Curriculum and Facilities for Agricultural Education:
An Agriscience Approach

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By Thomas W. Broyles

Abstract

Agricultural education has changed its curriculum, its focus, and its mission. The early days of agricultural education prepared pupils to enter the workforce by training for specific jobs. The emphasis in agricultural education has shifted to the integration of academics with career and technical education. This paradigm shift is called agriscience. The concept of agriscience is delivered utilizing classroom teaching, supervised agricultural experiences, and laboratory learning.

Facilities are the linking point from classroom instruction to problem solving and hands-on experience. Facilities must be furnished with equipment and modules that are highly correlated with the curriculum being implemented. Laboratory experiences must be modernized to reflect the integration of academics with agricultural education. A facility problem being encountered is that agricultural educators do not know the essential components needed for a functional agriscience facility.

The purpose of this study was to ascertain essential components needed for a functional agriscience course taught in Virginia entitled Biological Applications in Agriculture. Specific objectives of the investigation were to determine the essential agriscience laboratory and classroom components needed to implement the Virginia course entitled Biological Applications in Agriculture.

Identifying essential components of a functional agriscience facility was achieved using the modified Delphi methodology. The panel for this investigation was comprised of

17 adult individuals representing three constituency groups. The groups were categorized as agricultural educators, local school administrators, and career and technical education directors.

The respondents completed questionnaires spread over two rounds. The Round I included an initial list of 49 pieces of equipment and components from similar courses taught in Georgia, North Carolina, and New York. The expert panel added an additional 41 pieces of equipment and components to the Round I questionnaire. The Round II questionnaire sought to obtain consensus of the list of essential equipment and components for an agriscience laboratory and classroom. The expert panel reached a consensus on the 90 items essential to implementing the course Biological Applications in Agriculture.

Dedication

This task was by no means a “walk in the park”. I dedicate this educational journey to my wife Liz. You were always there for me while completing my degree. You are my partner and friend. It is with your love and support that this task is now another chapter in our lives. You believed in me and for that I am grateful.

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Chapter 1

INTRODUCTION

Agricultural education has developed and changed since the founding of the United States. Benjamin Franklin advocated the teaching of agriculture in every town as early as 1749 (Shelly-Tolbert, Conroy, & Dailey, 2000). Agriculture was an integral part of the total educational curricula in the early 1900s. From 1901 to 1905, 33 public high schools offered agriculture in their curricula. Five years later, the agriculture curriculum was an integral part of 413 more high schools (Barrows, 1919). On February 23, 1917, agricultural education as we know it today, was created when President Woodrow Wilson signed the Smith-Hughes Act, which provided federal funding for vocational education (Cremin, 1964). The Smith-Hughes Act specified vocational programs, created administrative procedures, and prescribed skills-based training programs for instruction in agriculture, trade and industries, and home economics (Tanner & Tanner, 1980).

Since 1917, agricultural education has changed its curriculum, focus, and mission. In the early days, agricultural education prepared pupils to enter the workforce by training for specific jobs. In recent decades agricultural education has been updating the curriculum to emphasize science and integrating academics with agricultural education. This paradigm shift is called “agriscience.” Agriscience instruction utilizes: (a) classroom teaching; (b) supervised agricultural experiences; (c) the intra-curricular student organization FFA; and (d) laboratory learning. Laboratory learning, the fourth component, serves as the basis for this research. This research study will focus on facilities and their adequacy for incorporating agriscience into the agricultural education curriculum.

The use of facilities enables the student to develop through cognitive, affective, and psychomotor learning. As far back as 1972, a researcher concluded that "…education has a great potential for helping the learner in his [or her] 'evolving' process by providing him [or her] with meaningful, sequentially organized movement activities" (Harrow, 1972 p. 7).

The "learning through doing" concept stems back to the three domains of learning which are cognitive, affective, and psychomotor. Crunkilton and Krebs (1982) stated:

> The principle of practice may at first glance seem to apply only to psychomotor or manipulative skills being taught to students. A reflective attitude on the part of the teacher will soon highlight the fact than [*sic*] this principle of learning applies equally well to the development of affective and cognitive learning. (p. 36)

Background of the Study

Legislative Influence

Legislation has pushed for the integration of academic subject matter into career and technical education curricula. Four pieces of legislation specifically advocating such integration were: (a) the 1990 Amendments to the Carl D. Perkins Vocational and Applied Technology Education Act; (b) the Goals 2000: Educate America Act of 1994; (c) the National Skills Standards Act of 1994; and (d) the School-to-Work Opportunities Act of 1994 (North Central Regional Educational Laboratory, n.d.).

The most influential legislation that corresponds with career and technical education was the 1990 Amendments to the Carl D. Perkins Vocational and Applied Technology Act. The purpose of this Act was to develop the academic, career, and technical skills of secondary students and post-secondary students who enroll in career and technical education programs (Academic Innovations, 2000).

The Carl D. Perkins legislation has undergone many revisions since its beginning in the 1980s. The start of this legislation was the Carl D. Perkins Vocational Education Act of 1984, which concentrated on improving career and technical programs, as well as serving students with special needs (American Vocational Association, 1998).

The Carl D. Perkins Vocational Education Act of 1984 was later reauthorized in 1990 as the Carl D. Perkins Vocational and Applied Technology Education Act. The 1990 Act increased the emphasis on the integration of academic and vocational proficiencies (Academic Innovations, 2000). The American Vocational Association (1998) noted that the 1990 Act allotted federal funding for "Tech Prep" and that ". . . both tech prep and the integration of vocational instruction were intended to position the Perkins Act as a tool for educational reform by linking vocational education more closely with academics…" (p. 8). The term Tech Prep means a program of study that:

1. is carried out under an articulation agreement between the participants in the consortium;
2. combines at a minimum two years of secondary education (as determined under State law) with a minimum of two years of postsecondary education in a nonduplicative, sequential course of study, with a common core of required proficiency in mathematics, science, reading, writing, communications, and technologies designed to lead to an associate's degree or a postsecondary certificate in a specific career field;
3. integrates academic, and vocational and technical instruction, and utilizes work-based and worksite learning where appropriate and available;
4. meets academic standards developed by the State;

5. provides technical preparation in a career field such as engineering technology, applied science, a mechanical, industrial, or practical art of trade, agriculture, health occupations, business, or applied economics;
6. links secondary schools and 2-year postsecondary institutions, and if possible and practicable, 4-year institutions of higher education through nonduplicative sequences of courses in career fields;
7. builds student competence in mathematics, science, reading, writing, communications, economics, and workplace skills through applied, contextual academics, and integrated instruction, in a coherent sequence of courses;
8. leads to an associate or baccalaureate degree or a postsecondary certificate in a specific career field; and
9. leads to placement in appropriate employment or to further education (Virginia Community College System, n.d.).

In 1998, a new Perkins Act was signed into law. The 1998 Carl D. Perkins Vocational and Technical Education Act identified development of rigorous academic standards and accountability as additional priorities (Academic Innovations, 2000). The most recent legislation continues the reform of integrating academics with career and technical instruction.

A second piece of legislation that called for integration of academics with career and technical education was the Goals 2000: Educate America Act of 1994. The third goal in the Educate America Act of 1994 stated in part that students would demonstrate competence in challenging subject matter including mathematics and science (Lankard, 1993). The Goals 2000: Educate America Act of 1994 called for states to coordinate school-to-work strategies, such as integration of academic and vocational education, with their school reform efforts (North Central Regional Educational Laboratory, n.d.).

A third piece of legislation that called for the integration of academics and career and technical education was the National Skills Standards Act of 1994 which established a National Skills Standards Board to adopt a ". . . national system of skill standards and of assessment and certification of attainment of skill standards" (United States Department of Education, n.d.). The attainment of skill standards can be used by schools as a ". . . framework to design curricula that integrate academic and vocational learning in occupational contexts" (North Central Regional Educational Laboratory, n.d.).

The fourth piece of legislation that has called for the integration of academics and career and technical education is the School-to-Work Opportunities Act of 1994. The School-to-Work Opportunities Act suggested that schools should implement:

1. Career awareness and career exploration and counseling (beginning at the earliest possible age, but not later than the 7th grade) in order to help students who may be interested to identify, and select or reconsider, their interests, goals, and career majors, including those options that may not be traditional for their gender, race, or ethnicity.

2. Initial selection by interested students of a career major not later than the beginning of the 11th grade.

3. A program of study designed to meet the same academic content standards the State has established for all students, including, where applicable, standards established under the Goals 2000: Educate America Act, and to meet the requirements necessary to prepare a student for postsecondary education and the requirements necessary for a student to earn a skill certificate.

4. A program of instruction and curriculum that integrates academic and vocational learning (including applied methodologies and team-teaching strategies), and incorporates instruction, to the extent practicable, in all aspects of an industry, appropriately tied to the career major of a participant.

5. Regularly scheduled evaluations involving ongoing consultation and problem solving with students and school dropouts to identify their academic strengths and weaknesses, academic progress, workplace knowledge, goals, and the need for additional learning opportunities to master core academic and vocational skills.

6. Procedures to facilitate the entry of students participating in a School-to-Work Opportunities program into additional training or postsecondary education programs, as well as to facilitate the transfer of the students between education and training programs. (North Central Regional Educational Laboratory, n.d.)

Agricultural Education Background

Today agricultural education has two major purposes. First, it provides knowledge and skills needed by many individuals to enter and advance in agricultural careers; and, second, it develops agricultural literacy (Lee, 2000). To achieve its purposes, agricultural education has four basic program components; supervised experiences, student development, classroom instruction, and laboratory instruction.

Supervised agricultural experience (SAE) in agricultural education is defined as work-based learning that promotes hands-on learning and career exploration. SAE provide real world applications of knowledge and aptitude. Student development, achieved through the FFA, provides leadership qualities. Classroom and laboratory instruction, according to Phipps and Osborne (1988)

> . . . provide unique and essential skill development opportunities. In the classroom, students are taught the principles, concepts, and theories pertinent to the agricultural specialty being studied. In the laboratory, students transform theory into supervised practice toward skilled proficiency. The linkage between classroom and laboratory teaching should be strong, clear, planned, and a purposeful one. Appropriate laboratory practice should be incorporated into every problem. (p. 411)

The use of problem solving is being emphasized in new curricula that incorporate academics into career and technical content. The integration of career and technical instruction and academics is the push for a new reform in education.

For years agricultural educators have struggled with issues related to the curriculum. The National Research Council (1988) noted that the agricultural curriculum has failed to keep up with modern agriculture. Shelhamer (1993) noted that "change is necessary, as agricultural educators strive to keep curriculum content current with technological innovations. When considering change, agricultural teachers may find that laboratory facilities, equipment, and tools are limiting curriculum change" (p. 21). This continues to be the case today.

To help overcome problems encountered by agricultural education programs, the National Council for Agricultural Education (2000) devised a strategic plan that called for all students to "have access to seamless, lifelong instruction in agriculture, food, fiber and natural resources systems through a wide variety of delivery methods and educational settings" (p. 3). From the strategic plan, the National Council for Agricultural Education developed the following objectives:

- Collaboration among educators and educational entities ensures students benefit from educational effectiveness and efficiency.
- All students in urban, suburban and rural schools have access to high-quality agricultural education programs.
- Students are prepared for successful careers in global agriculture, food, fiber and natural resources systems.

- Every agriculture student has opportunities for experiential learning and leadership development.
- Agricultural education instructional systems and materials provide for diverse learning styles.
- Student enrollments in agricultural education represent the diversity of the school-aged population. (p. 3)

The two objectives that are crucial to facilities in agricultural education are: (a) every student has opportunities for experiential learning and leadership development, and (b) agricultural education instructional systems and materials provide for diverse learning styles.

Phipps and Osborne (1988) defined laboratory instruction as generally occurring in a setting other than the classroom, but the laboratory is not restricted to indoor activities. Phipps and Osborne further stated:

> Effective laboratory instruction requires teacher demonstration and supervision of student practice. Laboratory instruction in vocational agriculture serves as the major setting where students develop psychomotor skills and apply principles learned through classroom instruction. Laboratory instruction is the essential link between classroom instruction and skill development. (p. 8)

Newcomb et al. (2004) explained the importance of laboratory instruction when they stated:

> When students are able to practice what they have learned, they have completed the teaching-learning cycle. Through their application students are better able to see the real meaning of theory. They have a concrete idea of relationships and better understand concepts which are interrelated. (p. 216)

Planning and equipping the teaching-learning facility has its drawbacks. While good programs are generally expensive, poor programs tend to cost nearly as much or more on a per student basis (National Research Council, 1988). "Students are too important to have anything less than a first-class facility. A facility does not make a program, but there cannot be much of a program without an appropriate facility" (Lee, 2000, p. 57).

Importance of Facilities

Facilities are the linking point from classroom instruction to problem solving and hands-on experience. Storm (1993) noted that:

> Instructors of academic subjects are concerned with establishing effective communication with their students. Occupational instructors, in addition to communicating effectively, need to provide learners with a smoothly functioning laboratory in which they can acquire and practice their new occupational skill. (p. 1).

Facilities must be operational with equipment and components that are highly correlated with the curriculum being implemented. Shelhamer (1993) reported that the laboratory experiences "must be modernized to reflect the new image for agricultural education, and that these activities must be effectively marketed to local communities" (p. 21). To help determine essential agriscience laboratory and classroom components, this study will utilize a Delphi panel.

Importance of Study

The findings of this study will be useful to state departments of education to provide guidelines or publications concerning facilities for implementation of agriscience courses. Secondary school personnel who assist with facility design, renovation, and updating may use the results from the research to alter local programs. Agricultural educators in universities offering agricultural education teacher preparation programs will also find this research useful. Universities can develop or update laboratory or facility management courses, update program planning courses, and curriculum design and implementation courses to include agriscience and agriscience facilities.

Legislation such as the Vocational Education Act of 1963 provided money for maintaining equipment, implementing new programs, and acquiring needed equipment. Cooper (1980) stated that the "Vocational Education Act of 1963 and federal legislation for special areas, such as that to relieve poverty in the Appalachian Mountain area, have done much to update facilities for vocational programs in agriculture" (p. 4).

The agricultural education curriculum is changing to be more science-based, thus facilities should change. Sledge and Bjoraker (1980) indicated the importance of educational objectives, and the basic curriculum will determine the need for buildings and facilities. The findings of this research will help school administrators, career and technical directors, and secondary educators provide essential facilities for implementing relevant agriscience curricula.

Problem Statement

Students need an understanding of basic scientific concepts (National Research Council, 1988; Shelly-Tolbert, Conroy, & Dailey, 2000). The understanding of basic scientific concepts has generated incorporation of academics into career and technical education and a change in the agricultural education curricula. The curriculum of production agriculture is changing to encompass scientific principles and concepts called agriscience (Buriak, 1989; Lee, 2000).

The curricula shift to integration of scientific principles into agriculture is forcing current agricultural education programs to alter the curricula. This change is forcing educators to use facilities that were developed for traditional agricultural education programs rather than scientific agriculture. This research study will make recommendations for 21st century agriscience facilities and equip facilities to enhance the teaching of the agriscience curriculum.

Change in the agricultural education curriculum naturally forces change in the nature of facilities (Colling & Farnsworth, 1969; Sledge & Bjoraker, 1980). However, providing adequate facilities to support science-based programs is difficult due to lack of equipment and funding (Thompson, 1998; Thompson & Balschweid, 1999). To be effective, the integration paradigm must include appropriate facilities for scientific agriculture.

Agricultural education researchers suggest that facilities and facilities components have not sufficiently changed to support the integrated agriscience curriculum (Lee, 1980; Terry, 1993). Research suggests that agriscience facilities should resemble a science laboratory (Newman & Johnson, 1993; Vernon & Briers, 1991). The major facility problem being encountered by agricultural education is that school personnel do not know what essential facility components are needed to support a functional agriscience program.

Definitions

Agriscience - Instruction in agriculture emphasizing the principles, concepts, and laws of science and their mathematical relationships, which support, describe, and explain agriculture (Buriak, 1989, p. 18).

Biological Applications in Agriculture – Agricultural education course offered in Virginia designed to integrate science and agriculture. Students explore the world of agriculture and the biological principles associated with it. Competencies emphasize and reinforce standards of learning for biology with agricultural applications (Virginia Department of Education, 2003).

Component - any part or ingredient of any instrument, machine, apparatus, or set of articles that meets the definition of equipment.

Classroom Component – Facilities, tools, equipment, and materials utilized by teachers and students for classroom activities.

Equipment - Any instrument, machine, apparatus, or set of articles that meets the following criteria: (a) retains its original shape, appearance, and character with use; (b) does not lose its identity through fabrication; (c) non-expendable; and (d) expected to serve its principal purpose for at least one year (Virginia Department of Education, July 2003).

Experiential Learning - Hands-on application of theory.

Facility - Educational space, including the classroom and laboratories, which allows for the teaching and application of theory.

Laboratory - Educational space utilized for experiential learning and application of theory. Examples include greenhouses, aquaculture systems, and outdoor laboratories.

Laboratory Component – Educational space, tools, and materials utilized by students for laboratory activities.

Laboratory Instruction - Organized teaching that occurs in laboratory settings, such as greenhouses, land laboratories, and agricultural mechanics laboratories (Phipps & Osborne, 1988, p. 409).

Supervised Agricultural Experience – Work-based learning that promotes hands-on learning and career exploration.

Theoretical Framework

The concept of experiential learning is the theoretical basis for this study. Dewey (1939) was a pioneer philosopher in the area of experiential learning who believed that it was the role of educators to arrange for practices that promote more favorable experiences.

Kolb (1984) suggested that the process of experiential learning can be described as a four-stage cycle involving four adaptive learning modes: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Powell and Wells (2002) summarized Kolb's four stage cycle when they said:

- Stage one (concrete experience) puts the learner in the position to approach a situation and relate it to previous life understanding using feelings more than logic;
- Stage two (reflective observation) allows the learner to scrutinize ideas and reflects on the information from different points of view;
- Stage three (abstract conceptualization) allows the learner to develop generalizations or theories to use in problem solving; and
- Stage four (active experimentation) allows the learner to diagnose the situation or problem and uses behavioral skills to take action.

Kuri (2000) related Kolb's four stage cycle to four teaching methods. Kuri's four teaching methods were:

1. **questioning**, which generates personal involvement and commitment to the immediate learning objective, and which also establishes the motivation to learn;
2. **didactics**, which facilitates the efficient transfer of knowledge, and requests consistent organization of the content and clear presentation of the information;
3. **coaching**, which frequently involves active experimentation and work with abstract concepts, helping the student to learn how to work alone;
4. **simulating**, which involves the active experimentation and the concrete experience placing the student in contact with a professional world so that they solve real, open, and complex problems (p. 5).

Dixon (cited by Stice, 1987) concluded that 20% of knowledge is retained if only abstract conceptualization is used. If both reflective observation and abstract conceptualization are used, retention is increased to 50% percent. If one uses concrete experiences plus reflective observation, and abstract conceptualization, retention rises to 70%. Ninety percent is retained if all four learning stages are employed.

Experiential learning is a major component of agricultural education. Terry (1993) emphasized the importance of facilities in agricultural education instructional programs. He noted that while each of the three areas is still important (SAE, FFA, class work); the classroom/laboratory is disproportionately emphasized. Terry further noted "while FFA and SAE are essential parts of a total educational experience, they are of lesser importance and are more an opportunity to apply what is learned in the classroom/laboratory rather than the focus of the entire program" (p. 9). The opportunity to apply what is learned in the laboratory must coincide with the curricula of the program.

Agricultural education facilities are highly correlated with curriculum. Miller (1993) stated "facilities in agricultural education have traditionally reflected the curriculum. As the curriculum expands, so do the demands placed upon agricultural education facilities. Both new and existing facilities must be designed to support a diversifying curriculum" (p. 4).

Facilities are crucial to psychomotor teaching methods and enable students the opportunity to apply skills. Educators provide coaching or laboratory instruction through the use of experiments, exercises, or applied projects. Such facilities also provide an environment to simulate real world applications. The North Carolina State Department of Public Instruction (1997) indicated that workforce development education labs are custom designed for specific classes or programs and "provide work environments in which practical applications of instruction and skills practice may be accomplished effectively and safely" (p. 7).

Purpose and Objectives of the Study

The purpose of this study was to ascertain essential components needed for a functional agriscience course taught in Virginia entitled Biological Applications in Agriculture. Specific objectives of the investigation were to:

- Determine the essential agriscience laboratory components needed to implement the Virginia course entitled Biological Applications in Agriculture.

- Determine the essential agriscience classroom components needed to implement the Virginia course entitled Biological Applications in Agriculture.

Assumptions

For the purpose of this study, it was necessary to make the following assumptions prior to beginning the study:

1. Curriculum dictates the composition of the agriscience facility.
2. Current agricultural education facilities are not appropriate for an agriscience curriculum.
3. Identifying the agriscience facility components needed for the course titled Biological Applications in Agriculture can be accomplished through the implementation of the Delphi technique.
4. The Delphi method is a valid method of obtaining consensus.
5. Career and technical administrators, secondary school administrators, and secondary agricultural educators are considered experts in the area of facilities.
6. Panel participants will provide valid, reliable, and unbiased information.

Limitations

The following limitations to the study were recognized:

1. Conclusions can only be inferred to Commonwealth of Virginia agricultural education facilities;
2. Conclusions can only be inferred to the course entitled Biological Applications in Agriculture.

Organization of the Study

Chapter 1 includes the introduction, a discussion of legislative influences, agricultural education background, importance of facilities, Delphi technique, importance of the study, purpose and objectives of the study, problem statement, definitions of terms, theoretical framework, assumptions of the study, limitations of the study, delimitations of the study, and organization of the study.

Chapter 2 provides a review of literature including integrating science with the agricultural education curriculum, barriers to integration, problems associated with facilities, guidelines for designing and evaluating facilities, and the Delphi technique.

Chapter 3 describes the methodology of the study. The chapter explains the design of the study, panel experts, the instrument, and methods and procedures used to collect and analyze the data for this study.

Chapter 4 reports the data and findings.

Chapter 5 presents the summary, discussions, conclusions, implications, and recommendations generated from the findings.

Summary

Agricultural education is changing its focus to incorporate more science in the curriculum. The integration of science, called agriscience, has forced school systems and educators to change their way of teaching and thinking. Teaching scientific principles through the use of agriculture will enable students to apply the scientific knowledge gained. A review of relevant literature indicates that experiential learning assists in student retention of knowledge.

Agricultural education has four parts as its focus: classroom, laboratory, supervised agricultural experience (SAE), and FFA. However, educators are changing and updating the agricultural education classrooms and facilities to implement new curricula.

Changing curriculum to incorporate scientific concepts is forcing educators to use facilities intended for traditional agricultural education programs and not of scientific agriculture. The research study will explain through the literature problems with 21^{st} century agriscience facilities, and help equip facilities that will enhance the teaching of a science-based curriculum in agriculture.

Chapter 2

REVIEW OF LITERATURE

The purpose of this study was to determine essential agriscience laboratory and classroom components needed to implement the Virginia course titled Biological Applications in Agriculture. Chapter 2 examines the literature as it relates to agriscience and agriscience facilities. The main topics included are curriculum changes and facilities, curriculum integration, barriers to integration, and problems with agricultural education facilities. Finally, the chapter includes an overview of the Delphi technique and the rationale for its use in this study.

Curriculum Changes and Facilities

Students need an understanding of basic scientific concepts (National Research Council, 1988; Shelly-Tolbert, Conroy, & Dailey, 2000). The understanding of basic scientific concepts has precipitated incorporation of academics into career and technical education and change in agricultural education curricula. The curriculum of production agriculture has changed to incorporate scientific principles and concepts called agriscience (Buriak, 1989; Lee, 2000).

Change in the agricultural education curriculum also must alter the nature of facilities (Colling & Farnsworth, 1969; Sledge & Bjoraker, 1980). Providing adequate facilities to support science-based programs is difficult due to lack of existing scientific equipment and inadequate funding for the latest science based-technology (Thompson, 1998; Thompson & Balschweid, 1999).

Researchers have suggested that agriscience facilities should resemble a science laboratory (Newman & Johnson, 1993; Vernon & Briers, 1991). Further, agricultural education researchers suggest that facilities and facilities components have not sufficiently changed to support the integrated agriscience curriculum (Lee, 1980; Terry, 1993).

Curriculum Integration

Integration

The integration of academics is becoming more and more prevalent in career and technical education. The integration of science is of particular interest to agriculture education. Roegge and Russell (1990) noted that the integration of science into agriculture curricula is a more effective way to teach science. Balschweid and Thompson (2002) also noted that "students taught by integrating agricultural and scientific principles demonstrated higher achievement than did students taught by traditional approaches" (p. 1).

Connors and Elliot (1995) conducted a study using seniors in four Michigan high schools and found that high school seniors who had agriscience and natural resource classes performed very well on the science achievement tests. The research indicated that the students who had agriscience and natural resources learned the same scientific concepts as those students enrolled in academic science courses. The researchers recommended that school boards examine the concept of offering science credit for agricultural education courses that implement a scientific focus. Mabie and Baker (1996) suggested that "since agriculture is by nature a hands-on discipline, it would seem to be a perfect match for integration into the science education curriculum" (p. 2).

Shift to Agriscience

The perfect match for integrating science into the agricultural education curricula has evolved the term agriscience. Sikinyi and Martin (2002) stated "the history of agricultural education has seen many changes both in quality and structure of programs. Some of the most recent changes have involved changes in the curriculum from the traditional curriculum area of production agriculture to a more technological and science related curriculum" (p. 8).

Peasley and Henderson (1992) conducted a study to investigate teacher utilization, attitudes, and knowledge toward an agriscience curriculum. The researchers surveyed 160 high school production agriculture teachers in the state of Ohio. The results showed a positive attitude toward an agriscience curriculum.

Shelley-Tolbert, Conroy, and Dailey (2000) conducted a qualitative study using interview methodology. Researchers interviewed two high school students, six undergraduate students enrolled in postsecondary agricultural education programs, three graduate students enrolled in agricultural education programs, one United States Department of Education representative, one United States Department of Agriculture representative, three college/university staff members, and four university faculty members. The research found that science-based agricultural education needs to retain experiential learning and leadership opportunities. The researchers noted, "The unique experiential learning and leadership components of agricultural education are viewed as being valuable enough to retain, regardless of any program focus" (p. 59).

The paradigm shift to agriscience does have a negative aspect. By integrating so much basic science, the agriculture curriculum may become a science course, which can negatively impact the learning of agricultural concepts. Vaughn (1993) stated that agricultural education must resist the temptation to integrate too much science and make sure the courses are agriscience rather than basic science. Vaughn further indicated that the only way to be sure the course is agriscience is by always “using laboratory instruction and supervised experience to make instruction in agriscience applied” (p. 4).

The literature describes the benefits of integrating science into the agricultural education curricula. If integrating science is beneficial, what are the barriers to implementing an agriscience program?

Barriers to Integration

Agricultural educators who have integrated science into the agricultural education curriculum have identified many barriers. The barriers include knowledge of content, equipment, and facilities. Newman and Johnson (1994) conducted research to identify and assess the in-service education needs of teachers who taught pilot agriscience courses in Mississippi and to determine their need for additional instruction materials. The study concluded that teachers are more competent in the traditional areas of animal science, plant science, soil science, supervised agricultural experience, and leadership development than in the areas of computers, biotechnology, mechanical technology, entomology, environmental science, and aquaculture. The researchers also concluded that the three most pressing needs of in-service education were in the areas of biotechnology, computers, and mechanical/physical technology. Deficiencies were also identified in the areas of entomology, environmental sciences, and application of the scientific method.

Lawver and Fraze (1992) stated that the biological sciences are not the only subject area where agriculture teachers are able to teach and reinforce scientific curriculum in agricultural education. There are also ways to provide instruction and reinforcement in the physical sciences such as the topic of aquaculture. Aquaculture is the art of cultivating aquatic species in channels or tanks and is an example of ways to provide instruction and reinforcement in the physical sciences.

Wigenbach, Gartin, and Lawrence (2000) conducted a study "to establish baseline data for all northeastern secondary agricultural education programs that incorporated aquaculture in the total curriculum during 1996-1997" (p. 2). One of the objectives of the study was to identify barriers associated with teaching aquaculture. Aquaculture is a component of agriscience in which experiences complement theory in science and math (Conroy & Walker, 2000). The investigation showed that respondents believed the potential barriers to implementing an aquaculture program were limited facilities to house the program, high cost of equipment to teach aquaculture, low teacher knowledge about aquaculture, and the high costs of remodeling facilities.

Conroy (1999) conducted a study in which 750 teachers were surveyed about aquaculture education and its implementation. Conroy found that persons teaching aquaculture and those who did not teach aquaculture rated the same three items as the most serious barriers: high cost of remodeling facilities for aquaculture, high cost of equipment to teach aquaculture, and limited facilities to house the program.

Thompson and Balschweid (1999) conducted a study using Oregon agricultural science and technology teachers employed during the 1997-1998 school year. They found that over 83% of the respondents agreed or strongly agreed that lack of appropriate equipment is a barrier to integrating science.

Thompson (1998) conducted a study to determine what impact integrating science has had on agricultural education programs. The population consisted of all state, regional, and national winners of the National FFA AgriScience Teacher of the Year Award program from the years of 1988-1995. Thompson found that teachers were undecided about the lack of appropriate equipment being a barrier to integrating science into the agricultural education program. Lack of appropriate equipment scored a mean of 3.99 on a five-point Likert scale where l=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree. The researchers defined "undecided" as a mean score of three to four. None of the items in the category of barriers to integrate science scored above a four, demonstrating that teachers are undecided about barriers to integration.

Balschweid and Thompson (2002) conducted a study to find what teachers identified as specific barriers to integrating scientific concepts into their programs. The three barriers receiving the highest scores on the Likert-type scale included: lack of appropriate equipment; a lack of adequate funding to support their integration efforts; and a lack of in-service workshops and courses for learning how to integrate science into their curriculum.

Literature findings have identified barriers to the integration of academics into the agricultural education curricula as financial, equipment, and facilities. Studies also indicate several other problems existing with agricultural education facilities.

Facilities

Literature related to facilities for agricultural education classrooms and laboratories can be divided into five categories. These major categories are: (a) facility problems; (b) facility needs; (c) designing facilities; (d) evaluating facilities; and (e) agriscience facilities.

Facility Problems

Facilities are used to implement the important hands-on element of teaching agricultural education. The purpose of this section is to identify problems with current agricultural education facilities.

A problem with agricultural education facilities that has been identified in the literature is the lack of equipment and supplies. Hamilton and Goecker (1973) conducted a research study in which 271 Indiana vocational agriculture teachers were asked what limits the laboratory use. The results indicated that 34% of the respondents stated equipment and 32.9% of the respondents stated supplies as factors that limit the use of the laboratory.

Kalme and Dyer (2000) conducted a study to determine principals' perceptions of secondary education programs in Iowa high schools with agricultural education programs. The researchers surveyed 147 principals in Iowa high schools. The study showed that principals were uncertain as to whether agricultural education facilities and equipment were up-to-date.

There is a poor perception of facilities because agricultural educators are sometimes criticized for "simply taking the students to the shop" (Schumacher, 1993 p. 11). Schumacher further noted that much structure is needed in laboratory instruction:

> Units must be planned well in advance, and classroom discussions must focus on the knowledge and competencies to be learned. Demonstrations must be planned and delivered to maximize student learning and retention. Laboratory instruction requires as much thought and planning as preparing for a classroom learning activity. (p. 12)

Literature has identified insufficient funding as a cause for not updating or improving agricultural education facilities. The Vocational Education Act of 1963 assisted with funding facilities for vocational agriculture programs that helped tremendously to update facilities for vocational programs in agriculture at that time (Carson, 1977; Cooper, 1980). Prior to the passage of the Vocational Education Act of 1963, facility planning was a simple matter, since agricultural education's main emphasis was preparing students for production agriculture (Carson, 1977).

Now that curricula have changed and technological advances are rapidly changing, it is imperative to update facilities that were equipped with monies provided from the Vocational Education Act of 1963. Shelhamer (1993) stated that "laboratory experiences must be modernized to reflect the new image for agricultural education, and that these activities must be effectively marketed to local communities" (p. 21).

Terry (1993) noted:

> Many facilities need only some "sprucing up" to help reform the image they project. An agriscience classroom should look more like the high school biology classroom than the vocational agriculture classroom of old. To take things a step further, science equipment could be obtained. If the vocational agriculture classroom did not have microscopes and other science lab equipment, the agriscience classroom should. (p. 10)

Mayer and McInervey (1984) stated that some of the concepts needed for agriscience competency areas, like microbiology, could be readily demonstrated using simple organisms such as E. coli with little expense and with equipment that is already available in secondary school laboratories.

The concern of aging facilities is not as limiting to a program as is the nature of facility itself (Lee, 1980). Lee further noted:

> Old facilities can be modern. New facilities can be out of date. The key is the instructional capability of the facilities. Some new facilities are not modern in terms of the kinds of competencies which can be taught. The reason some new facilities are not modern is that a modern instructional program was not planned before the facility was planned. (p. 3)

Shelhamer (1993) stated that change is necessary as agricultural educators strive to keep curriculum content current with technological innovations. "When considering change, agriculture teachers may find that laboratory facilities, equipment, and tools are limiting curriculum change" (p. 21).

The problems of facilities include equipment, funding, and perception. Determining the needs for facilities can help alleviate problems related to equipment. Determining facility needs is associated with the educational program objectives and needs of the students.

Facility Needs

Agricultural education relies on facilities to enhance instruction with similarities to problems encountered in the workplace. The purpose of this section is to explain the facility needs based on the literature.

Agricultural educators have the opportunity to provide instruction not only in the classroom, but in a variety of laboratories such as the agricultural mechanics laboratory, horticulture greenhouse, and land laboratories (Sledge, 1980). Kunsela and Noakes (1957) found that the quality of the agricultural course is dependent to a large extent on how well the school provides the facilities to make effective learning possible. Educators must plan curricula to meet the educational needs of the students.

The Arkansas State Department of Education (1990) conducted a survey in the Valley Springs School District. The researchers surveyed 85 students and found that each agricultural education department needed a laboratory to develop skills and competencies of students enrolled in agricultural education. The study also concluded that administrators and school boards must recognize the benefits of a school laboratory and the need for financial support.

The need for facilities must be based on the educational objectives and focus of the program. Colling and Farnsworth (1969) concluded that one of the most fundamental concerns in planning a facility is assuring that educational requirements dictate the nature of the facilities.

Sledge (1980) produced a formula that stated needs or educational objectives plus what is taught in the curriculum is equal to determining needs for buildings and facilities. Sledge and Bjoraker (1980) stated it is important to keep in mind that the educational objectives and the basic curriculum will determine the need for buildings and facilities. Sledge and Bjoraker further stated that educators cannot simply follow layouts that already exist. The planning of facilities must include an assessment of the program needs and conform to the local community.

Miller (1993) indicated that laboratories have common needs that must be satisfied. Those needs included:

- Reflecting the agricultural community served
- Serving the curriculum efficiently

- Facilitating effective and efficient use of teacher time
- Providing student and teacher safety
- Reflecting industry-current technology
- Providing security
- Arranging components efficiently (p. 4)

Meeting the educational needs of students through the use facilities relies on the design of a functional facility. Designing a facility with equipment and objectives in mind is a lengthy planning process.

Designing Facilities

Facility planning is important for several reasons. Colling and Farnsworth (1969) stated that learning can be divided into three distinct modes--reaction learning, interaction learning, and action learning. Action learning, which usually occurs in a laboratory instructional area, shows the individual student how to learn by doing. The purpose of facilities, classrooms, and other learning laboratories, according to Sledge (1980), is to provide a sound educational program in agriculture/agribusiness. Sledge further stated that modern buildings and support facilities should exist to help create a learning environment in which instructors function best.

Planning a facility that meets the educational requirements of today as well as meeting the educational requirements of the future is the challenge. Williams (1976) stated "facility and curriculum development represents a planning process, that, when properly developed, produces a curriculum and facility geared to meet the student's interest, needs, employment opportunities, and needs of the employer" (p. 3).

Bear (1976) indicated that a curriculum based on the needs of the community and region should be the first prerequisite for planning the facility. The capabilities of the staff are of secondary importance.

Williams (1976) indicated that foreseeing future needs or demands which will be placed on an educational facility is essential in designing a school. Williams further noted that considerations for future expansion should be considered so that expansion of the facility in the future can be accomplished at minimal cost. Colling and Farnsworth (1969) stated that facilities need to be sufficiently planned to permit needed modification and programmatic changes over the lifetime of the building. The North Carolina State Department of Public Instruction (1997) also noted that flexibility is an important concept in facility planning.

Planning a facility for the present and future is a difficult task. Carter (1976) indicated that three questions needed to be answered when planning facilities. The three questions are:

1. Who will be served and in what numbers?
2. What instructional program will be offered?
3. What are the space needs?

Bruce (1980) reported that having an adequate facility available is an important and necessary component if a quality teaching environment is to be provided. Bruce further indicated that all programs need a classroom large enough to accommodate the number of students enrolled and a laboratory designed to support the curriculum. "It would also be helpful for students to have access to farms, agricultural businesses, horticultural facilities, and other things where they may have opportunities for supervised practice" (p. 18). The

North Carolina State Department of Public Instruction (1997) indicated that facilities are "custom designed for specific classes or programs and provide work environments in which practical applications of instruction and skills practice may be accomplished effectively and safely" (p. 7).

Kunsela and Noakes (1957) stated that the content of the agricultural curriculum is based on a functional analysis of problems. The design of building facilities needs to make provision for the psychomotor domain so educational tasks can be accomplished efficiently and effectively.

Designing facilities is one part of the equation to enable learners to reach their full potential of applying theory in real world applications. Evaluating school facilities is the rest of the equation to ensure functional learning environments are provided to students.

Evaluating Facilities

The Missouri State Department of Elementary and Secondary Education (1984) indicated that due to the time and energy required to replace or expand buildings and equipment, it is important that present needs are met, and that provision is made for future expansion. The time and energy required to replace buildings can be less strenuous if evaluation of the facility is consistently practiced.

Evaluating the needs for buildings and facilities must be a continuous process (Sledge, 1980). Sledge further noted that educational buildings and facilities need to address several factors:

- Adequacy of existing facilities;

- Relationship of current buildings and facilities to the nature of the curriculum and the educational objectives being implemented for students;
- Environmental aspects of present facilities, including modernization of lighting, safety features, accessibility to handicapped students, and energy saving features; and
- Changing nature of students served and the educational delivery system established or planned by the vocational agriculture instructors. (p. 1)

Agriscience Facilities

The need to ensure that facilities are evaluated and altered to meet the demands of the curriculum was seen prior to the shift to agriscience. The South Carolina State Department of Education (1968) noted that expanding programs of agricultural education had placed increasing demands on existing facilities. Even in 1968, the South Carolina State Department of Education concluded that facility requirements of the new curricula could not be met by the existing facilities designed for the production agriculture curriculum. The South Carolina Department of Education further noted that the equipment and supplies needed for the newer curricula were also quite different.

Research indicates that established facilities and facility components are not adequate for newer curricula offerings in agricultural education. The Missouri State Department of Elementary and Secondary Education (1984) suggested that "schools with established departments find that new developments in farming, especially in mechanization, the use of power, adult education, agricultural business, and the resulting changes in instructional needs make it necessary to replace or extensively improve their facilities" (p. 5).

Lee (1980) reported that traditional agricultural facilities have included classrooms and shops and that agricultural education must move away from the so-called traditional facility and start moving toward educational laboratories and classrooms. "The day when all that is needed in vo-ag facilities is a shop and classroom has passed" (p. 3).

Traditional facilities and activities have included woodworking, painting, tool conditioning, cold metal work, pipe work, soldering, sheet metal work, arc and acetylene welding, plumbing, concrete, and masonry work, electrification, hot metal work, small engine maintenance and repair, and project repair or construction (Florida State Department of Education, 1968). The current agriscience activities include understanding: cell structure and functions, basic plant structures and basic functions, and basic hydroponics plant production (Lee, 2000).

Newman and Johnson (1993) indicated that the move to more science-based instruction in agriculture required the development of different types of facilities. The move to more science-based instruction, according to Newman and Johnson, changes the old agricultural education facility to resemble chemistry, biology, or physics laboratories. Newman and Johnson suggested that agriscience programs require the use of microscopes, test tubes, Bunsen burners, aquaria, light stations, incubators, and other equipment not considered when the facilities were constructed.

Vernon and Briers (1991) stated that today's agriscience laboratories should be designed and used in a manner more parallel with science. Vernon and Briers further noted that agriscience facilities should be developed to look like the type of lab that has test tubes, microscopes, and chemical reagents.

Miller (1993) iterated that agricultural education facilities were once geared for production agriculture. Miller also stated that facilities need to accommodate curriculum changes and laboratory facilities such as:

- Technologically current science-based mechanics laboratories;
- Animal science-land/livestock laboratories;
- Landscape and turf laboratories;
- Greenhouse and horticultural production laboratories;
- Biotechnology laboratories;
- Aquaculture laboratories;
- Food science laboratories;
- Computer/agribusiness/CAD laboratories; and
- Production agriculture laboratories (p. 4).

Some researchers have suggested that agricultural education programs are not renovating facilities to meet the needs of the agriscience curriculum. Gliem (1991) reported "many programs that I have seen have simply changed their name and are going about business as usual while at the same time hyping the teaching of agriscience" (p. 11).

Terry (1993) stated the "temple of the agriscience program is its facilities. The appearance of facilities provides information that helps to form perceptions about what you teach and how you teach" (p. 10). Terry further noted "unfortunately I must say that most facilities I have seen do not look like agriSCIENCE classrooms. If science is being taught, it is hidden very well. However, in most cases, it would not take too much effort to improve the situation" (p. 10).

Improving the situation of the agriscience program is the purpose of this study. To determine the essential components needed to implement the course entitled Biological Applications in Agriculture, the Delphi methodology will be utilized.

Delphi Technique

Norman Dalkey and Olaf Helmer (1963) developed the basic notion, theoretical assumptions, and methodological procedures of the Delphi method of inquiry in the 1950s and 1960s at the RAND Corporation. The goal of the Delphi method is to obtain the most reliable consensus of opinion of a group of experts by using a series of questionnaires combined with opinion feedback (Dalkey & Helmer, 1962).

Andranovich (1995) stated that the Delphi technique was designed for non-interacting groups. Non-interacting groups can include members who are geographically distant, groups whose members tend to clash, or groups in which status differences might affect decision making.

Linstone and Turoff (1975) listed situations in which it would be best to use the Delphi technique. These situations are:

- The problem does not lend itself to precise analytical techniques but can benefit from subjective judgments on a collective basis.
- The individuals needed to contribute to the examination of a broad or complex problem have no history of adequate communication and may represent diverse backgrounds with respect to experience or expertise.

- More individuals are needed than can effectively interact in a face-to-face exchange.
- Time and cost make frequent group meetings unfeasible.
- The efficiency of face-to-face meeting can be increased by a supplemental group communication process.
- Disagreements among individuals are so severe or politically unpalatable that the communication process must be refereed and/or anonymity assured.
- The heterogeneity for the participants must be preserved to assure validity of the results, i.e. avoidance of domination by quantity or by strength of personality ("bandwagon effect"). (p. 4)

Martin and Frick (1998) summarized Harold Sackman's characteristics of the Delphi technique. They listed the following characteristics:

- The data collection is via a structured, formal questionnaire administered to a group of individuals identified as appropriate subject matter specialists. There is no definitive questionnaire kind or format.
- The Delphi director or the participants may generate the questionnaire items. In some cases, it may be a cooperative effort.
- The participants receive specific instructions to ensure proper completion of the questionnaire.
- The questionnaires following the first one include statistical feedback from the previous round.
- The statistics are typically a measure of central tendency and one of variability.

- The Delphi director may solicit verbal feedback from some or all of the participants and publish that information on subsequent rounds.
- Individual responses are kept anonymous during all administrations of the questionnaire.
- The Delphi director generally requires written justification for extreme responses.
- The cycle of iteration and feedback continues until the Delphi director determines that a sufficient convergence of opinion is reached. (p. 1)

Strengths of the Delphi Technique

As with any research methodology, there are strengths and weaknesses to the Delphi technique. The literature has identified the following strengths of this methodology. The first strength is anonymity of the individual responses, which is the heart of the procedure (Andranovich, 1995). The Delphi technique is used to bring participants together without physical confrontation. It reduces the effect of dominating individuals and allows the group to share responsibility. Shared responsibility also promotes satisfaction through participation in and ownership of the resulting decision (Andranovich, 1995).

The second strength of the Delphi technique is the controlled feedback through several rounds of the procedure. "Several rounds reduce direct confrontation and the disadvantages that conflict leads to quickly accepting or dismissing other opinions, focusing on personalities rather than the issue at hand, or closing off discussion of novel or different ideas are recognized as serious problems for interacting groups" (Andranovich, 1995, p. 2).

A third strength of the technique is the use of statistics. Statistics ensure each person's response or opinion is reflected in the final response. The capability of each respondent to provide information contributes to the shared responsibility for not only the outcome of the Delphi study but also in the process that eventually provides the outcome (Andranovich, 1995).

Limitations of the Delphi Technique

The limitations of the Delphi technique include regression to the mean, time commitment, and the need to have written and oral communication skills. It is common for respondents to change their answers to become more similar to the group mean if too many rounds are conducted. After three questionnaires are administered, the only significant change that occurs in the responses is that they begin to cluster closer to the mean (Stone Fish & Busby, 1996).

Another limitation to the methodology is time commitment. Andranovich (1995) stated the Delphi is labor intensive and time consuming. Stone Fish and Busby (1996) stated that if the respondents take the time to carefully think about their answers, several hours can be spent to complete the questionnaires.

A third limitation of the Delphi is that participants need to have writing skills and must be highly motivated. Andranovich (1995) stated that the Delphi is grounded in written communication; it is critical that all group members can read and write.

Panel Characteristics

The panel for a Delphi study is comprised of "experts" who are sought for their expertise or knowledge. Helmer and Rescher (1959) stated:

> We resort to an "expert" precisely because we expect his [her] information and the body of experience at his [her] disposal to constitute an assurance that he [she] will be able to select the needed items of background information, determine the character and extent of their relevance, and apply these insights to the formulation of the required personal probability judgments. (p. 43)

One of the most significant considerations when implementing a Delphi study is selecting the panel of experts (Stone Fish & Busby, 1996). The selection of the panel cannot be one of preference or convenience, it must follow specific criteria. Ziglio (1996) stated the criteria may vary from one application to another, depending on the aims and context within which the Delphi process is carried out.

Delbecq, Van de Ven, and Gustfason (1986) stated "in most Delphi situations, three different groups of people will carry out the process: (a) the top management decision makers who will utilize the outcomes of the Delphi study; (b) the professional staff member together with his support team; and (c) the respondents to the Delphi questionnaire whose judgments are being sought." (p. 85).

Scheele (1975) noted that three kinds of panelists are needed for creating a successful panel: "stakeholders, those who are or will be directly affected; experts, those who have an applicable specialty or relevant experience; and facilitators, those who have skills in clarifying, organizing, synthesizing, stimulating. . . plus, when it seems appropriate, individuals who can supply alternative global views of the culture and society" (p. 68).

Delbecq et al (1986) stated the respondent panel should:

1. feel personally involved in the problem of concern to the decision makers;
2. have pertinent information to share;
3. be motivated to include the Delphi task in their schedule of completing tasks; and
4. feel the aggregation of judgments of a respondent panel will include information which they too value and to which they would not otherwise have access. (pp. 87-88)

Panel Size

Panel size is of crucial importance. The size of the respondent panel is variable (Delbecq et al., 1986). Delbecq et al. (1986) further stated "with a homogeneous group of people, ten to fifteen participants might be enough. Our experience indicates that few new ideas are generated within a homogeneous group once the size exceeds thirty well-chosen participants" (p. 89).

Fitch et al. (2001) stated the earliest RAND panels were composed of nine members. "There is nothing magical about this number, though, and other studies have used panels ranging from seven to 15 members" (p. 24).

Turoff (1975) reported that "given a small committee of around ten individuals with sufficient time to consider and explore the issues, and some assurance that the privacy of their respective remarks will be respected outside the committee room, it is doubtful that any of the above issues would greatly inhibit the process"(p. 86).

Research Using Delphi

Frick (1993) conducted a study to develop a document that could provide agricultural educators with the subjects and topics that constitute the core curriculum for a middle school agricultural education program. Using the Delphi procedure, the researcher selected the following criteria for the panel. A panel member must have possessed an interest in middle school agricultural education; had the time to devote to the study; and was a middle school agricultural education teacher.

Johnson and Schumacher (1989) conducted a study to determine the laboratory management competencies needed by secondary agriculture instructors. The study was conducted using the Delphi technique. The researchers identified the "experts" as all postsecondary, college, and university agricultural mechanics specialists serving on the National FFA Agricultural Mechanics Contest Committee during the 1986-87 school year. The respondents had to list 25 agricultural mechanics laboratory management competencies that they felt were most important.

Chizari and Taylor (1991) conducted a study to determine the critical educational needs, major obstacles, and support needed in the planning and delivery of adult education programs in agricultural production in the southern region of the United States. The study involved the use of Delphi. Panel selection was based on state supervisors of agricultural education from 13 southern states nominating five secondary agriculture teachers from their respective state who had outstanding adult/young farmer education programs in agricultural production. Sixty-five nominees were identified and recommended for the panel. The researchers concluded that the most critical educational needs in agricultural production included farm management and use of the latest farming technology. The researchers further noted that insufficient time is the major obstacle in conducting adult education programs.

Summary

A review of relevant literature indicates that integration of academics into agricultural education improves achievement test scores. However, barriers such as equipment, funding, and educator knowledge have been identified as barriers to integration. Agricultural education has changed its curriculum to integrate academic concepts called agriscience. Agriscience uses classrooms and facilities to achieve the objectives of the course. Agriscience facilities must meet the educational objectives of the course. Several agricultural education professors stated that agriscience facilities should resemble a science lab. However, educators must design and evaluate facilities to keep up with technological change. Researchers suggested that essential facilities and facility components for teaching agriscience are not in place.

Chapter 3

METHODOLOGY

Chapter 3 examines the procedures of collecting and analyzing data for the study. Anderson (1998) stated there are four general approaches to data collection: (a) non-personal interaction with a subject who provides data, (b) personal interaction with a subject who provides data, (c) observation of a setting, and (d) examination of documents and artifacts (p. 164).

Chapter 3 describes the methods used to obtain opinion consensus concerning essential components necessary to implement the course entitled Biological Applications in Agriculture. To describe the methods of the research, this chapter includes the problem statement, purpose and objectives of the study, criteria for serving on the expert panel, definition of a panel expert, panel size, panel selection, the data collection process, and statistical techniques used to analyze the data.

Problem Statement

Students need an understanding of basic scientific concepts (National Research Council, 1988; Shelly-Tolbert, Conroy, & Dailey, 2000). The instructional emphasis of basic scientific concepts has brought forth incorporation of academics into career and technical education and a change in the agricultural education curricula. The production agriculture curriculum has changed to incorporate scientific principles and concepts called agriscience (Buriak, 1989; Lee, 2000).

Societal emphasis on integrating science into the secondary school curricula has challenged schools that offer agricultural education programs to alter and upgrade their curricula. Changing curricula to incorporate scientific concepts has forced educators to use facilities that were developed with the intent of teaching technical production agriculture with little emphasis on the scientific concepts. This research study will help to identify problems encountered with agriscience facilities and help plan, design, and equip facilities that will enhance the teaching of agriscience in the course entitled Biological Applications in Agriculture.

Change in the agricultural education curriculum also must alter the nature of facilities (Colling & Farnsworth, 1969; Sledge & Bjoraker, 1980). Providing adequate facilities to support science-based programs is difficult due to lack of equipment and funding (Thompson, 1998; Thompson & Balschweid, 1999).

Agricultural education researchers suggest that facilities and facility components have not sufficiently changed to support the integrated agriscience curriculum (Lee, 1980; Terry, 1993). Research suggests that agriscience facilities should resemble a science laboratory (Newman & Johnson, 1993; Vernon & Briers, 1991). The major facility problem being encountered by agricultural education programs is that school personnel do not know the essential facility components needed to support a functional agriscience program. Therefore the problem being investigated by this study is to determine essential laboratory components needed to implement the Virginia course entitled Biological Applications in Agriculture.

Delphi Technique

The Delphi technique has become a widely used tool in a variety of disciplines for measuring, aiding forecasting, and decision making (Rowe & Wright, 1999). The Delphi research procedure was developed by the RAND Corporation after World War II. According to Duboff and Spaeth (2000), the Delphi technique is based on the premise that "many types of minds are better than fewer and that an iterative process is one of the best ways to figure out what might happen in the future" (p. 40). Linstone and Turoff (1975) characterized the Delphi technique as a method for "structuring a group communication process so that the process is effective in allowing a group as a whole to deal with a complex problem" (p. 3).

The Delphi technique lends itself to this study because it helps arrive at consensus on the essential facilities needed for implementing an agriscience program of agricultural education. Wilhelm (2001) stated:

> Many social problems are not amendable to solution by pure positivistic or scientific methods. Where there is insufficient data on the problem under investigation and incomplete theory on both its cause and effects, there are two options. The first is to wait until an adequate theory emerges based on scientific knowledge, enabling the problem to be addressed. The second is to make the most out of an unsatisfactorily situation and try to obtain the relevant intuitive insight of experts and to use informed judgment as systematically as possible. (p. 6)

Use of the Delphi technique or structured group communication is accomplished by providing "some feedback of individual contributions of information and knowledge; some assessment of the group judgment or view; some opportunity for individuals to revise views; and some degree of anonymity for the individual responses" (Linstone & Turoff, 1975, p. 4).

The modified Delphi technique used in this study provided the expert panel with a partial listing of equipment and components derived from equipment lists from the states of Georgia, North Carolina, and New York. These states have courses that are comparable to the Virginia course entitled Biological Applications in Agriculture.

Purpose and Objectives of the Study

The purpose of this study was to ascertain essential components needed for a functional agriscience course taught in Virginia entitled Biological Applications in Agriculture. Specific objectives of the investigation were to:

- Determine the essential agriscience laboratory components needed to implement the Virginia course entitled Biological Applications in Agriculture.
- Determine the essential agriscience classroom components needed to implement the Virginia course entitled Biological Applications in Agriculture.

Design of the Study

Identifying essential components of a functional agriscience facility was achieved using a modified Delphi methodology. Delphi methodology was chosen over other data collection methods such as survey, interviews, and observation. The researcher chose Delphi because the research questions being addressed are subjective judgments, which according to Linstone and Turoff (1975) lend itself to this technique. The researcher chose not use survey research due to a lack of baseline data to determine the essential equipment and components needed to implement the course. Interview and observation were not chosen because these types of research methods have higher costs associated for travel.

The Delphi panel consisted of 24 individuals selected based on their expertise with agriscience and the Virginia course entitled Biological Applications in Agriculture. The respondents were asked to complete a series of questionnaires spread over two rounds. The Round I questionnaire sought to obtain opinions of essential components for an agriscience laboratory and classroom utilized in teaching the course Biological

Applications in Agriculture. The Round II instrument sought to obtain consensus on the items identified by the panel. The researcher used Microsoft Excel to analyze the data.

Required procedures for using human subjects in research were followed. A request for exemption of research involving human subjects was completed and approved by a departmental reviewer and chair of the Virginia Tech Institutional Review Board (Appendix A).

Panel of Experts

The Delphi technique uses a panel of experts to participate as the respondents. Delbecq, Van de Ven, and Gustafson (1986) defined respondents as those “people whose judgments are being sought, and who agree to answer the questionnaires” (p. 86).

Ziglio (1996) indicated that appropriate experts are not based on a statistical process, but rather are selected based on explicit criteria. Ziglio defined the explicit criteria as four components: knowledge, willingness of the individual to explore the problem, dedication of time to the project, and skill in written communication.

The panel of experts for this investigation was defined as individuals who met the following criteria:

- knowledgeable in the area of agriscience and facilities associated with the course entitled Biological Applications in Agriculture;
- willing to accept change and provide an in-depth analysis of the questions;
- willing to complete the study and provide the same energy and thought in each round; and
- able to communicate through email and have skills in written communication.

For the purpose of this study, 100% of the population was used. The population consisted of Virginia career and technical administrators of local education agencies, building-level administrators of local secondary education agencies, public secondary school agricultural educators, and business and industry leaders from the local school communities.

Panel Size

The panel of experts was comprised of individuals from Virginia secondary schools that have offered or are currently offering the course entitled Biological Applications in Agriculture. Five school systems reported that they were implementing the course Biological Applications in Agriculture. Two school systems reported teaching a collaborative agricultural science course not titled Biological Applications in Agriculture. The collaborative teaching was accomplished through the efforts of an agricultural education instructor and a science instructor. According to Delbecq et al. (1986), panel size is variable. Delbecq et al. further indicated that few new ideas are generated once the size of the panel exceeds 30 respondents.

The panel for this investigation was comprised of 24 individuals representing four constituency groups. The groups were categorized as career and technical administrators, secondary agricultural educators, local secondary school administrators, and business and industry leaders. The category of career and technical administrators was comprised of individuals who were secondary career and technical directors in the participating school districts. The category of secondary agricultural educators consisted of experts who were implementing or have implemented the curriculum entitled Biological Applications in

Agriculture in the secondary school system. The administrators' category consisted of individuals who were secondary school principals in local school agencies implementing the course entitled Biological Applications in Agriculture. The fourth category of business and industry leaders was defined as individuals associated with advisory committees, architects, or individuals serving agricultural education from the industry perspective.

Selection of Panel of Experts

The panel size of 24 participants ensured a purposefully selected group of agricultural educators, administrators, and industry leaders for this study. The group dynamics included seven agricultural educators, six administrators, five career and technical administrators, and six industry leaders. One of the agricultural educators that had previously implemented the Biological Applications course changed to a school district not currently offering the course. Also, a career and technical administrator had a dual role of building-level principal. Therefore, that individual is only counted once as a participant.

An email was sent to the Agricultural Education Specialist of the Virginia Department of Education requesting nominations of individuals and schools that have implemented the curriculum entitled Biological Applications in Agriculture. The nominations were then sent back to the researcher. An email was also sent to the Virginia Association of Agricultural Educators listserv requesting information from teachers who are teaching the course or a course that integrates biology with agriculture. The researcher compiled the email responses in a database.

After compiling all email messages and the response from the Department of Education, a list of nominees was created. The list of nominees was verified by the two Virginia curriculum specialists, a teacher educator from Virginia Polytechnic Institute and State University, and the state specialist for Agricultural Education. Curriculum Specialists are research associates in the Department of Agricultural and Extension Education that work closely with Virginia school systems providing curriculum updates, creation of new curriculum, and assistance with implementation of new curriculum.

An email was sent to all prospective panel experts to inform them of their nomination. The researcher asked the following three questions to determine if each nominee is by definition an expert:

1. Do you consider yourself to be knowledgeable of the course entitled Biological Applications in Agriculture and the facilities needed to implement this course?
2. If selected, will you participate in this investigation?
3. If selected, will you donate the time needed to complete the study?

If the nominee answered yes to all of the questions, they were accepted as an expert in the area of facilities needed to implement the course entitled Biological Applications in Agriculture. A phone call was made to each panel member to acknowledge their membership on the expert panel.

Instrument and Data Collection

The instrument used for the investigation was developed based on panel responses to the Delphi question from round one of the study. The Delphi question was the fundamental component of the process. Delbecq et al. (1986) reported that if the respondents do not understand the initial question, they may answer incorrectly or become frustrated resulting in a loss of interest.

The modified Delphi questionnaire was developed by creating an instrument with a list of course competencies and preliminary list of equipment and components created by the researcher (Appendix B). Specifically, the questionnaire was developed from equipment lists from the state of Georgia, North Carolina and New York. The modified Delphi question was pilot tested by graduate students and faculty members from Virginia Tech for clarity and accuracy. Graduate students and faculty completed the questionnaire and provided written feedback suggesting alterations to the instrument.

First Round

The data collection process and all correspondence with the participants were through the use of email. The panel experts were sent a cover letter and a copy of the Delphi question (Appendix D). Panel experts were asked to return the instrument electronically within one week. For non-respondents, a follow up letter was sent to the individuals reminding them to complete and return the instrument. Panel experts who did not send back the instrument after the follow-up email were telephoned as a reminder to return the instrument. There was no reason to code the instrument as each response was emailed back and could be identified by the return email address. Anonymity of each participant was protected and assured in the cover letter.

The responses were categorized and redundant responses were deleted. Respondents were contacted by email for clarification of a statement or further explanation if needed. Once the generated list of items was completed, the participants received the generated list. The cover letter contained directions for the second part of the study (Appendix E).

Second Round

The second round of the Delphi method asked each panel expert to rate their agreement or disagreement with the items generated during the first round of the study. A pilot test using graduate students and faculty members was used to check for clarity and accuracy of the instrument. The graduate students and faculty members completed the questionnaire and provided written feedback suggesting alterations to the instrument.

A cover letter and a copy of the instrument were sent to the participants for completion (Appendix E). The respondents rated the list of items using a Likert Scale containing five options: (a) Strongly Disagree; (b) Disagree; (c) Neither Agree /Nor Disagree; (d) Agree; and (e) Strongly Agree. The researcher used Neither Agree/Nor Disagree to encourage the participant to answer the items for which the participant had no rating. The term "Not Sure" was not used in the instrument purposefully to help clarify the response. "Not Sure" could have been interpreted as not knowing the answer or having no opinion. The panel of experts returned the completed instrument within one week. A follow-up was sent to non-respondents, as a reminder to complete the instrument. Panel experts who did not send back the instrument after the follow-up in two days were telephoned as a reminder to return the instrument. Panel experts who did not respond to the follow-up email and telephone call were removed from the panel. The final sample size for the panel of experts was 18.

The data were collected and analyzed. Items were grouped into two categories, agreement and disagreement. Once the analysis was completed, the participants were sent a cover letter and the analysis of the results.

Analysis of Data

The data analysis procedure for this Delphi investigation utilized measures of central tendency. Means and standard deviations were used to categorize and analyze the data.

The panel experts rated each essential classroom and laboratory component needed to implement the curriculum Biological Applications in Agriculture using a Likert Scale. The Likert-Scale items ranged from "Strongly Disagree" to "Strongly Agree." Responses were coded and entered in a database as follows: Strongly Disagree (SD) = 1, Disagree (D) = 2, Neither Agree/Nor Disagree (NA/ND) = 3, Agree (A) = 4, and Strongly Agree (SA) = 5.

Research has shown that item consensus for Delphi studies can be achieved using means, standard deviations, or panel member agreement (Murphy & Terry, 1998; Frick, 1993). For the purpose of this study, item consensus was defined with 50% of the panel members being in agreement. Items were accepted or rejected based on the following criteria:

1. A priori decision was made to keep all statements that reached consensus by one half of the panel with a score of 4, or 5. (Agree or Strongly Agree);

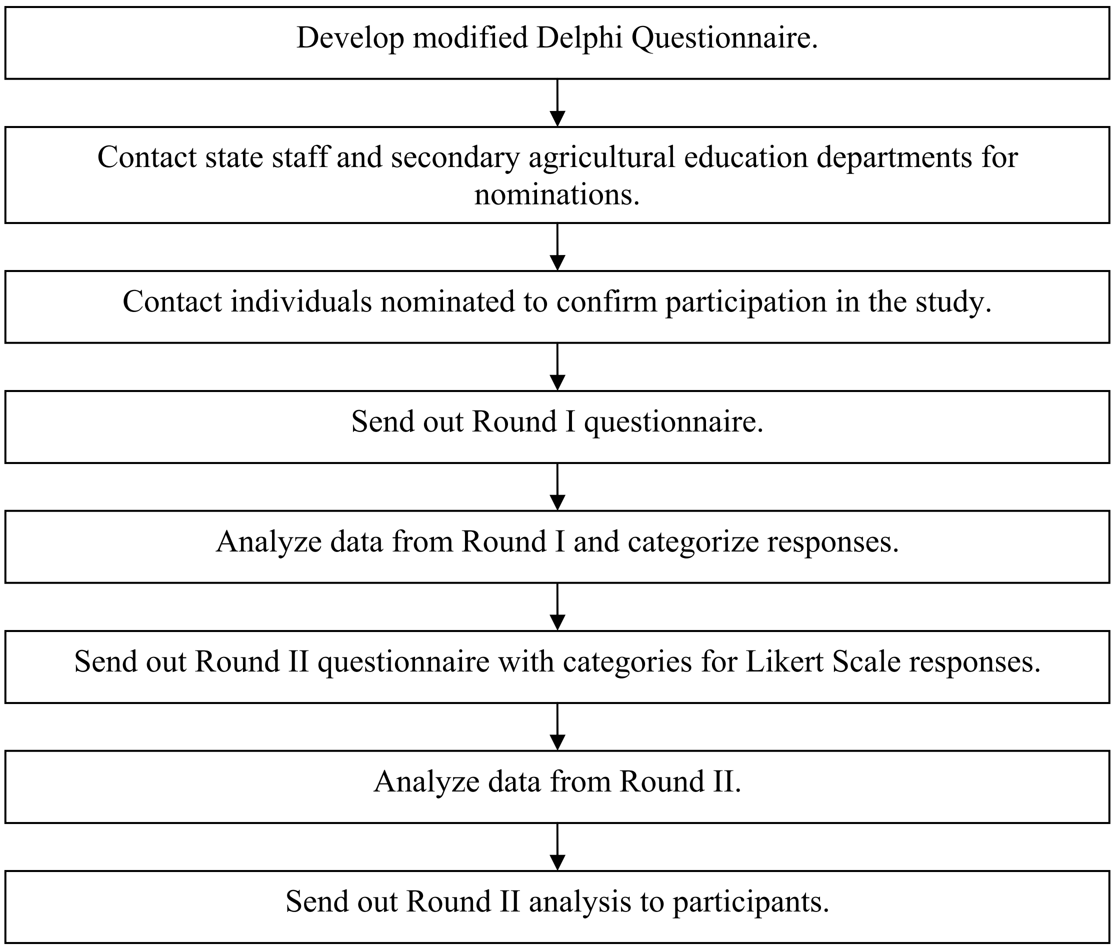
2. A priori decision was made to discard all statements that established consensus by one half of the panel with a score of 1, 2, or 3. (Neither Agree/Nor Disagree, Strongly Disagree or Disagree).

Summary

The Delphi methodology for this investigation contained two rounds. Prior to starting the rounds, identifying the expert panel was of utmost importance. Experts were nominated by state staff and university faculty from the Commonwealth of Virginia.

The Delphi technique is widely used for forecasting and can vary in rounds and methodology. Figure 1 represents the steps used for this investigation.

Figure 1. Schematic of the Delphi Process



Chapter 4

FINDINGS

The purpose of this study was to determine essential agriscience laboratory and classroom components needed to implement the Virginia course entitled Biological Applications in Agriculture. Chapter 4 examines the findings as it relates to the purpose and objectives of the study. The main topics included are purpose and objectives, background information to the study, instrument information for Round I, results from the Round I instrument, instrument information for Round II, , and results from Round II instrument.

Purpose and Objectives

The purpose of this study was to ascertain essential components needed for a functional agriscience course taught in Virginia entitled Biological Applications in Agriculture. Specific objectives of the investigation were to:

- Determine the essential agriscience laboratory components needed to implement the Virginia course entitled Biological Applications in Agriculture.
- Determine the essential agriscience classroom components needed to implement the Virginia course entitled Biological Applications in Agriculture.

Background Information

The original panel experts consisted of 24 participants who agreed to serve. Eighteen of the 24 members responded to Round I of the study. Six panelists who did not return the first instrument were dropped from the study. All 18 panel experts who returned instruments were complete and deemed valid for Round I of the study. For Round II of the study, out of the remaining 18 panelists, 17 instruments were returned and deemed valid. In the 17 remaining participants, the composition of the expert panel included agricultural educators, career and technical education directors, and local building level administrators. A follow-up email and phone call was sent or made to the non-respondent for Round II. Round I response rate was 75% and the Round II response rate was 94%.

Instrument Information for Round I

The objective of the Round I instrument was to further develop a list of laboratory and classroom equipment and components essential to implement the course entitled Biological Applications in Agriculture. The instrument for Round I was developed from a list of equipment and components used to teach similar courses from the states of Georgia, North Carolina, and New York. The developed list consisted of 49 pieces of equipment and component items needed to implement the course. Figure 2 illustrates the preliminary list that was developed for the instrument. The list was e-mailed to the panel experts on April 25, 2004 with a due date of April 30, 2004. The instrument was constructed with an abbreviated list of the competencies addressed in the course and the preliminary list of equipment and components (Appendix D).

Figure 2. Original Equipment and Components List

Equipment and Component List	
3 gallon hand sprayer	Microscopes, electric
Aquaculture pumps	Misting system (6 mist nozzles complete with pipe, risers, timers)
Aquaculture tanks	Nitrate test kits
Aquariums	Petri dishes
Atom models	pH meters
Beakers	pH test kits
Biofilter	Pipette pumps
Calculators	Pipettes
Camcorders	Power sprayer (cart with hose and sprayer gun)
Computers	Printers
Digital cameras	Refrigerator
Flasks	Root growth chamber
Graduated cylinders	Scales or balances
Greenhouse (with ventilation system, evaporative cooling system, heating system and humidifier)	Scalpels
Hydroponics unit	Scissors
Incubators	Solubridge tester (device used to measure electrical conductive properties of soil paste)
Internet connections	Stirring rods
Lab jackets	Stove/oven
Laboratory tables	Test tube racks
LCD projectors	Test tube thermometers
Lenses, hand	Test tubes
Lenses, magnifying	Thermometers
Microscope slides and cover slips	Tweezers or forceps
Microscopes, binocular	Water quality test kits
Microscopes, dissecting	

Results from Round I

The results of the Round I instrument show that an additional 41 items were added to the original equipment and components list by the panel experts. Figure 3 illustrates all responses added by the panel experts. All responses were checked for duplication and any duplicated items were deleted. The additional items added by the panel and the preliminary items were used to develop Round II instrument for the study.

Figure 3. Additional Equipment and Components List

Equipment and Component List	
3 gallon hand sprayer(1 sprayer for herbicides and 1 sprayer for insecticides)	Grafting knives
1 gallon hand sprayer(1 sprayer for herbicides and 1 sprayer for insecticides)	High intensity discharge lamps (Metal halide or High Pressure Sodium)
Air blower	Hoses and nozzles
Aquaculture tanks (hauling, quarantine)	Hydroponics unit, Ebb & Flow
Aquaculture tank heater	Hydroponics unit, Drip hydroponics
Ammonia Test kit	Macro-invertebrate test kit
Benches, greenhouse	Nets or seines
Buckets	Nitrite test kits
Cabinets, pesticide storage	Phosphorus test kit
Cabinets, storage	Plant grow tables
Chloride test kits	Pots, various sizes
Chlorine test kit	Potting media table
Conductivity meter	Pressure Washer
Dissection kits	Seed mode
Dissection pans	Sterilizing equipment
Dissolved Oxygen meter	Television
Dissolved Oxygen test kit	Tissue Culture kit
Fertilizer dispenser	Trowels
Filter, solid for culture tanks	Video Cassette Recorder (VCR)
Flats with propagation lids	Water pumps
Generator, back-up	

Instrument Information for Round II

In Round II, the expert panel were asked to rate a list of 90 items. The instrument was comprised of the 49 preliminary items and the additional 41 items added by the expert panel to the Round I instrument. The list of equipment and component items was placed in alphabetical order. Each item was rated on a five point Likert scale. The scale included 1 = Strongly Disagree; 2 = Disagree; 3 = Neither Agree /Nor Disagree; 4 = Agree; and 5 = Strongly Agree. Consensus to include items was reached if at least 50% of the panel experts agreed or strongly agreed to each item.

The Round II instrument was e-mailed to the 19 remaining panel experts May 3, 2004 with a return date of May 7th, 2004 (Appendix E). Panel experts were emailed a note on May 5, 2004 as a reminder of the instrument due date. A follow-up phone call was made to one non-respondent. The Round II instrument asked each participant to rate each item and also participants were instructed to provide a comment if any item was rated with a 1 = Strongly Disagree; 2 = Disagree; or 3 = Neither Agree /Nor Disagree. The response rate for Round II was 94%.

Results for Round II

The 90 items all reached consensus in Round II (consensus was met if 50% of the panel experts rated each item with agree or strongly agree). The panel experts provided comments for items they rated with a strongly disagree, disagree, or neither favor/nor oppose. Table 1 lists all equipment and components that met consensus for the study. The panel experts were also asked to establish if each item fit the definition of either equipment or a component. The following definitions used for equipment and component were supplied to each expert panel member. Equipment was defined as any instrument, machine, apparatus, or set of articles that meets the following criteria: (a) retains its original shape, appearance, and character with use; (b) does not lose its identity through fabrication; (c) non-expendable; and (d) expected to serve its principal purpose for at least one year. Component was defined as any part or ingredient of any instrument, machine, apparatus, or set of articles that is equipment. As a result of consensus on all items, subsequent rounds were not needed.

Summary

This study used the modified Delphi methodology and was comprised of two rounds of questionnaires. The Round I questionnaire sought to develop a list of essential equipment and components needed to implement the course entitled Biological Applications in Agriculture. The Round II questionnaire sought the opinions of the expert panel using a five-point likert scale.

The Round I instrument identified 41 pieces of equipment and components used in similar courses from New York, Georgia, and North Carolina. The expert panel added 49 additional 49 pieces of equipment and components. The expert panel achieved consensus on all 90 pieces of equipment and components.

Table 1.

Equipment/Components That Met Consensus in Round II (N = 17)

Equipment and Component List	Equipment/ Component	Number of panel experts rating 4 or 5	M	SD
Cabinets, storage	Equipment	17	4.59	0.51
Computers	Equipment	17	4.59	0.51
Nitrate test kits	Equipment	17	4.59	0.51
pH meters	Equipment	17	4.59	0.51
Safety goggles	Equipment	17	4.59	0.51
Dissection kits	Equipment	17	4.53	0.51
Dissection pans	Equipment	17	4.53	0.51
Internet connections	Component	17	4.53	0.51
Laboratory tables	Equipment	17	4.53	0.51
Microscope slides and cover slips	Component	17	4.53	0.51
Microscopes, binocular	Equipment	17	4.53	0.51
Microscopes, dissecting	Equipment	17	4.53	0.51
Nitrite test kits	Equipment	17	4.53	0.51
pH test kits	Equipment	17	4.53	0.51
Refrigerator	Equipment	17	4.53	0.51

Table 1 (continued). **Equipment/Components That Met Consensus in Round II**

Equipment and Component List	Equipment/ Component	Number of panel experts rating 4 or 5	M	SD
Television	Equipment	17	4.53	0.51
Video Cassette Recorder (VCR)	Equipment	17	4.53	0.51
Nets or seines	Equipment	17	4.47	0.51
Printers	Equipment	17	4.47	0.51
Test tube racks	Component	17	4.47	0.51
Test tubes	Equipment	17	4.47	0.51
Water quality test kits	Equipment	17	4.47	0.51
Buckets	Equipment	17	4.41	0.51
Calculators	Equipment	17	4.41	0.51
Greenhouse	Equipment	17	4.41	0.51
Petri dishes	Equipment	17	4.41	0.51
Phosphorus test kit	Equipment	17	4.41	0.51
Thermometers	Equipment	17	4.41	0.51
Graduated cylinders	Equipment	17	4.35	0.49
Lenses, magnifying	Equipment	17	4.35	0.49
Pots, various sizes	Component	17	4.35	0.49

Table 1 (continued). **Equipment/Components That Met Consensus in Round II**

Equipment and Component List	Equipment/ Component	Number of panel experts rating 4 or 5	M	SD
Scales or balances	Equipment	17	4.35	0.49
Beakers	Equipment	17	4.29	0.47
Dissolved Oxygen meter	Equipment	15	4.29	0.69
Dissolved Oxygen test kit	Equipment	15	4.29	0.69
LCD projectors	Equipment	15	4.29	0.69
Pipettes	Equipment	17	4.29	0.47
Potting media table	Equipment	17	4.29	0.47
Scissors	Equipment	17	4.29	0.47
Benches, greenhouse	Component	15	4.24	0.97
Cabinets, pesticide storage	Equipment	15	4.24	0.97
Macro-invertebrate test kit	Equipment	16	4.24	0.75
Test tube thermometers	Equipment	15	4.24	0.66
Tissue Culture kit	Equipment	15	4.24	0.66
Chloride test kits	Equipment	15	4.18	0.95
Chlorine test kit	Equipment	15	4.18	0.95
Flasks	Equipment	14	4.18	0.73

Table 1 (continued). **Equipment/Components That Met Consensus in Round II**

Equipment and Component List	Equipment/ Component	Number of panel experts rating 4 or 5	M	SD
Hoses and nozzles	Component	15	4.18	0.64
Misting system	Component	17	4.18	0.39
Scalpels	Equipment	15	4.18	0.64
Tweezers or forceps	Component	14	4.18	0.73
Lab jackets	Equipment	16	4.12	0.70
Seed model	Equipment	16	4.12	0.49
Trowels	Equipment	15	4.12	0.60
Aquariums	Equipment	15	4.06	0.90
Flats with propagation lids	Component	15	4.06	0.56
Plant grow tables	Equipment	15	4.06	0.56
1 gallon hand sprayer	Equipment	14	4.00	0.94
Ammonia Test kit	Equipment	15	4.00	0.87
High intensity discharge lamps	Equipment	15	4.00	0.50
Microscopes, electric	Equipment	14	4.00	0.61
Water pumps	Component	14	4.00	0.61
Digital cameras	Equipment	15	3.94	0.83

Table 1 (continued). **Equipment/Components That Met Consensus in Round II**

Equipment and Component List	Equipment/ Component	Number of panel experts rating 4 or 5	M	SD
Fertilizer dispenser	Component	14	3.94	0.56
Incubators	Equipment	14	3.94	0.56
Stirring rods	Component	15	3.94	0.83
Sterilizing equipment	Equipment	14	3.94	0.90
Stove/oven	Equipment	16	3.94	0.24
3 gallon hand sprayer	Equipment	14	3.88	0.86
Conductivity meter	Equipment	15	3.88	0.78
Hydroponics unit, Ebb & Flow	Equipment	15	3.88	0.78
Lenses, hand	Equipment	14	3.88	1.22
Camcorders	Equipment	15	3.82	0.73
Pipette pumps	Component	15	3.82	1.13
Aquaculture tanks	Equipment	14	3.76	0.90
Biofilter	Component	12	3.76	0.90
Filter, solid for culture tanks	Component	11	3.76	0.66
Air blower	Component	13	3.71	0.92
Aquaculture pumps	Component	12	3.71	0.99

Table 1 (continued). **Equipment/Components That Met Consensus in Round II**

Equipment and Component List	Equipment/ Components	Number of panel experts rating 4 or 5	M	SD
Aquaculture tank heater	Component	12	3.71	0.99
Hydroponics unit, Drip hydroponics	Equipment	13	3.71	0.77
Power sprayer	Equipment	13	3.71	0.59
Root growth chamber	Equipment	13	3.71	0.77
Generator, back-up	Equipment	11	3.59	1.12
Grafting knives	Component	13	3.53	1.01
Pressure Washer	Equipment	11	3.47	0.80
Solubridge tester	Equipment	12	3.47	1.01

Note. 1 = Strongly Disagree 2 = Disagree 3 = Neither Agree /Nor Disagree 4 = Agree and 5 = Strongly Agree. Agreement of equipment and components were achieved by a majority.

Chapter 5

CONCLUSIONS, DISCUSSION, AND RECOMMENDATIONS

Chapter 5 contains the purpose and objectives of the study, summary of the research methodology, summary of the results of Round I and II of the study, conclusions and implications, and recommendations developed from the results of the study.

Purpose and Objectives

The purpose of this study was to ascertain essential components needed for a functional agriscience course taught in Virginia entitled Biological Applications in Agriculture. Specific objectives of the investigation were to:

- Determine the essential agriscience laboratory components needed to implement the Virginia course entitled Biological Applications in Agriculture.
- Determine the essential agriscience classroom components needed to implement the Virginia course entitled Biological Applications in Agriculture.

Summary of the Research Methodology

The research methodology utilized for this study was Delphi methodology. The data were acquired by means of two questionnaires. The Delphi method was used to gain consensus on essential equipment and components needed to implement the Virginia course entitled Biological Applications in Agriculture.

The goal of the Delphi method for this study was to obtain essential equipment and components based on the consensus of an expert panel. The expert panel was comprised of agricultural education teachers, career and technical directors, and local building-level administrators on essential items According to Dalkey and Helmer (1962), the Delphi method obtains a reliable consensus of opinion of experts by using a series of questionnaires combined with opinion feedback.

The data were collected through electronic communications. All questionnaires were emailed to each panel experts' personal email account. All responses from each panel member were returned through email to the researcher. Andranovich (1995) stated that the Delphi technique was designed for groups who are geographically distant, and this was true for this study.

One of the most significant considerations when implementing a Delphi study is selecting the panel of experts (Stone Fish & Busby, 1996). The original 24 panel experts consisted of agricultural educators; local building level administrators, career and technical administrators, and business and industry individuals of schools that have implemented the Virginia course entitled Biological Applications in Agriculture. The 18 panel experts who completed the study consisted of agricultural educators, local building level administrators, career and technical administrators. The panel experts were located from schools and school divisions from throughout the state of Virginia.

The research study involved two rounds of questionnaires. The original questionnaire included a list of laboratory and classroom equipment/components. The panel experts were asked to offer any additions to the list. The second round questionnaire involved the ranking of the items generated in Round I. All items generated in Round I met consensus in Round II. Consensus for this study was defined as items for which 50% of the panel experts agreed or strongly agreed to the item.

Summary of Round I

The Round I questionnaire asked each participant to add any additional equipment or components to 49 items on the list generated by the researcher. The participants added an additional 41 items to the list. The items added included equipment and components for a greenhouse or an aquaculture laboratory.

The additional items added to the Round I questionnaire were then added to the Round II instrument. Round II instrument asked each participant to rank each piece of equipment or component.

Summary of Round II

The second round of the Delphi method asked each panel member to rate their agreement or disagreement with the items generated during the first round of the study. The respondents rated the list of items using a Likert Scale containing five options: (a) Strongly Disagree; (b) Disagree; (c) Neither Agree /Nor Disagree; (d) Agree; and (e) Strongly Agree.

The data were collected and analyzed. Items were grouped into two categories, agreement and disagreement. Once the analysis was completed, the participants were sent a cover letter with analysis of the results. Consensus was achieved the Round II, there was no need for further rounds.

Conclusions

The conclusions of this investigation were based on the study's findings. The following conclusions were derived: (a) since the researcher used equipment lists from three other states implementing a course similar to Biological Applications in Agriculture and the expert panel added an additional 41 items, a comprehensive list of scientific equipment and components does not exist in Virginia to implement the agriscience course Biological Applications in Agriculture; (b) an essential equipment and component list should be generated for the Virginia course entitled Biological Applications in Agriculture; and (c) there is a need for a list of equipment and components for the Virginia course entitled Biological Applications in Agriculture that should include items for both the agricultural education classroom and laboratory.

Recommendations for Implementation

The following recommendations are based upon the findings of the study.

1. The items that reached consensus derived from this study should be added to the current Virginia agricultural education equipment list.
2. Agricultural education programs currently implementing the Biological Applications in Agriculture course should conduct an inventory of equipment and components to determine the percentage of equipment and components possessed on the list. After determining equipment and components, schools should investigate the need to purchase equipment or components derived from the list generated to meet the needs of the curricula.
3. States that are offering courses similar to the Biological Applications in Agriculture should consider adding the equipment and components list generated from this study to their state equipment lists.

Recommendations for further research

1. Conduct a study with an agricultural education program that has implemented the equipment and components list derived from this study to determine the accuracy and completeness of the list.
2. Conduct a study to determine total costs to purchase and implement the equipment and components that have been listed.
3. Conduct a study to gain perceptions of science educators as they relate to the Biological Applications in Agriculture course and the equipment and components list derived from this study.
4. Conduct a study about students' perceptions of integrating science in the agricultural education courses and the types of equipment needed to implement science based courses in agricultural education programs.
5. Replicate the study with other agricultural education courses that are integrating science and agriculture.
6. Replicate this study on a regional and national level to further validate the equipment and component list to similar courses in other states.
7. Laboratory learning is a major part of agricultural education. Therefore a research agenda should be developed to determine if facilities are equipped with essential items to conduct agricultural education courses.
8. Conduct a study to determine how the implementation of scientific equipment correlates to current space, ventilation and light requirements for a facility.
9. Conduct a study to determine if integrating academics into agriculture affects critical thinking skills, employability, or higher achievement on standardized tests.

10. Conduct a study to determine the importance of agriscience in the secondary school system.
11. Conduct a study to determine if agricultural educators are competent with using equipment and components that met consensus.

Implications

The findings of this study will be useful to state departments of education to provide guidelines or publications concerning facilities for implementation of agriscience courses. Secondary school personnel who assist with facility design, renovation, and updating may use the results from the research to alter local programs. Facility design should be based on the needs of the curricula. The results of this study explain the needs of the Biological Applications in Agriculture course. Agricultural educators in universities offering agricultural education teacher preparation programs will also find this research useful. Universities can develop or update laboratory or facility management courses, update program planning courses, and curriculum design and implementation courses to include agriscience and agriscience facilities. The results of this study suggest the need to implement competencies in laboratory management courses on maintaining and using aquaculture tanks and various types of microscopes.

Sledge (1980) produced a formula that stated needs or educational objectives plus what is taught in the curriculum is equal to determining needs for buildings and facilities. The results of this study were based on the curriculum of the Biological Applications in Agriculture course. The participants were provided with the competencies for the course and suggested items and instructed to add any additional items. Therefore their responses were based on the curriculum. Sledge and Bjoraker (1980) stated it is important to keep in mind that educational objectives and the basic curriculum will determine the need for buildings and facilities. Sledge and Bjoraker further stated that educators cannot simply follow layouts that already exist.

The agricultural education curriculum is now changing to be more science-based, thus facilities should change. The results of this study concluded that the expert panel agreed or strongly agreed that scientific equipment and components should be utilized in the Biological Applications in Agriculture classroom and laboratory. Shelhamer (1993) reported that the laboratory experiences "must be modernized to reflect the new image for agricultural education, and that these activities must be effectively marketed to local communities" (p. 21).

The new image of agricultural education includes integrating academics into the curriculum. The results of this study indicated that the agriscience laboratory and classroom, to implement the Biological Applications curriculum should resemble both a science laboratory/classroom and a traditional agricultural laboratory/classroom. Research suggests that agriscience facilities should resemble a science laboratory (Newman & Johnson, 1993; Vernon & Briers, 1991). The scientific laboratory/classroom components and equipment that the panel deemed important included water testing kits, laboratory tables, various types of microscopes, test tubes, beakers, hydroponics units, root growth chambers, and sterilizing equipment. The panel also agreed that certain equipment and components typically found in a traditional agricultural laboratory/classroom need to remain in the facility. Equipment and components such as sprayers, potting media, televisions, and VCRs, the panel agreed or strongly agreed need to remain a part of the facility.

Change in the agricultural education curriculum also must alter the nature of the classroom and laboratory (Colling & Farnsworth, 1969; Sledge & Bjoraker, 1980). Terry (1993) noted that many facilities need only some "sprucing up" to help reform the image they project. The equipment and components generated from this study, if implemented will project an image of a scientific agricultural education course.

Summary

Agricultural education has changed its focus to incorporate more science in the curriculum. The integration of science, called agriscience, has forced school systems and educators to change their way of teaching and thinking. Teaching scientific principles through the use of agriculture will enable students to apply the scientific knowledge gained. A review of relevant literature indicates that experiential learning assists in student retention of knowledge.

A review of relevant literature also indicates that integration of academics into agricultural education improves achievement test scores. However, barriers such as equipment, funding, and educator knowledge have been identified as barriers to integration. Agricultural education has changed its curriculum to integrate academic concepts called agriscience. Agriscience uses classrooms and facilities to achieve the objectives of the course. Agriscience facilities must meet the educational objectives of the course. Several agricultural education professors stated that agriscience facilities should resemble a science lab. However, educators must design and evaluate facilities to keep up with technological change. Research suggests that essential facilities and facility components for teaching agriscience are not in place.

This study used the modified Delphi methodology and was comprised of two rounds of questionnaires. The Round I questionnaire sought to develop a list of essential equipment and components needed to implement the course entitled Biological Applications in Agriculture. The Round II questionnaire sought the opinions of the expert panel using a five-point likert scale.

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Appendix A

Request for Exemption of Research Involving Human Subjects

Request for Exemption of Research Involving Human Subjects

[please print or type responses below]

Investigator(s): Thomas Broyles Faculty Advisor: Dr. Stan Burke
Department(s): Ag. & Extension Ed Mail Code: 0343 E-mail: tbroyles@vt.edu Phone: 231-6088
Project Title: Curriculum and Facilities for Agricultural Education: An Agriscience Approach # of Human Subjects 25
Source of Funding Support: _X_ Departmental Research ____ Sponsored Research (OSP No.:_______)

[X] All investigators of this project are qualified through completion of the formal training program or web-based training programs provided by the Virginia Tech Office of Research Compliance.

Note: To qualify for Exemption, the research must be (a) of minimal risk to the subjects, (b) must not involve any of the special classes of subjects, and (c) must be in one or more of the following categories. A full description of these categories may be found in the Exempt Research section of the Virginia Tech "*IRB Protocol Submission Instructions Document* or in the federal regulations [45 CFR 46.101(b)(1-6)]. (http://ohrp.osophs.dhhs.gov/humansubjects/guidance/45cfr46.htm#46.101)

Please mark/check the appropriate category or categories below which qualify the proposed project for exemption:

[X] 1. Research will be conducted in established or commonly accepted educational settings, involving normal educational practices [see item (1), page 6 of the "Instructions" document].

[ ] 2. Research will involve the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, **unless** the subjects can be identified directly or through identifiers linked to the subjects **and** disclosure of responses could reasonably place the subjects at risk or criminal or civil liability or be damaging to the subjects' financial standing , employability or reputation [see item (2), page 6 –"Instructions"].

[ ] 3. Research will involve the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under item 2) above **if** the subjects are elected or appointed public officials or candidates for public office; **or** Federal statute(s) require(s) that the confidentiality or other personally identifiable information will be maintained [see item (3), page 6 of the "Instructions" document].

[ ] 4. Research will involve the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified directly or through identifiers linked to the subjects [see item (4), page 7 of the "Instructions" document].

[ ] 5. Research and demonstration projects designed to study, evaluate, or otherwise examine public benefit or service programs, procedures for obtaining benefits or proposed changes in such programs [see item (5), page 7 of the "Instructions" document].

[ ] 6. Taste and food quality evaluation and consumer acceptance studies [see item (6), page 7- "Instructions].

Thomas W. Broyles	Thomas W. Broyles	4/19/2004
Investigator(s)	Print name	Date
Departmental Reviewer	Print name	Date
Chair, Institutional Review Board		Date

Informed Consent

Project Title: Curriculum and Facilities for Agricultural Education: An Agriscience Approach

Principal Investigators: Thomas W. Broyles, PhD Candidate, Career and Technical Education
Dr. Stan Burke, Associate Professor Emeritus, Agricultural and Extension Education

1. I hereby agree to participate in the project known as Curriculum and Facilities for Agricultural Education: An Agriscience Approach. I understand that my participation is voluntary, and I will be asked about my experiences related to questions of agricultural education facilities.

2. I understand that I will be asked to participate in at least 4 rounds of Delphi technique, which will take no longer than 60 minutes for each round.

3. I understand that I can withdraw from the project at any time without penalty of any kind. In the event that I withdraw from the project, any data collected will be either given to me or destroyed.

4. I understand that I will receive no compensation for my participation in this project, though I will be given a copy of the analysis for my own record.

5. I understand that there are no known risks to participating in this. I also understand that the benefits of this project are great, as my experiences may help inform the profession to improve the laboratory facility to increase educational effectiveness.

6. I understand all questionnaires will be administered through email and I will remain anonymous in any information pertaining to the study.

7. This project has been approved, as required, by the Institutional Review Board for Research Involving Human Subjects at Virginia Polytechnic Institute and State University, by the Department of Teaching and Learning.

8. If I feel I have not been treated according to the descriptions in this form, or that my rights as a participant in the research have been violated during the course of this project, I know I can contact Dr. David Moore, Chair, IRB, Research Division, Virginia Tech, or Thomas W. Broyles, Principal Investigator, Career and Technical Education, Virginia Tech at the phone numbers listed below.

9. I voluntarily agree to participate in this study according to the terms outlined above. I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project.

Signature Date

Should I have any questions about the research project of procedure, I may contact:

Thomas W. Broyles	Dr. Stan Burke	Dr. David Moore
Principal Investigator	Advisor	Chair, IRB
(540) 231-8188	(540) 231-6836	(540) 231-4991

PARTICIPANTS WILL BE GIVEN A COPY OR DUPLICATE ORIGINAL OF THIS CONSENT FORM

Protocol to Accompany Institutional Review Board
Request for Exemption
Virginia Polytechnic Institute and State University

Project Title: Curriculum and Facilities for Agricultural Education: An Agriscience Approach

Principal Investigators: Thomas W. Broyles, PhD Candidate, Career and Technical Education
Dr. Stan Burke, Advisor and Assistant Professor Emeritus, Agricultural and Extension Education

Justification of Project

Agricultural education has changed its curriculum, its focus, and its mission. The early days of agricultural education prepared pupils to enter the workforce by training for specific jobs. Currently the emphasis in agricultural education is shifting to the integration of academics with career and technical education. This paradigm shift is called agriscience. The concept of agriscience is taught utilizing classroom teaching, supervised agricultural experiences, and laboratory learning.

Facilities are the linking point from classroom instruction to problem solving and hands-on experience. Facilities must be equipped with equipment and modules that are highly correlated with the curriculum being implemented. Laboratory experiences must be modernized to reflect the integration of academics with agricultural education. The major facility problem being encountered by agricultural education is that agricultural education does not know what essential components are needed for a functional agriscience facility.

The purpose of this study is to ascertain essential components needed for a functional agriscience course taught in Virginia entitled Biological Applications in Agriculture. Specific objectives of the investigation are:

- Determine the essential agriscience laboratory components needed to implement the Virginia course entitled Biological Applications in Agriculture.
- Determine the essential agriscience classroom components needed to implement the Virginia course entitled Biological Applications in Agriculture.
- Develop a list of the essential agriscience classroom and laboratory components needed to implement the Virginia course entitled Biological Applications in Agriculture.

Procedures

Identifying essential components of a functional agriscience facility will be achieved using Delphi methodology. The panel for this investigation will be comprised of twenty-five adult individuals representing four constituency groups. The groups are categorized as agricultural educators, local school administrators, career and technical education directors, and business and industry leaders. An email will be sent to state agricultural education staff requesting nomination of individuals they would consider experts in the area of agriscience and agriscience facilities. The respondents will be asked to complete questionnaires spread over four rounds. The questionnaires will seek to obtain opinions of essential components for an agriscience laboratory and classroom. The questionnaires will then seek to obtain consensus on the items identified by the panel. Consensus will be achieved when 50% of the panel experts agree on Likert-Type items. The data will be analyzed by means and standard deviations.

Risks and Benefits
There are no risks to the panel experts to conduct the study.
The findings of this research will aid school administrators, career and technical directors, and secondary educators in providing essential facilities for implementing a relevant agriscience curriculum.

Confidentiality/Anonymity
Only the investigator and my advisor will have access to the data. At no time will panel experts be able to identify other members of the panel. All efforts will be made to ensure anonymity of the participants. Written responses or justifications will not be accompanied with names or affiliations to institutions. Reporting of data will be based on statistical analysis of the whole panel. Personal information such as names and affiliations to institutions will not be published. All data and information pertaining to the study will be filed in my office.

Biographical Sketch
The principle investigator of the project is
Thomas W. Broyles
Ph.D. candidate
Department of Career and Technical Education
College of Human Resources and Education

I am a graduate student of Virginia Tech in the department of Career and Technical Education, specializing in Agricultural and Extension Education. I am currently employed by Virginia Tech, as an instructor concentrating my efforts as an teacher educator in the area of agricultural mechanics and agricultural education.

Prior to my decision of obtaining my Ph.D. degree, I was employed by Fauquier County School Board as an educator in the Agriculture Education department. During my years of teaching I taught classes at the middle school and high school levels. These classes are primarily hands-on courses with emphasis of learning material in the laboratory setting. This background allows me to be very familiar with the agriculture education facility and the knowledge needed to research this area of education.

The faculty member guiding the research process is
Dr. Stan Burke
Associate Professor, Emeritus
Department of Agricultural and Extension
College of Agriculture and Life Sciences

Stan Burke is currently retired from the Department of Agricultural and Extension Education and will be following each step of the proposed study. His research background is in the area of safety, agricultural mechanics, and facilities. Stan Burke graduated from the University of Missouri with a Ph.D. from the Department of Agricultural Education

Appendix B

Biological Applications in Agriculture Unit and Competency list

Biological Applications in Agriculture

Unit and Competency list

Developing Leadership Skills

- Identify benefits and responsibilities of FFA membership.
- Identify duties of all officers in the FFA.
- Prepare and deliver an oral presentation or speech.
- Develop communication skills.
- Use parliamentary procedure.
- Develop recordkeeping skills using the Virginia SAE record book.
- Complete FFA award and/or officer application.
- Participate in a community improvement project.
- Set personal goals and develop an annual plan for Supervised Agricultural Experiences.

Understanding the Study of Living Things

- Define Agriculture, Biology, and Aquatic Biology.
- Explain the key steps of the scientific method.
- Develop experimental procedures to solve a problem or answer a question.
- Demonstrate safe laboratory practices.
- Draw an atom and its parts.
- Describe the relationship of atoms and molecules.
- Explain the roles of carbohydrates, proteins, lipids, and nucleic acids.

Understanding Cell Structure and Functions

- Describe the cell as the building block of life.
- Explain how knowledge of the functions of cells is important to agriculture.
- Analyze the differences between the plant and animal cells.
- Explain the variations in the different types of cells.
- Describe the structures found in cells.
- Give examples of how agriculture makes use of structure found in cells.
- Analyze the functions of the various parts of cells.
- Explain the process of diffusion.
- Explain the process of osmosis.
- Explain the concept of homeostasis.
- Explain the process of mitosis.

Understanding Basic Genetics

- Explain how Mendel developed his theories and genetics.
- Explain the Mendelian Law of genetics.
- Analyze a Punnett Square.
- Discuss the makeup of chromosomes in a cell.
- Discuss the process of DNA transfer.
- Specify how genetic principles are used in plant breeding.
- Explain how hybrid plant varieties are developed.
- Identify how animal breeding has benefited the producer.
- Determine how the principles of genetics are used in animal breeding programs.

- Identify how computers are used in the selection of breeding animals.
- Explain how genetic mutations are used to develop new breeds of animals.

Principles of Genetic Engineering

- Define genetic engineering.
- Explain the process of gene mapping.
- Define recombinant DNA.
- Analyze the methods used in gene splicing.
- Cite examples of how genetic engineering is currently being used.
- Predict some future uses of genetic engineering.
- Assess societal concerns about the use of genetic engineering.
- Summarize the laws affecting parents of genetically altered organisms.
- Evaluate the safeguards used in research using genetic engineering.

Understanding Basic Plant Structures and Functions

- Explain how plants make food.
- Describe the roles of air, water, light, and media in relation to plant growth.
- Trace the movement of minerals, water, and nutrients in plants.
- Describe the ways that various plants store food for the future.
- Compare the activity in a plant during exposure to light and periods of darkness.
- Explain how plants protect themselves from disease, insects, and predators.
- Distinguish between reproduction and plant improvement.

- Explain the relationship between reproduction and plant improvement.
- Identify the reproductive parts of flowers and seeds.
- Identify the primary methods of asexual reproduction.
- Explain the procedures used to propagate plants by tissue culture.
- Identify the different growing media for a nutrient spray bag system.

Understanding Basic Hydroponic Plant Production

- Identify the principles associated with a nutrient film system.
- Identify disease and insect problems associated with hydroponics.
- Identify the types of plants, which can use a hydroponic system.
- Identify the methods of quality control.

Understanding Structures and Functions of Aquatic Animals

- Define aquaculture.
- Discuss the role of science and technology in the development of aquaculture.
- Discuss the morphology, anatomy, and physiology of common aquatic animals.
- Identify the nine body systems of aquatic animals.
- Identify the internal and external anatomy of a fish.
- Demonstrate a familiarity with the scientific names for different aquatic animals.

Managing Aquatic Animals

- Identify guidelines for transporting fish to long-distance markets.

- Identify marketing procedures for fish.
- List methods of managing fish to control overpopulation.
- Identify the terms related to harvesting and hauling of fish.
- Compare total and partial harvest of fish.

Understanding Fundamentals of Aquatic Nutrition

- Find the protein, energy, vitamin, and mineral requirements for fish.
- Describe the role of non-nutritive factors in feed.
- Know what toxic substances to watch for in fish.
- Identify methods for preparing and feeding fish.
- Identify potential ingredients for fish diets.
- Explain different feeding practices for different species.
- Calculate the amount of feed required.
- Calculate the feed conversion ratio (FCR).
- Identify the parts of the digestive system.
- Explain the role of the digestive system in absorption.
- Explain how anatomy and behavior affect feeding.
- List factors that influence energy requirements.
- List three sources of energy.
- Identify factors that affect the digestibility of fat.
- Explain the role of essential fatty acids and essential amino acids.
- List the fat-soluble vitamins.
- Describe ten effects of vitamin deficient diets.

Understanding Principles of Aquatic Animal Health

- Outline fish health management.
- List behavioral signs of sick fish.
- List common physical signs of sick fish.
- List common stressors of fish.
- Outline general management measures for preventing disease outbreaks.
- List and compare treatment methods.
- Complete a list of general guidelines for treatment of fish disease.
- Define terms associated with disease conditions.
- Explain disease resistance.
- Define terms associated with severity of disease or condition.
- Describe the immunization of fish.
- List signs of stress and disease.

Understanding the Principles of Water Quality

- Explain why water is important in aquaculture.
- Explain the quality features of water for aquaculture.
- Define terms related to water quality management.
- Calculate treatments for volumes of water.
- List causes of dissolved oxygen loss.
- List signs of dissolved oxygen efficiency.
- Select facts about the prevention of oxygen depletion.

- List methods of correcting dissolved oxygen deficiency.
- Know what causes turbidity.
- List ways to dispose of wastewater.
- Explain how changes in water affect aquatic life.
- Identify the role of temperature in oxygen management.
- List chemicals, compounds, and elements that are determined to water quality.
- Understand the importance of nitrogen compounds in water quality management.
- Identify methods of managing pH cycles.
- Analyze key issues relating to water quality and agriculture.

Identifying the Roles of Federal and State Agencies and Regulations

- Identify agencies of the U.S. Department of Agriculture involved in aquaculture.
- Identify agencies concerned with the production of food.
- Identify the services that provide diagnostic assistance to aquaculture operations.
- Describe the role of FDA in aquaculture.
- Describe the role of the U.S. Fish and Wildlife Service in aquaculture.
- Explain the role of the EPA in aquaculture.
- Give the State location of the five Regional Aquaculture Centers.
- List four individual responsibilities when starting and/or changing an aquaculture operation.

Identifying Career Opportunities in Aquaculture

- List the occupational areas of aquaculture.
- Describe the general duties of employees in aquaculture occupations.
- Describe the education and experience needed to enter a career in aquaculture.

Appendix C

Letter to accept invitation to study

Dear ___________

The purpose of this email is to ask for your assistance in ascertaining the essential equipment/components needed for a functional agriscience facility that is implementing the Virginia course entitled Biological Applications in Agriculture. You have been identified as an expert in the area of Biological Applications in Agriculture through your course offerings in your local school division. The title of the study is " Curriculum and Facilities for Agricultural Education: An Agriscience Approach". The purpose of this study is to ascertain essential components needed for a functional agriscience course taught in Virginia entitled Biological Applications in Agriculture. Specific objectives of the investigation are: (1) Determine the essential agriscience laboratory equipment/components needed to implement the Virginia course entitled Biological Applications in Agriculture; and (2) Determine the essential agriscience classroom equipment/components needed to implement the Virginia course entitled Biological Applications in Agriculture.

The research study will utilize the Delphi methodology for data collection. The Delphi method is used to gain consensus. There will be no more than four rounds and each round will take no longer than one hour to complete. Data collection will be conducted by email and Microsoft Word documents. Your responses to the questions will be kept confidential and you will remain anonymous throughout the study. You will also receive a copy of the results at the conclusion of the study.

Please accept the nomination and participate in the study to ascertain the essential equipment/components needed for a functional agriscience facility that is implementing the Virginia course entitled Biological Applications in Agriculture. The research will benefit Agricultural Education.

Please reply to me acknowledging your acceptance of the nomination by <u>Monday April 26, 2004 by 5:00 pm</u>. If you have any questions regarding this message please do not hesitate to contact me either through email or phone. My contact information is located below.

Thank you for your assistance with this matter.

Sincerely

Thomas W. Broyles
Agricultural and Extension Education
282 Litton-Reaves Hall
Virginia Tech (Mail Code 0343)
Blacksburg, VA 24061
Voice: (540)231-8188, Fax:(540)231-3824

Appendix D

Round I Instrument

Dear Delphi Panel Member:

Thank you for agreeing to serve on this panel. As a panel member you are making an important contribution to research in the area of agriscience facilities.

This is the first of three instruments. The purpose of the first instrument is to develop a list of equipment/components. You will have a chance to rate each piece of equipment/component in later rounds. Please complete this questionnaire and return via email to tbroyles@vt.edu. I realize you are very busy; however, it would be greatly appreciated if you return the instrument before April 30th, 2004 at 5:00 pm.

The purpose of this study is to ascertain essential components needed for a functional agriscience course taught in Virginia entitled Biological Applications in Agriculture. Specific objectives of the investigation are:

- Determine the essential agriscience laboratory equipment and components needed to implement the Virginia course entitled Biological Applications in Agriculture.
- Determine the essential agriscience classroom equipment and components needed to implement the Virginia course entitled Biological Applications in Agriculture.

Sincerely

Thomas W. Broyles

Curriculum and Facilities for Agricultural Education: An Agriscience Approach

Thomas W. Broyles

Directions: Please list in the Additional Equipment/Component column any essential agriscience laboratory and classroom equipment/component needed to implement the Virginia course entitled Biological Applications in Agriculture. Any Additional Equipment/Component you add may pertain to one or all of the competencies for a given unit.

Definitions:
Equipment – any instrument, machine, apparatus, or set of articles that meets the following criteria:

1. retains its original shape, appearance, and character with use;
2. does not lose its identity through fabrication;
3. non-expendable;
4. expected to serve its principal purpose for at least one year

Component – any part or ingredient of any instrument, machine, apparatus, or set of articles that meets the definition of equipment.

Developing Leadership Skills		
Unit/Competency Overview	**Recommended Equipment/Component**	**Additional Equipment/Component**
• FFA membership • Oral presentations • Communication skills • Recordkeeping skills • FFA Awards • Community projects • Goal setting and Supervised Agricultural Experiences	• Computers • Printers • Internet connections • LCD projectors • Digital cameras • Camcorders	• • • • •
Understanding the Study of Living Things		
Unit/Competency Overview	**Recommended Equipment/Component**	**Additional Equipment/Component**
• Scientific method • Experimental procedures • Safe laboratory practices • Atoms and its parts • Carbohydrates, proteins, lipids, and nucleic acids	• Calculators • Atom models • Laboratory tables • Safety goggles • Lab jackets	• • • • •

Understanding Cell Structure and Functions		
Unit/Competency Overview	**Recommended Equipment/Component**	**Additional Equipment/Component**
• Functions of cells • Differences between plant/animal cells • Variations in types of cells • Structures and use found in cells • Diffusion, osmosis, homeostasis, mitosis	• Microscopes, electric • Microscopes, dissecting • Microscopes, binocular • Refrigerator • Stove/oven • Beakers • Flasks • Graduated cylinders • Incubators • Lenses, hand • Lenses, magnifying • Petri dishes • Pipettes • Pipette pumps • Stirring rods • Scales or balances • Scalpels • Scissors • Microscope slides and cover slips • Test tube thermometers • Test tube racks • Test tubes • Tweezers or forceps	• • • • •

Understanding Basic Genetics		
Unit/Competency Overview	**Recommended Equipment/Component**	**Additional Equipment/Component**
• Mendelian Law of genetics • Punnett Square • Chromosomes • DNA transfer • Genetic principles used in plant breeding • Hybrid plant varieties • Animal breeding benefits • Animal breeding programs • Computers used in selection	• Greenhouse (with ventilation system, evaporative cooling system, heating system and humidifier) • Misting system (6 mist nozzles complete with pipe, risers, timers) • 3 gallon hand sprayer • Power sprayer (cart with hose and sprayer gun)	• • • •

of breeding animals • Genetic mutations and new breeds of animals	• Solubridge tester (device used to measure electrical conductive properties of soil paste)	•
Principles of Genetic Engineering		
Unit/Competency Overview	**Recommended Equipment/Component**	**Additional Equipment/Component**
• Genetic engineering • Gene mapping • Recombinant DNA • Gene splicing • Future uses of genetic engineering • Societal concerns about genetic engineering • Laws affecting parents of genetically altered organisms • Safeguards used in research using genetic engineering	• Greenhouse (with ventilation system, evaporative cooling system, heating system and humidifier) • Misting system (6 mist nozzles complete with pipe, risers, timers)	• • • • •
Understanding Basic Plant Structures and Functions		
Unit/Competency Overview	**Recommended Equipment/Component**	**Additional Equipment/Component**
• How plants make food • Roles of air, water, light, and media in relation to plant growth • Movement of minerals, water, and nutrients in plants • Plant food storage • Plant activity during exposure to light and darkness • Plant protection from disease, insects, and predators • Reproduction and plant improvement • Reproductive parts of flowers and seeds • Asexual reproduction • Tissue culture • Nutrient spray bag system	• Root growth chamber • Greenhouse (with ventilation system, evaporative cooling system, heating system and humidifier) • Misting system (6 mist nozzles complete with pipe, risers, timers)	• • • • •

Understanding Basic Hydroponic Plant Production		
Unit/Competency Overview	**Recommended Equipment/Component**	**Additional Equipment/Component**
• Nutrient film system • Disease/insect problems with hydroponics • Hydroponics system plants • Methods of quality control	• Hydroponics unit • Greenhouse (with ventilation system, evaporative cooling system, heating system and humidifier) • Misting system (6 mist nozzles complete with pipe, risers, timers)	•
		•
		•
		•
		•
Understanding Structures and Functions of Aquatic Animals		
Unit/Competency Overview	**Recommended Equipment/Component**	**Additional Equipment/Component**
• Define aquaculture • Role of science/technology in development of aquaculture • Morphology, anatomy, and physiology of common aquatic animals • 9 body systems of aquatic animals • Internal/external anatomy of fish • Scientific names for aquatic animals.	• Aquaculture pumps • Aquaculture tanks • Aquariums • Biofilters • Nitrate test kits • pH meters • pH test kits • Water quality test kits • Thermometers	•
		•
		•
		•
		•
Managing Aquatic Animals		
Unit/Competency Overview	**Recommended Equipment/Component**	**Additional Equipment/Component**
• Transporting fish to markets • Marketing procedures for fish • Managing fish to control overpopulation • Harvesting and hauling of fish • Total/partial harvest of fish.	• Aquaculture pumps • Aquaculture tanks • Aquariums • Biofilters • Nitrate test kits • pH meters • pH test kits • Water quality test kits • Thermometers	•
		•
		•
		•
		•

Understanding Fundamentals of Aquatic Nutrition		
Unit/Competency Overview	**Recommended Equipment/Component**	**Additional Equipment/Component**
• Protein, energy, vitamin, mineral requirements for fish • Role of non-nutritive factors in feed • Toxic substances to watch for in fish • Methods for preparing and feeding fish • Ingredients for fish diets • Feeding practices for different species • Calculate amount of feed required • Feed conversion ratio • Parts of digestive system • Role of the digestive system • Anatomy/behavior affect feeding • Energy requirements • Sources of energy • Factors affect digestibility of fat • Essential fatty acids amino acids • Fat-soluble vitamins • Effects of vitamin deficient diets	• Aquaculture pumps • Aquaculture tanks • Aquariums • Biofilter • Nitrate test kits • pH meters • pH test kits • Water quality test kits • Thermometers	• • • • •

Understanding Principles of Aquatic Animal Health		
Unit/Competency Overview	**Recommended Equipment/Component**	**Additional Equipment/Component**
• Fish health management • Behavioral signs of sick fish • Physical signs of sick fish • Stressors of fish • Preventing disease outbreaks • Treatment of fish disease • Disease resistance • Severity of disease or condition • Immunization of fish • Signs of stress and disease	• Aquaculture pumps • Aquaculture tanks • Aquariums • Biofilters • Nitrate test kits • pH meters • pH test kits • Water quality test kits • Thermometers	• • • • •

Understanding the Principles of Water Quality		
Unit/Competency Overview	**Recommended Equipment/Component**	**Additional Equipment/Component**
• Water importance in aquaculture • Quality features of water for aquaculture • Terms related to water quality management • Calculate treatments for volumes of water • Causes of dissolved oxygen loss • Dissolved oxygen efficiency • Prevention of oxygen depletion • Correcting dissolved oxygen deficiency • Turbidity • Dispose of wastewater • Changes in water affect aquatic life • Temperature in oxygen management • Chemicals, compounds, and elements that determine water quality • Nitrogen compounds in water quality management • Managing pH cycles • Water quality and agriculture issues	• Aquaculture pumps • Aquaculture tanks • Aquariums • Biofilter • Nitrate test kits • pH meters • pH test kits • Water quality test kits • Thermometers	• • • • •

Identifying the Roles of Federal and State Agencies and Regulations		
Unit/Competency Overview	**Recommended Equipment/Component**	**Additional Equipment/Component**
• Agencies of U.S. Department of Agriculture • Agencies concerned with the production of food. • Diagnostic assistance to aquaculture operations • Role of Food and Drug Administration • Role of the U.S. Fish and Wildlife Service • Role of the Environmental Protection Agency • Location of 5 Virginia Regional Aquaculture Centers • Starting and/or changing aquaculture operation	• Computers • Printers • Internet connections • LCD projectors • Digital cameras • Camcorders	• • • • •
Identifying Career Opportunities in Aquaculture		
Unit/Competency Overview	**Recommended Equipment/Component**	**Additional Equipment/Component**
• Occupational areas • Duties of employees • Education and experience needed	• Computers • Printers • Internet connections • LCD projectors • Digital cameras • Camcorders	• • • • •

Appendix E

Round II Instrument

Dear Delphi Panel Member:

Thank you for agreeing to serve on this panel. As a panel member you are making an important contribution to research in the area of agriscience facilities.

This is the second of three instruments. The purpose of the second instrument is to rate the list of equipment/components. Please complete this questionnaire and return via email to tbroyles@vt.edu. I realize you are very busy; however, it would be greatly appreciated if you return the instrument before May 7th, 2004 at 5:00 pm.

The purpose of this study is to ascertain essential components needed for a functional agriscience course taught in Virginia entitled Biological Applications in Agriculture. Specific objectives of the investigation are:

- Determine the essential agriscience laboratory equipment and components needed to implement the Virginia course entitled Biological Applications in Agriculture.
- Determine the essential agriscience classroom equipment and components needed to implement the Virginia course entitled Biological Applications in Agriculture.

If you rate an item NA/ND = Neither Agree/Nor Disagree, D = Disagree, or SD = Strongly Disagree please explain your reasoning in the comments section. The justification will be meaningful in the later rounds.

Sincerely

Thomas W. Broyles

Curriculum and Facilities for Agricultural Education: An Agriscience Approach

Thomas W. Broyles

Directions:

1. Please rate the following classroom and laboratory equipment/components needed to implement the Virginia course entitled Biological Applications in Agriculture. Please use the following scale:

1=Strongly Disagree, 2=Disagree, 3=Neither Agree/Nor Disagree, 4=Agree, 5=Strongly Agree

2. Please place an "E" (Equipment) or "C" (Component) in the Equipment or Component Column if the item is blank. You may use the definition provided below to assist in this decision.

3. If you rate an item NA/ND = Neither Agree/Nor Disagree, D = Disagree, or SD = Strongly Disagree please explain your reasoning in the comments section. The justification will be meaningful in the later rounds.

Definitions:

Equipment – any instrument, machine, apparatus, or set of articles that meets the following criteria:

1. retains its original shape, appearance, and character with use;
2. does not lose its identity through fabrication;
3. non-expendable;
4. expected to serve its principal purpose for at least one year

Component – any part or ingredient of any instrument, machine, apparatus, or set of articles that meets the definition of equipment.

Example:

1=Strongly Disagree, 2=Disagree, 3=Neither Agree/Nor Disagree, 4=Agree, 5=Strongly Agree			
Rating	**Equipment or Component "E" or "C"**	**Item**	**Comments**
5	***E***	Aquaculture Tanks	

1=Strongly Disagree, 2=Disagree, 3=Neither Agree/Nor Disagree, 4=Agree, 5=Strongly Agree			
Rating	**Equipment or Component "E" or "C"**	**Item**	**Comments**
	E	3 gallon hand sprayer(1 sprayer for herbicides and 1 sprayer for insecticides)	
		1 gallon hand sprayer(1 sprayer for herbicides and 1 sprayer for insecticides)	
		Air blower	
	C	Aquaculture pumps	
	E	Aquaculture tanks (hauling, quarantine)	
		Aquaculture tank heater	
	E	Aquariums	
		Ammonia Test kit	
	E	Atom models	
	E	Beakers	
		Benches, greenhouse	

1=Strongly Disagree, 2=Disagree, 3=Neither Agree/Nor Disagree, 4=Agree, 5=Strongly Agree			
Rating	Equipment or Component "E" or "C"	Item	Comments
	C	Biofilter	
		Buckets	
		Cabinets, pesticide storage	
		Cabinets, storage	
	E	Calculators	
	E	Camcorders	
		Chloride test kits	
		Chlorine test kit	
	E	Computers	
		Conductivity meter	
	E	Digital cameras	
		Dissection kits	
		Dissection pans	
		Dissolved Oxygen meter	

1=Strongly Disagree, 2=Disagree, 3=Neither Agree/Nor Disagree, 4=Agree, 5=Strongly Agree			
Rating	**Equipment or Component "E" or "C"**	**Item**	**Comments**
		Dissolved Oxygen test kit	
		Fertilizer dispenser	
		Filter, solid for culture tanks	
	E	Flasks	
		Flats with propagation lids	
		Generator, back-up	
	E	Graduated cylinders	
	E	Greenhouse (with ventilation system, evaporative cooling system, heating system and humidifier)	
		Grafting knives	
		High intensity discharge lamps (Metal halide or High Pressure Sodium)	
		Hoses and nozzles	

1=Strongly Disagree, 2=Disagree, 3=Neither Agree/Nor Disagree, 4=Agree, 5=Strongly Agree			
Rating	**Equipment or Component "E" or "C"**	**Item**	**Comments**
	E	Hydroponics unit, Ebb & Flow	
	E	Hydroponics unit, Drip hydroponics	
	E	Incubators	
	C	Internet connections	
	E	Lab jackets	
	E	Laboratory tables	
	E	LCD projectors	
	E	Lenses, hand	
	E	Lenses, magnifying	
		Macro-invertebrate test kit	
	C	Microscope slides and cover slips	
	E	Microscopes, binocular	
	E	Microscopes, dissecting	

1=Strongly Disagree, 2=Disagree, 3=Neither Agree/Nor Disagree, 4=Agree, 5=Strongly Agree			
Rating	**Equipment or Component "E" or "C"**	**Item**	**Comments**
	E	Microscopes, electric	
	C	Misting system (mist nozzles complete with pipe, risers, timers)	
		Nets or seines	
	E	Nitrate test kits	
		Nitrite test kits	
	E	Petri dishes	
	E	pH meters	
	E	pH test kits	
		Phosphorus test kit	
	C	Pipette pumps	
	E	Pipettes	
		Plant grow tables	

1=Strongly Disagree, 2=Disagree, 3=Neither Agree/Nor Disagree, 4=Agree, 5=Strongly Agree			
Rating	Equipment or Component "E" or "C"	Item	Comments
		Pots, various sizes	
		Potting media table	
	E	Power sprayer (cart with hose and sprayer gun)	
		Pressure Washer	
	C	Printers	
	E	Refrigerator	
	E	Root growth chamber	
	E	Safety goggles	
	E	Scales or balances	
	E	Scalpels	
	E	Scissors	
		Seed model	

1=Strongly Disagree, 2=Disagree, 3=Neither Agree/Nor Disagree, 4=Agree, 5=Strongly Agree			
Rating	**Equipment or Component "E" or "C"**	**Item**	**Comments**
	E	Solubridge tester (device used to measure electrical conductive properties of soil paste)	
	C	Stirring rods	
		Sterilizing equipment	
	E	Stove/oven	
		Television	
	C	Test tube racks	
	E	Test tube thermometers	
	E	Test tubes	
	E	Thermometers	
		Tissue Culture kit	
		Trowels	
	E	Tweezers or forceps	

1=Strongly Disagree, 2=Disagree, 3=Neither Agree/Nor Disagree, 4=Agree, 5=Strongly Agree			
Rating	Equipment or Component "E" or "C"	Item	Comments
		Video Cassette Recorder (VCR)	
	E	Water quality test kits (includes water hardness)	
		Water pumps	

Vitae

Thomas W. Broyles

Home Address	Email Address	Employment Address
315 Meadow Drive Christiansburg, VA 24073 (540) 381-3133	tbroyles@vt.edu	282 Litton Reaves Hall Virginia Tech Blacksburg, VA 24061 (540) 231-8188

EDUCATION

Institution	**Dates of Attendance**	**Degrees**
Virginia Polytechnic Institute and State University	2000-June 2004	Ph.D., Career and Technical Education. • Emphasis in Teacher Education and Agricultural Mechanics. • 3.78 GPA.
Virginia Polytechnic Institute and State University	1999-2000	M.S., Vocational and Technical Education.
Virginia Polytechnic Institute and State University	1989-1994	B.S., Animal Science.

TEACHING EXPERIENCE

2003-2004 Virginia Polytechnic Institute and State University

- Courses and Accomplishments
  - Research Applications in Agricultural and Extension Education (Distance delivered), Methods of Program Planning, and Methods of Teaching in Career and Occupational Education course for the Agricultural and Extension Education Department.
  - Undergraduate Coordinating Counselor.
  - University supervisor for student teachers.
  - Advise over 25 undergraduate students.
  - Admissions and Financial Aid Taskforce member.
  - Advisor for Alpha Tau Alpha.
  - Departmental webmaster.

2002-2003 Virginia Polytechnic Institute and State University

- Courses and Accomplishments
  - Teaching Agricultural Mechanics, Agricultural Metal Fabrication, and Materials and Procedures of Agricultural Construction for the Agricultural and Extension Education Department.
  - Developed and distributed course materials through a course web site for both courses taught.
  - Developed a peer teaching program.

2000-2002 Virginia Polytechnic Institute and State University

- Courses and Accomplishments
  - Agricultural Buildings for the Agricultural Technology program.
  - Designed electronic curriculum materials to be distributed through a compact disc.

2000-2002 Virginia Polytechnic Institute and State University

  - Co-taught Methods of Teaching in Career and Occupational Education course for the Agricultural and Extension Education program.
  - Developed and distributed course materials through a course web site.
  - Assisted with curriculum updates and changes.
  - Created teaching lessons for pre-service teachers.

1996-1999 Fauquier County Public Schools Vocational Agricultural Educator

- Courses and Accomplishments
  - Agricultural Mechanics and Basic Plant Science, Agricultural Mechanics and Basic Animal Science, Agricultural Machinery Services I, II, III, and Natural Resource Management I, II, III.
  - Educated middle school students at two different middle schools.
  - Educated high school students at two different high schools.
  - Advised federation, area, and state FFA career development event contestants.
  - Advised FFA chapter with over two hundred members.

OTHER EXPERIENCE

2003 Virginia Governor's School for Agriculture

- Director
  - Responsible for budgets and operation of the program.
  - Responsibilities include planning, operating, and evaluating the School.
  - Supervised staff members for the duration of the school.

2003 Agricultural and Extension Education

- University Supervisor
  - Supervised two student teachers during student teaching internship.

2001-2003 Virginia FFA

- Career Development Coordinator
  - Designed and implemented Junior FFA State Agricultural Mechanics Career Development Event.
  - Designed and implemented Senior FFA State Agricultural Mechanics Career Development Event.

2001-2002 Virginia FFA

- Career Development Coordinator
  - Designed and implemented Middle School FFA State Agricultural Mechanics Career Development Event.

2000-2002 Virginia Governor's School for Agriculture

- Assistant Director
  - Assisted in creating and implementing the Governor's School for Agriculture.
  - Responsibilities include working closely with the Director in planning, operating, and evaluating the School.
  - Supervised staff members for the duration of the school.
  - Coordinated activities and transportation for activities.
  - Developed handbooks for students, parents, and faculty.

PRESENTATIONS AND PUBLICATIONS

National

Broyles, T .W. & Swafford, D. (2004). Project Farmbots: Fabricating Agricultural Machinery for the Benefit of Agriculture and Technology Students. Poster will be presented at the National Agricultural Education Research Meeting, St. Louis, MO.

Duncan, D. W., & Broyles, T. W. (2004) Virginia Governor's School for Agriculture: Did It Make a Difference? Poster will be presented at the National Agricultural Education Research Meeting, St. Louis, MO.

Broyles, T. W. (2003, October). *Virginia Governor's School for Agriculture.* Presentation made at the National Association Supervisors of Agricultural Education meeting, Louisville KY.

Broyles, T. W., & Camp, W. G. (2002). *Virginia Governor's School for Agriculture*. Poster presented at the National Agricultural Education Research Meeting, Las Vegas, NV.

Duncan, D. W., & Broyles, T. W. (2002). *Evaluation of students perceptions and attitudes toward agriculture before and after attending the Virginia governor's school for agriculture*. Paper presented at the 2002 North American Colleges and Teachers of Agriculture Annual Conference, Lincoln, NE.

Camp. W. G., Broyles, T. W., & Shantz, N. S. (2002). *A national study of the supply and demand for teachers of agricultural education in 1999-2001*. Paper posted on the American Association for Agricultural Education web page (http://www.aaaeonline.org).

Regional

Duncan, D. W., & Broyles, T. W. (2003). *Evaluation of students perceptions and attitudes toward agriculture before and after attending the Virginia governor's school for agriculture*. Paper will be presented at the 2004 SAERC Conference, Tulsa, OK.

Broyles, T. W., & Camp, W. G. (2002). *Virginia governor's school for agriculture*. Poster presented at the Southern Agricultural Education Research Meeting, Orlando, FL

Melton, B., Zience, A., Leonard, S., Pick, E., Thomasson, L., Camp, W. G., & Broyles, T. W. (2002). A comparison of behaviorist and constructivist-based teaching methods in psychomotor instruction. *Journal of Southern Agricultural Education Research, 53(1), 188-197.*

Melton, B., Zience, A., Leonard, S., Pick, E., Thomasson, L., Camp, W. G., & Broyles, T. W. (2002). *A comparison of behaviorist and constructivist-based teaching methods in psychomotor instruction.* Paper presented at the Southern Agricultural Education Research Meeting, Mobile, AL

State

Broyles, T. W. (2004, March). *OPEESA Small Engine Certification Workshop.* Presentation made to Agricultural Education and Trade and Industrial Teachers.

Broyles, T. W. (2004, March). *Methods of Instruction.* Presentation made at the Extension Programming Institute. March 10-11 Roanoke Virginia.

Broyles, T. W. (2004, January). *Virginia FFA Middle School Agricultural Mechanics Career Development Event.* Presentation made at the Virginia Middle School Workshop.

Broyles, T. W. (2003, October). *Workshop for Cooperating Teachers.* Presentation made at the Agricultural Education Leadership Conference.

Broyles, T. W., & Hillison, J. (2000). *Production Agriculture Lesson Plans.* Distributed by the Agricultural Education Program Area, Virginia Polytechnic Institute and State University.

Local

Broyles, T. W. (2002, March). *Virginia Governor's School for Agriculture.* Presentation made at the Southwest Virginia Agricultural Association, Inc. business meeting.

Broyles, T. W. (2003, September). *Virginia Governor's School for Agriculture.* Presentation made at the Appalachian Area Leadership Conference.

MEMBERSHIPS

National

American Association of Agricultural Education (AAAE)
- Member

Association for Career and Technical Education (ACTE)
- Member

American Vocational Education Research Association
- Member

National Association for Agricultural Educators (NAAE)
- Member
- Virginia Voting Delegate at the 2002 NAAE National Meeting

National FFA Agricultural Mechanics Career Development Event
- Committee Member

State

Virginia Association for Agricultural Educators (VAAE)

- Member

Virginia Association for Career and Technical Education (VACTE)

- Member

Honorary Organizations

Gamma Sigma Delta

- Member

Omicron Tau Theta

- President (2002-2003)
- Vice President (2001-2002)

Alpha Tau Alpha

- Vice President (2001-2002)

HONORS

Outstanding Graduate Poster Presentation Award at the 2002 Southern Region Agricultural Education Conference.

Nevin R. Frantz Award for the outstanding graduate student in Career and Technical Education at Virginia Tech.

Rufus Beamer Scholarship Award

GRANTS AND AWARDS

Governor's School for Agriculture

- 2003-2005 Principal Investigator
- Budget - $200,000 per year

RFP in progress for Governor's School for Agriculture

- 2006-2010 Principal Investigator
- Budget - $225,000 per year

RFP submitted to National Science Foundation

- 2004-2008 Co-Principal Investigator
- Total Budget for project- $167,500
- Collaboration with Texas A&M University
- Purpose of project is to increase science and math ability of students enrolled in agriculture education.