Public School Administrators' Ratings of the Biological and Physical Science Competencies Needed By Beginning Agricultural Science Instructors

Timothy D. Rocka[1]
Cypress Fairbanks Independent School District
Houston, TX 77065

Douglas G. Morrish[2]
Texas State University
San Marcos, TX 78666

Abstract

As we enter a new era of global competition, it is appropriate to examine science content needs of agricultural science instructors in order to keep agricultural education in the public school setting scientific and technologically advanced. This study examined public school administrators' ratings of the biological and physical science competencies needed by beginning agricultural science instructors.

A three-round Delphi technique was used to collect the data. Each round allowed the expert panelists (school administrators) to converge on a consensus that the identified biological and physical science competencies were ones needed by beginning agricultural science instructors. The study revealed that consensus (≥ 75% agreement) was reached for 12 competencies in the biological science area and 17 competencies in the physical science area. The study recommends that teacher education programs restructure to include a required course for future agricultural science instructors on how to effectively incorporate biological and physical science competencies in to the existing agriculture curriculum.

Introduction

In today's educational news, much is heard about increasing the science and math competencies of our school students due to the fact that the United States is lagging behind other countries in both discipline areas (OECD, 2010). To mend that situation, the STEM (science, technology, engineering, and mathematics) Coalition was developed to increase awareness in Congress about these four discipline areas (STEM Coalition, 2010). Also, state education agencies have incorporated more math and science credits into the graduation plan of the future students (No Child Left Behind, 2010). The Perkins Act (2006) provided funds to help with the integration of academics and technical education (Hyslop, 2008). The integration of science into agriculture courses has proven to be a difficult task though. Agriculture teachers do not posses confidence and self-efficacy about the subject matter (Warnick, 2004). Most recommending institutions of agricultural science instructors require the completion of courses similar to what was required in the past. Bruening et al., (2001) explain these past course requirements as the remains of an older production-manufacturing era of society even though it is evident that the purpose and scope of contemporary agricultural science has shifted away from the production model (National Council for Agricultural Education (NCAE), 1999).

Teacher education programs lag behind in preparing beginning teachers with the knowledge and skills required to fully integrate these science competencies into the agriculture classroom (Warnick, 2004). As a result, Joerger (2002) recommended that a need existed to provide up-to-date pre-service and in-service activities to agriculture teachers to prepare them for the changing technology of the discipline. Peake et al., (2007) discovered that Georgia agriculture teachers put a high importance on integrating science in to agriculture. The same researchers also discovered that the top rated pre-service and in-service training need for the teachers was the "integration of current agricultural technological advances in to the curriculum."

There have been a multitude of studies performed related to agricultural science instructor professional development competencies (Joerger, 2002; Edwards and Briers, 1999; Dobbins and Camp, 2000; Roberts and Dyer, 2004; Peiter et al., 2003). However, there has been little research related to biological and physical science competencies needed by beginning agricultural teachers. Currently, teacher credentialing agencies assume that these competencies of beginning teachers are gained by satisfying the requirements of a bachelor's degree in a scientific field such as agriculture. This creates a dilemma for newly hired agriculture teachers. Even though they have obtained bachelor's degrees in

[1]Director of Human Resources, Cypress Fairbanks Independent School District
[2]Assistant Professor, Department of Agriculture

agriculture (a high science area), they may not understand how to effectively implement science competencies in to the curriculum (Warnick, 2004).

Purpose and Objectives

The National Standards for Teacher Education (AAAE, 2001) indicated that a balanced curriculum for agricultural instructors consisted of three specific areas: general education, technical agriculture content, and pedagogy professional skills. Roberts et al., (2006) found that the document failed to indicate the specific competencies and traits agricultural science teachers should possess. The purpose of this study was to identify one facet of the specific competencies: the biological and physical science competencies needed by beginning agricultural science teachers. The specific objectives of the study were as follows:

1. Identify the biological and physical science competencies needed by beginning agricultural science instructors through a panel of public school administrators.
2. Formulate recommendations to be utilized for the future planning of teacher preparation.

Materials and Methods

This study focused on identifying the biological and physical science competencies needed by beginning agricultural science instructors. It was determined that the best means of collecting the necessary information would be obtained by utilizing the Delphi technique. The Delphi is a process used to provide a detailed examination of a topic or problem through the use of an expert panel (Beech, 1999; Adler and Ziglio, 1996; Chizari, 1990; Stufflebeam, et al., 1985). Delphi allows the development of a consensus on issues without bringing participants in face to face contact. At the initiation of the Delphi technique, the panelists will typically have opposing opinions and differentiated ideas related to the research questions; however, it is expected that consensus can be reached and obtained after the panel converges on the issues being studied.

A group of 12 innovative public school administrators from Texas was identified and nominated to serve as expert panelists. Demographical information of the group is presented in Table 1. These public school administrators were nominated by three primary sources: members of the state education agency, members of the State Board of Educator Certification, and graduate faculty from a university reputable for teacher training. All nominated participants on the panel were superintendents, principals, or career and technology directors who had experience with supervising agricultural education programs. Some expert administrators who were nominated included those serving on the State Board of Educator Certification Committee to aid in the development of standards for agricultural science and technology in Texas.

Table 1. Demographical Information of Expert Panelists

Characteristic		Number of ADM Experts
Age Range		
	21 to 30	1
	31 to 40	-
	41 to 50	5
	51 to 60	6
Gender		
	Female	-
	Male	12
Experience		
	Public School Teaching	12
	Public School Administration	12
	Other Professional Experience	-
Education Level		
	Master's Degree	9
	Doctoral Degree	3

A three-round Delphi was issued to collect the data. The objective of the first-round questionnaire was to ask the experts to identify the biological and physical science competencies needed by beginning agricultural science instructors. Biological science was defined as "the scientific study of living things, which include animals, plants, and other living organisms and can include those things which are closely associated with living organisms" (Merriam-Webster, 2010). Physical science was defined as "the scientific study of non-living things including physics, chemistry, and astronomy" (Merriam-Webster, 2010).

The second-round questionnaire included all of the competencies identified by the panel experts in the first-round and used a format of 1 to 6 scale to further refine their opinions. They were asked to rate the identified competencies using the following scale: 1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = somewhat agree, 5 = agree, and 6 = strongly agree. At least 75% of the experts had to rate the competencies a 5 or 6 in order for it to be considered a consensus agreement (Weatherman and Swenson, 1974). The round two instruments also provided a column for the participants to make comments. If the participants believed that a competency should be placed within a different conceptual area, another column was provided for the panelists to respond respectively. Also, a separate section was provided to allow panelists to add additional competencies to any of the two previous conceptual areas should they feel that additional competencies be identified.

The purpose and intent of the third-round was to further refine the responses identified in the second-round questionnaire. To accomplish that, a dichotomous "Yes or No" response instrument was used. Experts responded with a "Y" if they were in agreement that the specific competency was one needed by a beginning agricultural science instructor and with "N" if not. A consensus was reached with the use of the third-round questionnaire; therefore, the researchers determined that an additional fourth-round questionnaire did not need to be administered.

Results and Discussion

In round 1, expert panelists were asked to identify the biological science competencies needed by beginning agricultural science instructors. Due to extenuating circumstances, one identified expert panelist had to withdraw from the study. Respondents (n=11) listed as many biological competencies as deemed necessary for a beginning agriculture instructor to possess. As seen in Table 2, 25 competencies were recorded during this initial round. Upon examination of the 25 competencies, it was found that four major themes surfaced: animal science, plant and soil science, environmental science, and horticulture/floriculture science. Additionally, expert panelists were asked to identify the physical science competencies needed by beginning agricultural science instructors. Table 3 indicates that 26 competencies in this area were identified by expert respondents. These competencies also fell in to major theme areas: earth science, soil science, agricultural engineering, and chemical aspects of agriculture. Duplicate and redundant responses for both the biological and physical competencies were combined.

After the initial round, competencies were collected and expert panelists were asked to rate their agreement that each one was needed by a beginning agricultural science teacher. As shown in Table 4, all (100%) responding experts (n=11) were in agreement that plant and soil science, anatomy of animals, animal nutrition, and animal health were biological science competencies needed by beginning teachers. Eight additional biological science competencies fell in to the general consensus category (≥ 75% rated the competency a 5 or 6). For approximately half of the 25 identified biological competencies, experts did not reach the agreement level, thus they did not appear in the round 3 instrument. The two competencies that received the lowest level of agreement (36.3%) included: the economics of higher level of production through improved biology and specialty animals including canine, avian, and tropical fish.

Table 5 indicates that responding experts (n=11) reached 100% agreement in four physical science competency areas including plant science (fertilizers, minerals, inorganic and organic), feed rations / feed additives, welding (gas and electric), and water requirements of plants. In an additional 13 physical science competencies, the experts reached consensus agreement (≥ 75% rated the competency a 5 or 6). The remaining eight physical science competencies did not make consensus, thus were not deemed important by school administrators and did not make it to round three. Two physical science competencies related to weather had the lowest level of agreement with school administrators. These included concepts associated with moon phases and climatology (36.3% agreement) and modern technology used to influence weather (27.3% agreement). Even though two columns were made available for experts to make changes to the competencies or provide comments, the option was not utilized by any of the respondents on either the biological or physical science competencies.

The round-three instrument was developed from the responses of the round-two instruments. Again, the instrument used a dichotomous rating scale of Yes or No to measure whether or not the experts believed the biological or physical science competency was one that was needed by beginning agricultural science instructors. It

Table 2. Responses from Round-One: Biological Science

Biological Science Competencies	
Anatomy of animals-how life is sustained; cell growth	Entomology
Plant and animal reproduction	Agricultural biotechnology
The future role of genetics in the production of plants and animals	Environmental and natural resources systems
Global impact of biological science	Animal physiology systems; cardiovascular, nervous
The economics of higher level production through improved biology	Animal health and nutritional resources
Biotechnology and its future in our society	Agricultural chemicals
Animal anatomy and physiology	Microbiology
Animal genetics and reproduction	Skeletal systems
Food and fiber production	Animal nutrition
Environmental knowledge	Animal health and parasites
Breeds of livestock	Artificial Insemination/Embryo Transfer
Broad based knowledge of specialty animals- canine, avian, tropical fish: Applicable in urban environment	Horticulture/Floriculture
	Plants and soil science

Table 3. Response from Round-One: Physical Science

Physical Science Competencies	
Soil science; formations and types	The interaction of the physical environment with basic living organisms
Plant science; Fertilizers, minerals, inorganic and organic	Water requirements of plants
Earth science; Weather conditions/planning seasons	Soil classification systems
Feed rations/ feed additives	Inorganic and organic fertilizers
Welding; gas and electrical	The development of consumer products
Basic engineering physics for shop projects	General physic; Industrial, engineering, and manufacturing concepts
Chemical properties associated with plant and animal production	Soil structures
The influence of weather on production agriculture	Photosynthesis
Modern technology used to influence weather	Soil profiles
Physical concepts associated with power systems	Soil classes
Physical concepts associated with moon phases and climatology	Electricity; Basic terms and principals
Environmental issues facing our future generations	Engines and power supplies; internal combustion engines
Global warming and its effect on agriculture	

was decided a priori by the researchers that any competency which yielded a 75% or greater "Yes" rating among the administrator panel would be considered having reached consensus by the group. Table 6 shows the responses to the round-three instrument. Consensus for 12 competencies was reached in the biological conceptual area and for 17 competencies of the physical science conceptual area. All of the biological and physical science competencies that reached consensus in round two did so in round three. Thus, a panel of experts from public school administration was in agreement that 12 competencies in the biological science area and 17 competencies in the physical science area were needed by beginning agricultural science instructors.

Table 4. Percentage of Agreement for Round-Two Biological Science Competency

Competency	% Agreement
Plants and soil science	100.0%
Anatomy of animals-how life is sustained; cell growth	100.0%
Animal nutrition	100.0%
Animal health and parasites	100.0%
Plant and animal reproduction	90.9%
Animal anatomy and physiology	90.9%
Animal health and nutritional resources	90.9%
The future role of genetics in the production of plants and animals	81.8%
Horticulture/Floriculture	81.8%
Agricultural biotechnology	81.8%
Animal genetics and reproduction	81.8%
Breeds of livestock	81.8%
Food and fiber production	72.7%
Environmental knowledge	72.7%
Entomology	72.7%
Environmental and natural resources systems	72.7%
Agricultural chemicals	72.7%
Skeletal systems	72.7%
Artificial Insemination/Embryo Transfer	72.7%
Animal physiology systems; cardiovascular, nervous	54.5%
Microbiology	54.5%
Biotechnology and its future in our society	45.5%
Global impact of biological science	45.5%
The economics of higher level production through improved biology	36.3%
Broad based knowledge of specialty animals- canine, avian, tropical fish: Applicable in urban environment	36.3%

Table 5. Percentage of Agreement for Round-Two Physical Science Competency

Competency	% Agreement
Plant Science; fertilizers, minerals, inorganic and organic	100.0%
Feed rations/ feed additives	100.0%
Welding; gas and electrical	100.0%
Water requirements of plants	100.0%
Soil Science; formations and types	90.9%
Basic engineering physics for shop projects	90.9%
Inorganic and organic fertilizers	90.9%
Photosynthesis	90.9%
Electricity; basic terms and principals	90.9%
Engines and power supplies; internal combustion engines	90.9%
Chemical properties associated with plant and animal production	81.8%
The influence of weather on production agriculture	81.8%
Soil classification systems	81.8%
The development of consumer products	81.8%
Soil structures	81.8%
Soil profiles	81.8%
Soil classes	81.8%
The interaction of the physical environment with basic living organisms	72.7%
Earth Science; Weather conditions/planning seasons	72.7%
Physical concepts associated with power systems	72.7%
Environmental issues facing our future generations	63.6%
Global warming and its effect on agriculture	54.5%
General physic; Industrial, engineering, and manufacturing concepts	45.4%
Physical concepts associated with moon phases and climatology	36.3%
Modern technology used to influence weather	27.3%

Summary

The purpose of this study was to examine public school administrators' ratings of the biological and physical science competencies needed by beginning agricultural science instructors. The results of this study may be used to assist agricultural teacher education programs in making changes to existing curriculum and to start conversation about possibly adding a course to teach future instructors how to effectively implement science in their agriculture classrooms. It may seem that the biological and physical science competencies identified by the expert panelists in this study are nothing out of the ordinary, but as found by Warnick (2004), many agriculture teachers do not possess confidence to integrate scientific concepts in to their agriculture courses.

The study found that three-fourths or more of the administrators of agricultural education programs agreed on 29 competencies needed by beginning agricultural science instructors. Among these competencies, 12 were associated with the biological sciences and 17 were associated with the physical sciences. The biological and physical science competencies that did not reach consensus may have done so for two reasons. These reasons could include: 1) geographical locations of the agricultural education programs and 2) background experience of the expert panelists. Expert panelists that indicated that science concepts related to specialty animals (canine, avian, and tropical fish) were needed may have done so due to the fact that they live in an urban or suburban area and have a high enrollment rate of non-traditional agriculture students. Expert panelists who live in a geographical area with more of a traditional agriculture student population may have rated these competencies very low, thus dropping it to a level that was not high enough for general consensus. Additionally, if an expert had a strong background in mechanics or animal science, they may have the perception that all beginning agriculture instructors should be strong in this area.

Table 6. Percentage of Agreement for Round-Three Competency

Agricultural System	Competency	% Agreement
Biological Science	Anatomy of animals-how life is sustained; cell growth	100.0%
	Plant and animal reproduction	100.0%
	Animal anatomy and physiology	100.0%
	Animal genetics and reproduction	100.0%
	Breeds of livestock	100.0%
	Plants and soil science	100.0%
	Animal health and nutritional resources	100.0%
	Animal health and parasites	100.0%
	Horticulture/Floriculture	100.0%
	The future role of genetics in the production of plants and animals	90.9%
	Agricultural biotechnology	90.9%
	Animal nutrition	90.9%
Physical Science	Soil Science; formations and types	100.0%
	Plant Science; fertilizers, minerals, inorganic and organic	100.0%
	Feed rations/ feed additives	100.0%
	Welding; gas and electrical	100.0%
	Water requirements of plants	100.0%
	Soil classification systems	100.0%
	Inorganic and organic fertilizers	100.0%
	Soil structures	100.0%
	Photosynthesis	100.0%
	Soil profiles	100.0%
	Electricity; basic terms and principals	100.0%
	Engines and power supplies; internal combustion engines	100.0%
	Basic engineering physics for shop projects	90.9%
	Chemical properties associated with plant and animal production	90.9%
	The influence of weather on production agriculture	90.9%
	Soil classe	90.9%
	The development of consumer products	81.8%

With a national perspective in mind, the National Council for Agricultural Education conducted a comprehensive review of a strategic plan for agricultural education. It produced several initiatives, including the publication The *Reinventing of Agricultural Education for the Year 2020* (NCAE, 1999). Its mission focuses primarily on the career preparation of students with emphasis on making students aware of global agricultural systems, food and fiber systems, and natural resources systems that are related to agriculture. Because of this shift in focus of agricultural education as defined by the National Council for Agricultural Education (1999), our study was necessary to determine the appropriate biological and physical science competencies needed by beginning instructors of agricultural education. Teacher education programs should be restructured to incorporate all of the recommended biological and physical science competencies by the administrators of agricultural education included in this study; and teach future agriculture education instructors how to integrate these science-based competencies into their agriculture courses. Even if these competencies are already included in curriculum, it may strengthen the self efficacy and confidence of future teachers to add a course whose sole purpose is to teach the integration of science in to the agriculture classroom. This could add credibility to the agriculture program at the high school or middle school level in two ways: 1) if agriculture is not offered as a science credit, having a teacher with a strong background in science could strengthen the program and 2) team teaching opportunities could increase between the agriculture and science departments. Additionally, teacher education programs and state agriculture teacher organizations should provide frequent professional development opportunities for teachers to keep up to date with the changing pace of science competencies within agriculture.

Joerger (2002) recommended that pre-service activities should be current and keep up to date with changing technology. Many of the expert panelists identified competencies that deal with a science that is ever changing and becoming more highly advanced. Some of these areas include teaching cell physiology, animal reproduction practices, the role of genetics, soil sciences, biotechnological practices, and engines / alternative fuels. The future will require new, innovative approaches to teaching agricultural science using much different information. Teaching future agricultural science instructors how to effectively integrate these biological and physical science competencies is a start of how agricultural education can contribute to closing the gap between the United States and other countries in the discipline of science.

Since this study was directed toward Texas agricultural education instructors, generalizations can not be made beyond this population, but it raises the question of similar needs in other states. Science integration in to the agriculture classroom is not state specific and should be examined nationally to keep agricultural education on the forefront of scientific advances. The study examined only one group (administrators) of many to identify the biological and physical science competencies. It would be beneficial to examine the ratings of other groups, such as current agriculture instructors, science instructors, and teacher educators nationally.

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