Science Concepts Included in Courses Taken by Preservice Agricultural Education Teachers

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Abstract

This case study sought to identify the science concepts that preservice teachers had an opportunity to learn through coursework taken to complete their degree. It was found that 170 different courses were taken by the 59 preservice teachers to satisfy degree requirements in science. Of that, 73 different courses were taken in core sciences to satisfy the 9 credit hour requirement and 97 courses were taken in applied agricultural science to satisfy the 30 credit hours required. Using the science standards referenced in the AFNR Career Cluster Standards, students had the opportunity to learn the standards associated with Science as Inquiry, Life Science, Science in Personal & Social Perspectives, and the History & Nature of Science. In contrast, very few students had the opportunity to learn the standards associated with Physical Science and Earth & Space Science. The findings imply changes should be made in the courses taken by preservice teachers. Although this case study included data from only one university, the results herein may have implications for other universities, especially programs that have a large number of students that transfer from a community college. The research protocols established in this study can provide a transferrable model for examining this issue.

Introduction

Beginning with the 1988 National Research Council (NRC) report, agricultural education has steadily increased emphasis on science instruction integrated into the agriscience classrooms. With this emphasis on integration, teachers are being required to teach science concepts more explicitly. This emphasis has been so wide-spread that state legislation, as well as the national Carl D. Perkins Career and Technical Education Act (2006), have demanded more rigorous content taught in CTE courses (Public K-12 Educational Instruction, 2010). The emphasis continued via national calls for increasing science learning opportunities for students through reformed methods of teaching science (AAAS, 1989, 1993; NRC, 1996). The general message has been that agricultural education courses are great vectors for applying science concepts. Yet the underlying question is, are agricultural education teachers prepared for this task?

Theoretical Framework

This study was framed using an assumption that teachers need content knowledge, pedagogical knowledge, and pedagogical content knowledge (Roberts & Kitchel, 2010). Content knowledge refers to an understanding of subject matter and curriculum goals, pedagogical knowledge refers to standards of teaching, learning, and how learners develop, and pedagogical content knowledge refers to abilities to teach specific content matter (Bransford et al., 2000; Roberts & Kitchel, 2010). This study specifically examined content knowledge.

Several studies have begun to look at the issue of content knowledge. Teachers from Arkansas were surveyed for undergraduate courses taken in science to satisfy their degree requirement. Respondents took the most courses in biology, followed by chemistry, while physics was taken the least (Johnson, 1996). Earth science courses had the highest level of teacher success in undergraduate courses, while chemistry courses saw the lowest level of achievement during teachers' undergraduate studies (Johnson, 1996).

Other research showed that a lack of understanding science concepts is a deterrent to science integration. Preservice teachers felt insufficient in background knowledge in science content (Thoron & Myers, 2010). Additionally, Warnick and Thompson (2007) demonstrated that science teachers and agriculture teachers felt that agriculture teachers had a lack of science competence and that this was a barrier to integrating science.

Teachers' perceptions may not correspond with their capabilities. Secondary school agriculture teachers in Missouri felt capable of teaching all but one science standard from the state standards (Scales, Terry, & Torres, 2009). When the same population was assessed for their science content proficiency, less than 10% of the sample placed at the 'proficient' level for science competence (Scales et al., 2009). Thus, agricultural science teachers demonstrated a lack of mastery of content. In a separate study, one-third of Florida teachers perceived that insufficient background as a barrier (Myers & Washburn, 2008). However, the typical respondent for this study was a 15-year teacher veteran with at least a bachelor's degree in a field other than agricultural education, so these findings may not be indicative of new graduates.

Based on the literature above, many researchers have examined the science content knowledge of agricultural education teachers. These studies give insight into *what* teachers know, but not *where* and *how* they learned what they know. Only one study examined the coursework of preservice teachers and that study relied on secondary data (Johnson, 1996). This study will add to the understanding of this problem by using primary data from student records.

Purpose and Objectives

This purpose of this case study was to identify the science concepts that preservice teachers had an opportunity to learn as a part of their degree program. The objectives were:

1. List the courses taken by preservice teachers to satisfy the science requirements; and
2. Describe the science concepts included in those courses.

Methodology

This case study sought to identify the science competencies experienced by preservice teachers based on the National Agriculture, Food and Natural Resources (AFNR) career cluster content standards (National Council for Agricultural Education [NCAE], 2009). The science competencies are those standards from the National Science Education Standards aligned to the AFNR career cluster content standards (National Academy of Sciences, 1995; NCAE, 2009). There were 33 science standards present in the AFNR Standards (Table 1).

Table 1
Science Standards Referenced in the AFNR Career Clusters' Content Standards

Standard	Benchmark Number and Description	
A	*Content Standard: Science as Inquiry*	
	A1	Identify questions and concepts that guide scientific investigation.
	A2	Design and conduct scientific investigations.
	A3	Use technology & mathematics to improve investigations and communications.
	A4	Formulate & revise scientific explanations & models using logic and evidence.
	A5	Recognize and analyze alternative explanations and models.
	A6	Communicate and defend a scientific argument.
B	*Content Standard: Physical Science*	
	B1	Structure of atoms.
	B2	Structure and properties of matter.
	B3	Chemical reactions.
	B4	Motions and forces.
	B5	Conservation of energy and increase in disorder.
	B6	Interactions of energy and matter.
C	*Content Standard: Life Science*	
	C1	The cell.
	C2	Molecular basis of heredity.
	C3	Biological evolution.
	C4	Interdependence of organisms.
	C5	Matter, energy, and organization in living systems.
	C6	Behavior of organisms.
D	*Content Standard: Earth and Space Science*	
	D1	Energy in the earth system.
	D2	Geochemical cycles.
	D3	Origin and evolution of the earth system.
	D4	Origin and evolution of the universe.
E	*Content Standard: Science and Technology*	
	E1	Abilities of technological design.
	E2	Understanding about science and technology.
F	*Content Standard: Science in Personal and Social Perspectives*	
	F1	Personal and community health.
	F2	Population growth.
	F3	Natural resources.
	F4	Environmental quality.
	F5	Natural and human-induced hazards.
	F6	Science and technology in local, national, and global challenges.
G	*Content Standard: History and Nature of Science*	
	G1	Science as human endeavor.
	G2	Nature of scientific knowledge.
	G3	Historical perspectives.

A descriptive case study design was used to identify the science concepts that preservice teachers experienced throughout their degree programs. A descriptive case study presents a summary using numbers to characterize the different groups or individuals in an existing phenomenon (MacMillan & Schumacher, 2010). Courses taken to complete degree requirements were analyzed in two forms for the inherent science competencies. The researchers conducted a content analysis of the course syllabi, followed by a survey of instructors for validation. For each assessment, standards were evaluated as: (a) being present within the course, (b) standards needed prior to taking the course, or (c) a standard unrelated to the course.

For objective one, the population was courses taken by the 59 preservice teachers at [university] to satisfy degree requirements in core science and applied agricultural sciences over a five-year period (*N* = 170 courses). The sample for objective two was courses taken by a minimum of 10% of the students in the population from objective one (*n* = 33 courses). Researchers deemed that using the baseline of 10% removed atypical courses.

Student records were the original data source used to generate the list of courses for objective one. Approval was gained from the Institutional Review Board to have a third-party strip identifying information from the records. After the records were stripped, the researchers compiled and classified the list of courses into science and non-science courses to remove non-applicable courses. Then the science courses were further categorized as core science courses or applied agricultural science courses (MacMillan & Schumacher, 2010). The classification was completed using a coding book that was reviewed by a panel of experts and based on the [university] course catalog ([university], 2012). It is important to note that preservice teachers at the [university] often transfer to the university after completing some courses in the community college system. Core science courses were often completed at a community college.

Data for objective two were analyzed through a content analysis. Quantitative content analysis was defined by Berelson (1952) as “a research technique for the systematic, objective, and quantitative description of the manifest content” (p. 18). In this study, the manifest content was the science content expressed in the course syllabi. The assessment of such content requires interpretation of content supported by theoretical rationales and empirical evidence (Messick, 1989; Rourke & Anderson, 2004). According to the AFNR standards there are thirty-three science standards, which became the theoretical rationale for content assessment.

To ensure the data are reliably assessed, objectivity of coding is the main premise (Rourke, Anderson, Garrison, & Archer, 2001). As with test validity, a clearly defined coding protocol increases the objectivity of the coding procedure and in turn the reliability (Rourke et al., 2001). The protocol was defined as the science standards from the AFNR standards, which have been defined by a panel of experts (NCAE, 2009). To validate and elaborate on the content analysis of syllabi, instructors of the courses were also surveyed. To identify the point of contact, faculty were identified by the syllabi, by contacting department correspondents, or by recommendation by other faculty. Faculty were contacted via email with an electronic survey in accordance with the Tailored Design Method from Dillman, Smyth, and Christian (2009).

The same AFNR standards were items of the survey distributed to the identified instructors. The survey items asked instructors to judge whether the content of the science standards was: (a) present, (b) a prerequisite for, or (c) not a part of the course they taught. The researchers designed the survey instrument, and therefore the validity of the instrumentation needed to be established. Test validity relates to the appropriateness, meaningfulness, and usefulness of the numeric sores which are used to make the inferences for conclusions (MacMillian & Schumacher, 2010). To ensure that the inferences from the data collected were valid, the content of the items within the survey was based on domains of the science content as defined by a panel of experts (MacMillian & Schumacher, 2010). The science standards used for the survey items were defined by experts as part of the national academic standards for science. The science standards were defined through four years of work by twenty-two scientific and science education societies and over 18,000 individual contributors (National Academy of Sciences, 1995). These standards were aligned to the AFNR standards by a panel of experts, which consisted of both core academic and agricultural teachers (NCAE, 2009).

Results

Courses Taken by Preservice Teachers

Students took 170 different courses to satisfy the degree requirements for science and applied agricultural science. The courses were segregated into *core* science and *applied agricultural* science. Students took a total of 73 different courses to satisfy their degree requirements in core science (Table 2). Students took a total of 97 different courses to satisfy their degree requirements in applied agricultural science (Table 2). Of the 73 core science courses, 14 courses were taken by a minimum of 10% of the population. Of 97 applied agricultural sciences courses, 19 courses were taken by a minimum of 10% of the population.

Table 2

Courses Taken to Satisfy Science Degree Requirements of Preservice Teachers

Courses		Frequency
Core Science Courses		
BSC 2010	Integrated Principles of Biology 1	37
BSC 2007	Cells, Organisms and Genetics	35
BSC 2010L	Integrated Principles of Biology Laboratory 1	35
CHM 1025	Introduction to Chemistry	24
BSC 2005L[1]	General Education Biology Laboratory	23
BSC 2011	Integrated Principles of Biology 2	22
CHM 2045	General Chemistry 1	22
CHM 2045L	General Chemistry 1 Laboratory	21
CHM 1025L[1]	Introductory Chemistry Lab	19
BSC 2011L	Integrated Principles of Biology Laboratory 2	18
BSC 2009L	Laboratory in Biological Sciences	10
CHM 1083[1]	Chemistry for Consumers	10
CHM 2046	General Chemistry 2	10
CHM 2046L	General Chemistry 2 Laboratory	9
Agricultural Science Courses		
ANS 3006C	Introduction to Animal Science	58
AOM 3220	Agricultural Construction and Maintenance	58
SWS 3022[P]	Introduction to Soils in the Environment	58
SWS 3022L[P]	Introduction to Soils in the Environment Lab	58
FOS 2001[B]	Man's Food	39
ENY 3005[B]	Principles of Entomology	26
ENY 3005L[B]	Principles of Entomology Lab	25
PLS 3004C[B]	Principles of Plant Science	24
ENY 3007C	Life Science	24
WIS 2040[B]	Wildlife Issues in a Changing World	18
ANS 2002	The Meat We Eat	12
PKG 3001	Principles of Packaging	11
VEC 2100[B]	World Herbs and Vegetables	10
IPM 3022	Fundamentals of Pest Management	9
ORH 1030	Plants, Gardening and You	7
SWS 2007[P]	World of Water	7
AGG 3501[B]	Environment, Food and Society	6
HOS 3020	Principles of Horticulture Crop Production	6
VEC 3221C	Vegetable Production	6

Note. There were a total of 59 preservice teachers; [1]Courses completed at community colleges. [B]Courses count as biological science credit; [P]Courses count as physical science credit.

Science Standards Present in Courses Taken by Preservice Teachers

The 33 courses were examined to identify the presence of standards and benchmarks. Data could not be retrieved for 4 courses, AGG 3501, PKG 3001, PLS 3004C, and SWS 3022L. All benchmarks for standard A: *Science as Inquiry* were included in the following courses: BSC

2010L and BSC 2011L. No applied agricultural science course included or prerequired exposure to all standard A benchmarks. Courses BSC 2011 and ORH 1030 have no benchmarks from standard A. The complete matrix of courses and standards A and B is included in Table 3.

Table 3

Science as Inquiry (A) and Physical Science (B) Standards Present in Courses

	Science as Inquiry						Physical Science					
Course	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
BSC 2005L	X	X		X	X	X	P	P	P	P	P	P
BSC 2007	X	X				X			X		X	
BSC 2009L	X	X			X	X	P	P	X			
BSC 2010	X	X		X	X	X	X	P	X		X	X
BSC 2010L	X	X	X	X	X	X	P	P	X	P	P	X
BSC 2011							P	P	P	P	P	P
BSC 2011L	X	X	X	X	X	X			X			X
CHM 1025	X		X				X	X	X	X	X	X
CHM 1025L	X	X	P	X	X	X	X	X	X		X	X
CHM 1083	P	X	P	X	X	X	X	X	X		X	X
CHM 2045	X		P				X	X	X	X	X	X
CHM 2045L	X	X	X	P	P	X	P	X	X	X	X	X
CHM 2046	X	X		X	X	X	P	X	X		P	X
CHM 2046L	X	X		X	X	X	P	P	X		P	P
AGG 3501	*	*	*	*	*	*	*	*	*	*	*	*
ANS 2002	X		P	X	X	X	P	P	P			
ANS 3006C	P		X		X	X	P	P	P	P	P	P
AOM 3220	P		X		P	P	P	P	P	P	P	P
ENY 3005	X			X	X	X						
ENY 3005L	X		X	X		X						
ENY 3007C	X	X	X									
FOS 2001	X				X	X	P	X	X		X	
HOS 3020	X		X			P						
IPM 3022	X			X	X	X						
ORH 1030												
PKG 3001	*	*	*	*	*	*	*	*	*	*	*	*
PLS 3004C	*	*	*	*	*	*	*	*	*	*	*	*
SWS 2007	X		P	X	X		X	X	X	X	X	X
SWS 3022	X		P	X	X	P	P	P	P	P	P	P
SWS 3022L	*	*	*	*	*	*	*	*	*	*	*	*
VEC 2100	P	X	X			X			X			
VEC 3221C		X	X	X	X	X			X			
WIS 2040	X				X	X						

Note. X means standard present in course, P mean standard is a prerequisite, * = no response.

Standard B: *Physical Science* was included primarily in core science courses. The courses CHM 1025, CHM 2045, and SWS 2007 included all of the benchmarks for standard B. Benchmark B3: Chemical reactions was present or a prerequisite in all core science courses.

Three applied agricultural science courses, FOS 2011, VEC 2100, and VEC 3221C, included at least one benchmark from standard B. The applied agricultural science courses ANS 3006C and SWS 3022 required prior knowledge of all benchmarks in standard B. A complete matrix of courses and benchmarks for standard B is presented in Table 3.

Standard C: *Life Sciences* was included in all BSC biology core science courses, and not present in any CHM chemistry courses. Additionally, the courses BSC 2005L, BSC 2007, and BSC 2010 included all benchmarks for standard C. The applied agricultural courses ANS 2002, AOM 3220, ANS 3006C, ENY 3005, and ENY 3007C required prior knowledge or included all benchmarks for standard C. A complete matrix for standard C is presented in Table 4.

Standard D received less attention in the courses taken by preservice teachers. Benchmark *D4: Origins and evolution of the universe* was not included in any course. However, BSC 2011 and AOM 3220 required prior knowledge of the benchmark. A complete matrix of courses and benchmarks for Standard D is presented in Table 4.

Table 4
Life Science (C) and Earth & Space (D) Standards Present in Courses

	Life Science						Earth & Space Science			
Course	C1	C2	C3	C4	C5	C6	D1	D2	D3	D4
BSC 2005L	X	X	X	X	X	X		X	P	
BSC 2007	X	X	X	X	X	X	X			
BSC 2009L	X	X	X	X	X		X	X	X	
BSC 2010	X	X	X	X	X	X	X	X	X	
BSC 2010L	X	X	X	X					X	
BSC 2011	P	P	P	P	X	X			P	P
BSC 2011L	P	P	X	X	X		X	X	X	
CHM 1025										
CHM 1025L										
CHM 1083										
CHM 2045										
CHM 2045L										
CHM 2046										
CHM 2046L										
AGG 3501	*	*	*	*	*	*	*	*	*	*
ANS 2002	P	P	P	P	P	P	P	P		
ANS 3006C	P	X	P	P	X	X				
AOM 3220	P	P	P	P	P	P	P	P	P	P
ENY 3005	P	P	X	X	P	X				
ENY 3005L	P	P	P	X		X				
ENY 3007C	P	P	X	X	X	X		X		
FOS 2001	X	X	X	X	X					
HOS 3020	P									
IPM 3022		P	P	X	X	X				
ORH 1030			X	X		X			X	
PKG 3001	*	*	*	*	*	*	*	*	*	*
PLS 3004C	*	*	*	*	*	*	*	*	*	*
SWS 2007			X	X	X		X	X	X	
SWS 3022				X	X		X	X	P	
SWS 3022L	*	*	*	*	*	*	*	*	*	*
VEC 2100	X	X	X							
VEC 3221C		X	X	X	X	X	X	X		
WIS 2040	X		X	X		X		X		

Note. X means standard present in course, P mean standard is a prerequisite, * = no response.

The complete matrix for standard E and standard G is presented in Table 5. All applied agricultural science courses (excluding ANS 2002 and SWS 3022) included benchmark *E2: Understanding about science and technology*. CHM 2045 is the only course that included no benchmarks from standard *G: History and Nature of Science.* Of the 33 courses, 10 included all three benchmarks from standard G.

Table 5
Technology (E) and History & Nature of Science (G) Standards Present in Courses

	Technology		History & Nature of Science		
Course	E1	E2	G1	G2	G3
BSC 2005L			X	X	X
BSC 2007		X		X	X
BSC 2009L		X		X	
BSC 2010			X	X	
BSC 2010L	X	X	X	X	
BSC 2011	X	X	P	P	P
BSC 2011L	X	X	X	X	X
CHM 1025				X	X
CHM 1025L		X		X	
CHM 1083	X	X	X	X	X
CHM 2045		P			
CHM 2045L		X	P	X	P
CHM 2046		P	X	X	X
CHM 2046L			X	X	
AGG 3501	*	*	*	*	*
ANS 2002	P	P	X	X	X
ANS 3006C	X	X	P	P	X
AOM 3220	X	X	P	P	X
ENY 3005		X	X	X	X
ENY 3005L		X	X	X	
ENY 3007C		X	P	X	X
FOS 2001		X	X	X	X
HOS 3020		X			X
IPM 3022		X	P	P	X
ORH 1030		X	X		X
PKG 3001	*	*	*	*	*
PLS 3004C	*	*	*	*	*
SWS 2007	X	X	X	*	X
SWS 3022	*	*	X	X	X
SWS 3022L	*	*	*	*	*
VEC 2100	X	X	X	X	X
VEC 3221C	X	X	X	X	X
WIS 2040		X	P	X	X

Note. X means standard present in course, P mean standard is a prerequisite, * = no response.

For standard F*: Personal and Social Perspectives* the following courses included all of the benchmarks: BSC 2009L, BSC 2011L, ANS 2002, ANS 3006C, AOM 3220, IPM 3022, and SWS 2007. With one exception, all applied agricultural science courses included benchmarks *F3: Natural resources* and *F6: Science and technology in local, national, and global challenges*. The lacking courses were FOS 2001, for benchmark *F3*, and HOS 3020 for benchmark *F6*. The core science courses CHM 1025, CHM 2045, and CHM 2045L included no benchmarks from this standard. A complete matrix of standards and courses is presented in Table 6.

Table 6
Personal and Social Perspectives (F) Standards Present in Courses

Courses	F1	F2	F3	F4	F5	F6
BSC 2005L		X	X		X	X
BSC 2007		X	X	X	X	X
BSC 2009L	X	X	X	X	X	X
BSC 2010		X				X
BSC 2010L						X
BSC 2011	X	P	P	P	P	P
BSC 2011L	X	X	X	X	X	X
CHM 1025						
CHM 1025L			X			
CHM 1083	X		X	X	X	X
CHM 2045						
CHM 2045L						
CHM 2046				X		
CHM 2046L					X	
AGG 3501	*	*	*	*	*	*
ANS 2002	X	X	X	X	X	X
ANS 3006C	X	X	X	X	X	X
AOM 3220	X	X	X	X	X	X
ENY 3005		P	P			X
ENY 3005L			X			X
ENY 3007C		X	X	X		X
FOS 2001	X				X	X
HOS 3020	X		X	X		
IPM 3022	X	X	X	X	X	X
ORH 1030			X	X		X
PKG 3001	*	*	*	*	*	*
PLS 3004C	*	*	*	*	*	*
SWS 2007	X	X	X	X	X	X
SWS 3022		P	X	X	X	X
SWS 3022L	*	*	*	*	*	*
VEC 2100	X		X		X	X
VEC 3221C	X		X	X	X	X
WIS 2040		X	X	X	X	X

Note. X means standard present in course, P mean standard is a prerequisite, * = no response.

Conclusions, Implications, and Recommendations

Course Enrollment Patterns

Students completed a wide variety of courses to satisfy degree requirements. A total of 73 different courses were taken to satisfy the requirement of nine credit hours in science. Biology courses were taken most frequently and BSC 2010 Integrated Principles of Biology 1 was taken the most frequently, in tandem with the corresponding laboratory. An introductory chemistry course, such as CHM 2045 General Chemistry 1 or CHM 1083 Chemistry for Consumers, was also taken by the majority. Therefore, it is concluded that students typically complete a biology and a chemistry course, which is consistent with the literature (Johnson, 1996).

From the data it was also concluded that students are not taking advanced science courses. Less than half of the students took the second level of biology or chemistry. Just over a third of the students took Integrated Principles of Biology 2 to satisfy degree requirements while only one in six students took General Chemistry 2. This was also demonstrated by the infrequent completion of other advanced science courses, such as microbiology or anatomy and physiology.

Few agricultural education students took physical science courses, which was consistent with what Johnson (1996) found in an earlier study. Of the 73 various courses taken, seven courses were taken in physics, and five courses were taken in a physical or earth and space science. Additionally, only one or two students took these courses. It was concluded that students are not taking core science courses that will expose them to physical science principles.

Course taking patterns for applied agricultural science courses were also quite variable. Students took 97 different courses to satisfy the 30 credit hours of applied agricultural science required. The course-taking pattern aligned with the degree plan; all students took an introduction to animal science, introduction to soil science, and an introductory entomology course. Outside of the three prescribed courses, students took a great variety of courses to satisfy the remaining requirements, with animal science courses being the most frequent.

The variability of the courses taken is exacerbated by the high propensity for unique courses taken by students. Over half of the core science courses and over two-fifths of the applied agricultural science courses were taken by only one student. Additionally, only 33 of all courses taken were taken by at least six preservice teachers. It is concluded that the high variability of courses will yield a high variability in the science concepts that students learn.

Science Standards Present in Courses

The missing data for four courses is a limitation of this study. However, it may not be much of an issues because only 6 students took AGG 3501 and only 11 students took PKG 3001. SWS 3022L is linked with SWS 3022 and thus the responses related to SWS 3022 should be applicable, so that omission is probably negligible. The most problematic course is PLS 3004C, taken by 24 students. As an introductory plant science course, it is probably safe to assume that most of the *Life Science* (C) standards are included or prerequisites, but the extent of the inclusion of the other standards is unknown.

For the content standards B: *Physical Science* and C: *Life Science*, the results yielded expected outcomes. The physical science standards were covered predominantly by the chemistry courses and not in the biological or applied agricultural science courses. The opposite was true for the life science standards, which were present in the biological and applied agricultural science courses while not in the chemistry courses. Since all preservice students completed the introductory animal science and introductory soil science courses, they experienced the application all of the physical science standards. The life science standards were prerequisite standards, as well as present, in many applied agricultural science courses.

For the content standard D: *Earth and Space Science* far fewer courses taught or required knowledge on the component benchmarks. Additionally, benchmark *D4: Origin and Evolution of the Universe* was not present in any courses. Benchmark *B4: Motions and Forces* was only present in two different chemistry courses and one applied agricultural science course. It is concluded that preservice teachers may be deficient in this area.

For the standards A: *Science as Inquiry,* E: *Science and Technology,* F: *Personal and Social Perspectives,* and G: *History and Nature of Science* a myriad of courses in both core science and applied agricultural sciences contain or require prior experience in these standards. This follows with the expectations of such courses based on the descriptions and objectives of the courses related to these standards from the university requirements ([university], 2012). These standards are described as science skills within the literature (NCAE, 2009).

Preservice teachers in this study experienced all the life science and most physical science standards, excluding motions and forces, and earth and space science standards. Based on the existing literature on perceptions and barriers, the findings of this study support the plausibility that preservice teachers feel unable to integrate science content based on insufficient content knowledge of science related to physics and earth and space science. However, the current study would suggest that teachers should be comfortable for biological and chemical science content based. This is contradictory to some of the literature (Johnson, 1996; Scales et al., 2009; Thompson, 1998; Thoron & Myers, 2010; Warnick & Thompson, 2007).

Teacher educators at [university] should consider making changes to the required course of study. To combat the high level of variability within the courses chosen, a set of prescribed courses should be developed to meet the core science requirements for graduation. Typically, 9 credits translate into 3 courses. It is recommended that the course of study reflect the three content areas from the AFNR standards: Biology, Chemistry and Physics, and Earth and Space science. Therefore, one prescribed course in Biology, one prescribed course in Chemistry and/or Physics, and one prescribed course in Earth and Space science should be included.

The following are recommendations for the applied agricultural science courses within the course of studies. The three prescribed courses, ANS 3006C, AOM 3220, and SWS 3022 cover all standards either as a prerequisite or in the course, except *A2: Design and conduct scientific investigations.* The course AOM 3220 should be further investigated based on what content is actually being taught in the course. The instructor's responses yield a muddled picture about the science content in the course. Based on the description of the AOM course, content from the standard *B: Life Sciences* was expected to be outside of the scope of the course, yet the instructor responded to the instrument with a prerequisite for the life science knowledge.

Courses similar in rigor to the three prescribed courses should be further identified and included within the course of studies for agricultural education students. The variability of courses students are allowed to choose minimizes the ability to ensure that students continue to gain experience with science concepts they will be expected to teach. Much like the entomology credits, it is recommended that prescribed choices be established for applied agricultural science credits. As an example, the course VEC 3221C Vegetable Production was taken by only 6 preservice students but contained nearly 70% of the standards.

Although this case study included data from only one university, the results herein may have implications for other universities, especially programs that have a large number of students who transfer from a community college or offer great flexibility in course options for students. Teacher educators at other programs should examine their required coursework using a lens of the science standards to determine the extent that preservice teachers have the opportunity to learn the needed science content knowledge (Roberts & Kitchel, 2010). The research protocols established in this study can provide a transferrable model for examining this issue.

References

American Association for the Advancement of Science. (1989). *Science for all Americans: A project 2061 report on literacy goals in science, mathematics, and technology.* Washington, DC: AAAS.

American Association for the Advancement of Science. (1993). *Benchmarks for scientific literacy: Project 2061.* New York, NY: Oxford University Press.

Berelson, B. (1952). *Content analysis in communication research.* Glencoe, IL: Free Press.

Bransford, J. D., Brown, A., & Cocking, R. (Eds.). (2000). *How people learn*. Washington, DC: National Academies Press.

Carl D. Perkins Career and Technical Education Act, 20 U.S.C. § 2301 *et seq.* (2006).

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2009). *Internet, mail, and mixed-mode surveys: The tailored design method* (3rd ed.). Hoboken, NJ: John Wiley & Sons.

Johnson, D. M. (1996). Science credit for agriculture: Perceived support, preferred implementation methods and teacher course work. *Journal of Agricultural Education, 37*(1), 27-37. DOI: 10.5032/jae.1996.01022

MacMillan, J. H., & Schumacher, S. (2010). *Research in education: Evidence-based inquiry* (7th ed.). Boston, MA: Pearson Education.

Messick, S. (1989). Validity. In R. L. Linn (Ed.), *Educational measurement* (3rd ed, pp.13-103). New York, NY: Macmillan.

Myers, B. E., & Washburn, S. G. (2008). Integrating science in the agriculture curriculum: Agriculture teacher perceptions of the opportunities, barriers, and impact on student enrollment. *Journal of Agricultural Education, 49*(2), 27-37. doi: 10.5032/jae.2008.02027

National Academy of Sciences. (1995). *National science education standards.* Washington DC: National Academies Press.

National Council for Agricultural Education. (2009). *National agriculture, food and natural resources (AFNR) career cluster content standards.* Alexandria, VA: The Council.

National Research Council. (1988). *Understanding agriculture: New directions for education.* Washington, DC: National Academy Press.

National Research Council. (1996). *The national science education standards.* Washington, DC: National Academy Press.

Public K-12 Educational Instruction, 48 Flo. Stat. §§ 1003-413-492 (2010).

Roberts, T. G., & Kitchel T. (2010). Designing professional knowledge curriculum and instruction. In R. M. Torres, T. Kitchel, & A. L. Ball (Eds.) *Preparing and advancing teachers in agricultural education* (pp.100-111). Columbus, OH: The Ohio State University Curriculum Materials Service.

Rourke, L., & Anderson, T. (2004). Validity in quantitative content analysis. *Educational Technology Research and Development, 52*(1), 5–18. doi: 10.1007/BF02504769

Rourke, L., Anderson, T., Garrison, D. R., & Archer, W. (2001). Methodological issues in the content analysis of computer conference transcripts. *International Journal of Artificial Intelligence in Education, 12*(1), 8-22.

Scales, J., Terry, R., Jr., & Torres, R. M. (2009). Are teachers ready to integrate science concepts into secondary agriculture programs? *Journal of Agricultural Education, 50*(2), 102-113. doi: 10.5032/jae.2009.02100

Thompson, G. (1998). Implications of integrating science in secondary agricultural education programs. *Journal of Agricultural Education, 39*(4), 76-85. doi: 10.5032/jae.1998.04076

Thoron, A. C., & Myers, B. E. (2010). Perceptions of preservice teachers toward integrating science into school-based agricultural education curriculum. *Journal of Agricultural Education, 51*(2), 70-80. doi:10.5032/jae.2010.02070

University [state]. (2012). *Undergraduate Catalog 2012-13.* Retrieved from https://catalog.[university].edu/ugrad/current/Pages/home.aspx

Warnick, B. K., & Thompson, G. W. (2007). Barriers, support, and collaboration: A comparison of science and agriculture teachers’ perceptions regarding integration of science into the agricultural education curriculum. *Journal of Agricultural Education, 48*(1), 75-85. doi: 10.5032/jae.2007.01075