers related to the integration process, it was found that high school agricultural teachers had neutral attitude toward the majority of the general barriers and they indicated strong and positive agreement toward the top three barriers with less divergence: “the lack of equipment”, “the lack of funding” and “the lack of the curriculum resources”. However, “the lack of the support from school administrators” was cited as the least serious limitation. One-way ANOVA conducted for testing any statistically significant differences among teachers with different work years on the agreement of the general barriers revealed that, respondents with 31-40 years work experience performed a statistically significant higher agreement on “the low student academic ability” than those with 11-20 years work experience. Two application barriers, “the lack of knowledge on how to apply the science topics” and “the lack of knowledge on how to apply the technology topics” exited moderate/ substantial but significant relationships with owning or operating a farm. Teachers with farm experience showed less agreement on these barriers. Two barriers related with the technology area, “the limited knowledge of the technology” and “the lack of knowledge on how to apply the technology topics” had significant relationships with the degree held. Teachers with master’s degree showed more agreement on these barriers.

Conclusions

The following fourteen conclusions were drawn based on the findings of the study:

1. High school agricultural teachers who participated in this study were mainly middle-aged men with substantial years of work experience in a variety of discipline areas and held a bachelor's degree. They were involved in the related agricultural institutions positively, but were lacking farm experience.
2. Although high school agricultural teachers identified the majority of the fifteen selected science topics as important to be integrated into the curriculum, they seemed to value the advanced science topics (example: the differences between traditional plant breeding methods and gene splicing) more important than the traditional science topics (example: the structure of a selected fungus in agriculture).
3. The attitudes of high school agricultural teachers toward the level of importance of the traditional science topics were changed during the past two decades since the agricultural industry walked into an era of the gene.
4. Although high school agricultural teachers were in need of professional development on all of the fifteen selected science topics, their needs for the traditional science areas were a little weak.
5. New high school agricultural teachers needed less inservice education on some science topics related to both the traditional science areas and the advanced science areas.

6. Although high school agricultural teachers identified the majority of the fifteen selected technology topics as important to be integrated, they seemed to value the off-the-farm technology areas more important than the on-the-farm technology areas. To be specific, the novice teachers regarded the off-the-farm technology more important than the experienced teachers did.
7. High school agricultural teachers were in need of professional development on both the selected on-the-farm technology and the selected off-the-farm technology topics without any statistically significant differences.
8. Compared with their less need for professional development of some science topics, new high school agricultural teachers did need more inservice education in the application of some technology topics.
9. Perceptions of high school agricultural teachers regarding the level of importance of the selected science and technology topics in the integration process appeared to show a low need for professional development of many of these topics.
10. Having farm experience or not influenced the perceptions of high school agricultural teachers toward the level of importance and the need for professional development of some science topics, which were closely related to the farm management. While this trend was observed only toward the need for professional development of some technology topics.
11. The agricultural organizations provided their members the information and the associated inservice education on some science topics in the animal production

areas.

12. High school agricultural teachers' attitude toward the level of importance of the selected technology topics was not significantly influenced by demographics including the highest degree held, owning or operating a farm, and the organizations involvement.
13. Equipment, funding, and curriculum resources availability were cited as the main limitations to integrate science and technology topics into their instructional programs. These barriers were consistent with previous related studies and high school agricultural education literature. Interestingly, the lack of the support from superiors in this study was less serious than it in some previous related studies.
14. Experienced high school agricultural teachers regarded the academic ability of students as a necessary element in the integration process. Teachers without farm experience valued the application of science and technology in the integration process, while teachers with a master's degree valued the barriers related with technology.

Recommendations

Recommendations for action. The following recommendations for action were made based on the findings and conclusions of the study:

1. State supervisors, agricultural organizations and universities should provide more opportunities for Iowa high school agricultural teachers to acquire the necessary farm experience. Since teachers with farm experience were more

familiar with the science and technology topics related to the farm management, owning or operating a farm makes them more knowledgeable and enhance the teaching effectiveness.

2. State supervisors, agricultural organizations and universities should increase teachers' awareness of where the related equipment and curriculum resources are located. Since they identified lack of equipment and curriculum resources as major limitations to integrate science and technology topics, increasing location awareness may encourage the integration process.
3. The appropriate professional development for teachers should be provided by state supervisors, agricultural organizations and universities in order to increase their understanding of content area of the science and technology topics. Their awareness toward the importance of science and technology related to the integration process should also be increased during inservice education programs.
4. The agricultural organizations need to enlarge their project areas for their members. And their professional development programs need to attract more diverse audiences. The differences between the novice and experienced teachers should be taken into account during the inservice education.
5. Reasons for teachers not needing the professional development of the selected science and technology topics to the extent they perceived them to be important need to be discovered and addressed.

Recommendations for further research. This study found the following potential research areas that need to be addressed by further research:

1. A similar study needs to be replicated in other states of the United States in order to indentify other high school agricultural teachers' perceptions and attitudes toward the integrated curriculum. The different perspectives could emerge and improve the integration process nationally.
2. This study did not establish a causal relationship between perceptions of the level of importance and the need for professional development related to the selected science and technology topics. A causal-comparative or experimental study needs to be conducted to test this potential relationship.
3. High school agricultural teachers could be surveyed to better identify the equipment and curriculum resources they need in the integration process.

Implications and significance to high school agricultural education

The purpose of this study was to identify the perceived importance of the selected science and technology topics and the need for professional development of these topics by Iowa high school agricultural teachers in the integration process. Findings from this study were based on the data collected from a census of 220 high school agricultural teachers in Iowa, and hence can be generalized to Iowa State reasonably. There are implications from this study for improving the integration of science and technology in high school agricultural education, and inservice education of teachers. Further, these findings are also pertinent to: integrated curriculum based on other science and technology topics; integrated programs conducted in nonformal settings; and integrated curriculum offered in other states and countries.

The perceptions of Iowa high school agricultural teachers toward the level of importance of the selected science and technology topics were analyzed. As their perceptions will influence teaching effectiveness, it is important to improve teachers' understanding of the science and technology content through the professional development. Further, this study found the major barriers for teachers when integrating the science and technology into their instructional programs. These barriers should be realized and addressed by the related agricultural institutions and departments, in order to encourage high school teachers to promote such integrated curriculum in their classroom. Additionally, it was found that demographics including the work years, the highest degree held, owning or operating a farm, and the organizations involvement could influence teachers' attitude toward the selected science and technology topics to some extent. This results consistent with some literatures, which suggest that demographics play a role in helping determine an individual's attitudes and practice (Schommer, 1998; Cano et al., 1992).

Further, the findings from this study and the survey questionnaire used for this study have implications for designing future studies focused on the integration of science and technology in nonformal and formal agricultural educational settings. They could serve as potential Likert items or questions in the research survey instruments. Lastly, this study has significant implications for conducting research in other states in the United States and other countries where teaching science and technology is an indispensable component in most all high school agricultural education programs.

Overall, findings from this study encourage further development of the integrated curriculum in high school agricultural education, and lend teachers' opinions and needs to achieve such curriculum in their classroom. Given the information provided, the efforts of related agricultural departments can better meet the needs of Iowa high school agricultural teachers.

APPENDIX A. INSTITUTIONAL REVIEW BOARD APPROVAL FORM

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Resear
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2207
515 294-4566
FAX 515 294-4267

Date: 10/21/2011

To: Shaohong Feng
428 Stonehaven Dr #22
Ames, IA 50010

CC: Dr. Robert Martin
201 Curtiss Hall

From: Office for Responsible Research

Title: Extent to which Agricultural Educators are Integrating Science and Technology into their Instructional Programs

IRB ID: 11-493

Study Review Date: 10/21/2011

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b).

The determination of exemption means that:

- **You do not need to submit an application for annual continuing review.**

- **You must carry out the research as described in the IRB application.** Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

  Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

  Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. **Only the IRB or designees may make the determination of exemption**, even if you conduct a study in the future that is exactly like this study.

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.

APPENDIX B. INSTITUTIONAL REVIEW BOARD APPROVALMODIFICATION FORM

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Resear
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2207
515 294-4566
FAX 515 294-4267

Date: 11/4/2011

To: Shaohong Feng
428 Stonehaven Dr #22
Ames, IA 50010

CC: Dr. Robert Martin
201 Curtiss Hall

From: Office for Responsible Research

Title: Importance of Selected Science and Technology Topics in the Instructional Programs to Iowa High School Agricultural Educators

IRB ID: 11-493

Study Review Date: 11/2/2011

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- **You do not need to submit an application for annual continuing review.**

- **You must carry out the research as described in the IRB application.** Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

  Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

  Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. **Only the IRB or designees may make the determination of exemption**, even if you conduct a study in the future that is exactly like this study.

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.

APPENDIX C. APPROVED SURVEY QUESTIONNAIRE

Importance of selected science & technology topics in instructional programs pilot

Exit this survey

33%

Science:
Science includes a body of knowledge that covers general truths of the operation of general laws, and a process that can be used to obtain and test knowledge through the scientific method. In this study, we mainly focus on the natural science, which means the study of the natural world, such as Plant Science, Genetics, Animal Science, Soil Science, Microbiology, and Food Science.

Technology:
Technology is the usage of tools, machines, techniques or methods in order to solve a problem or improve performance. The technology combined with agriculture aims to use the agricultural resources and natural resources efficiently in the chain of production, processing and marketing. In this study, we focus on 1) the on-the-farm technology, which works on improving the productivity, such as biotechnology, automation technology, and power technology; 2) the agribusiness technology, which depends on strategic decision making, management, marketing, and processing systems.

Part 1: The importance of selected science and technology topics and the need for associated professional development

Given below are selected aspects of science. Please indicate the degree to which this competency area/knowledge is important in your agricultural education curriculum (A), and the extent to which you want professional development (B) on this topic.

Column A represents the Level of Importance: 1 = Not Important (NI), 2 = Of little Importance (LI), 3 = Somewhat Important (SI), 4 = Important (I), and 5 = Highly Important (HI). Column B represents the Need for Professional Development: 1 = None (N), 2 = Low Need (LN), 3 = Some Need (SN), 4 = High Need (HN), 5 = Very High Need (VHN).

	Level of Importance	Need for Professional Development
The knowledge of hydroponics		
The effect of growth hormones on the rate of vegetatively propagated plants		
Identification of plant growth regulators		
The differences between traditional plant breeding methods and gene splicing		
Mutation in plants		
Explanation on how cycling time can be increased in animal production		
The principles of sex linkage in animals		
The function of endocrines in animals		
The environmental factors contributing to soil erosion		
The biological properties of soil		
The structure of a selected fungus in agriculture		
The natural selection in plants		
Water holding capacity of soil		
The process of milk formation in cattle		
The way to use vinegar in the manufacture of canned vegetables		
Any others, please list below		

Others (please specify)

Given below are selected aspects of technology. Please indicate the degree to which this competency area/knowledge is important in your agricultural education curriculum (A), and the extent to which you want professional development (B) on this topic.

Column A represents the Level of Importance: 1 = Not Important (NI), 2 = Of little Importance (LI), 3 = Somewhat Important (SI), 4 = Important (I), and 5 = Highly Important (HI). Column B represents the Need for Professional Development: 1 = None (N), 2 = Low Need (LN), 3 = Some Need (SN), 4 = High Need (HN), 5 = Very High Need (VHN).

	Level of Importance	Need for Professional Development
Animal assessment methods		
Record tools used on the observation of a plant development		
Techniques used in genetic manipulations		
Processes used to produce animal hormones from transgenic organisms		
Wastewater treatment		
Recycling methods		
Operation advanced laboratory equipments		
Food preservation methods		
Quality-assurance tests on food products		
Methods of reducing the effects of animal agriculture on the environment		
Approaches to effective customer relationships		
A variety of strategies to evaluate goals		
Communication skills		
Problem-solving models		
Appropriate statistical techniques		

Other (please specify)

Next

Importance of selected science & technology topics in instructional programs pilot

Exit this survey

67%

Part 2: The general barriers

To what extent do you agree with the following barriers to adding the science and technology topics in the agricultural education programs?

1 = Strongly Disagree (SD), 2 = Disagree (D), 3 = Uncertain (U), 4 = Agree (A), 5 = Strongly Agree (SA)

	SD	D	U	A	SA
The limited knowledge of the science topics	○	○	○	○	○
The limited knowledge of the technology	○	○	○	○	○
The limited skill on how to teach science and technology in the curriculum	○	○	○	○	○
The lack of training on choosing the appropriate science topics	○	○	○	○	○
The lack of training on choosing the appropriate technology topics	○	○	○	○	○
The lack of equipment	○	○	○	○	○
The low student academic ability	○	○	○	○	○
The lack of classroom/lab space	○	○	○	○	○
The lack of the curriculum resources	○	○	○	○	○
The lack of knowledge on how to apply the science topics	○	○	○	○	○
The lack of knowledge on how to apply the technology topics	○	○	○	○	○
The lack of time to teach the selected topics	○	○	○	○	○
The lack of the support from school administrators	○	○	○	○	○
The lack of funding	○	○	○	○	○

Other (please specify)

Prev Next

Importance of selected science & technology topics in instructional programs pilot

Exit this survey

100%

Part 3: Demographics

How many years of experience do you have in teaching agriculture?

Gender

- Male
- Female

Age

Highest academic degree earned

- BS
- MS
- PhD

Other (please specify)

Major courses or units you teach (Please check all that apply):

- Plant science
- Animal science
- Environmental science
- Food science
- Agribusiness
- Agricultural Machinery
- Horticulture
- Natural resource

Other (please specify)

Do you own or operate a farm?

- Yes
- No

Are you a member of any agricultural education organizations?

- Yes
- No

If yes, please indicate

What suggestions do you have for improving the extent to which science and technology competency areas/knowledge are taught in your agricultural education program?

Please provide comments regarding the survey.

Prev Done

APPENDIX D. INFORMED CONSENT AND INTRODUCTION LETTER

Dear high school agricultural educator,

Throughout the history of agricultural development, the application of scientific and technological advances has greatly influenced the agriculture industry. In this context, the important role of science and technology in high school agricultural education should be respected. Although science and technology is being taught, we still need to know to what level of importance is science and technology to high school agricultural educators. Also, what, if any, professional development is needed.

The purpose of this descriptive study is to determine the degree to which the selected science and technology topics are important in agricultural education programs. A second purpose is to determine the need for professional development regarding the topics. This study will also collect some demographic information and suggestions for improving the extent of teaching science and technology in agricultural education programs.

We are collecting information from all the agricultural educators in high schools in Iowa. We expect that the findings of this study can offer some useful information for course offerings, teacher workshops and in-services, and the agricultural education curriculum.

We are collecting data through an electronic survey that will be sent to you via an email message. Your responses will be held in strictly confidence and used only for statistical analysis. Since we are interested in group data, code numbers assigned to the e-survey questionnaire will be used only to identify the non-respondents so they can be requested to return their surveys. The code numbers will be removed upon the receipt of the questionnaire. It is important for you to know that participation is completely voluntary and you can withdraw at any time during the study. Please answer every question that you feel comfortable answering.

Data from this study will be used to write a Master thesis and share with other professionals in Agricultural Education. Your cooperation in conducting this survey is therefore essential. The questionnaire will take 10-15 minutes to complete. Please complete and return the questionnaire electronically.

We greatly appreciate your participation in the study.

To begin the survey, please click the link below
http://www.surveymonkey.com/s/CGZDTZP

Sincerely,

Shaohong Feng
Graduate Student,
Agriculture Education & Studies

Dr. Robert A. Martin
Major Professor,
Agriculture Education & Studies

APPENDIX E. FOLLOW-UP LETTER

Dear high school agricultural educator,

I am conducting a survey to determine the degree to which the selected science and technology topics are important in agricultural education programs. A second purpose is to determine the need for professional development regarding the topics. Recently, a questionnaire was sent to you via email. I haven't yet received your responses to the questionnaire. Your participation in this study is very important.

If you have already completed and submitted the questionnaire prior to receiving this e-mail, please accept my sincere thanks. Otherwise, please complete the questionnaire and submit it as soon as possible.

For your reference, I am attaching the link for the questionnaire.
http://www.surveymonkey.com/s/CGZDTZP

If you have any questions regarding this study, please send a message to Shaohong Feng at fsh0929@iastate.edu.

Your cooperation in this study is greatly appreciated.

Sincerely,

Shaohong Feng
Graduate Student,
Agriculture Education & Studies

Dr. Robert A. Martin
Major Professor,
Agriculture Education & Studies

REFERENCES

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