ARIZONA AGRICULTURE TEACHERS’ PERCEIVED SELF-EFFICACY TO TEACH SCIENCE CONTENT

by

Hannah C. Parker

Copyright © Hannah C. Parker 2018

A Thesis Submitted to the Faculty of the

DEPARTMENT OF AGRICULTURAL EDUCATION

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

In the Graduate College

THE UNIVERSITY OF ARIZONA

2018
STATEMENT BY AUTHOR

The thesis titled Arizona agriculture teachers' perceived self-efficacy to teach science prepared by Hannah Parker has been submitted in partial fulfillment of requirements for a master's degree at the University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that an accurate acknowledgement of the source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: [Signature]

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

[Signature]

Dr. Amber Rice
Assistant Professor of Agricultural Education

05/11/2018
Date
TABLE OF CONTENTS

Abstract ....................................................... 4
Introduction .................................................... 5
Literature Review ............................................. 6
Need for Study ................................................. 9
Conceptual Framework ..................................... 10
Theoretical Framework ..................................... 14
Purpose and Research Objectives ..................... 15
Methods ......................................................... 16
Findings ......................................................... 17
Discussion ....................................................... 21
Recommendations for Practice ......................... 24
Recommendations for Research ......................... 26
References ...................................................... 27
Abstract

The purpose of this study was to describe the relationship between sources of science content knowledge and the perceived self-efficacy to teach science content among practicing Arizona agriculture teachers. Bandura’s (1977) theory of self-efficacy was the theoretical framework that guided this study. Sources of science content knowledge were derived from Rice and Kitchel’s (2015) conceptual framework. On average, agriculture teachers were somewhat confident to teach science. A moderate bivariate correlation was found between teachers’ high school agriculture program experience as a youth, current teaching experience, experiences with agriculture jobs and internships, and their self-efficacy to teach science content. A simultaneous multiple regression was implemented; explaining 29% of agriculture teachers’ self-efficacy to teach science content from six of the seven sources of content knowledge. Teaching experience, SBAE, internet and other media, professional development, agriculture related jobs and internships, and years spent teaching contribute to R². Further research recommendations include applying qualitative methods to explore unexplained variance and identify additional sources of knowledge. Recommendations for practice include exploring content specific professional development opportunities, such as CASE, and encouraging teacher preparation programs to re-evaluate curricula to include science specific PCK to enhance the preparation of preservice teachers.

Key words: Self-Efficacy; Science Content; Agriculture Teachers; Content Knowledge
Introduction

After the National Academy of Science published *Understanding Agriculture: New Directions for Education* (1988), secondary school-based agricultural education programs (SBAE) across the United States heard their call: revise, improve, and expand vocational agricultural education programs. The pressure drove SBAE programs to become increasingly diverse, incorporate more than just vocational education into the curriculum, and better prepare students for college and future careers in agriculture (National Academy of Science, 1988).

As a result, SBAE has a long history of integrating science into agriculture curriculum, partially due to agriculture teachers’ desire to be competitive and current with national trends (Dailey, Conroy, & Shelly-Tolbert, 2001). The American Association for the Advancement of Science (1990) suggested incorporating science concepts in SBAE would create equal academic achievement opportunities for agriculture students as compared to traditional biology courses. Dormody (1992) proposed that science could be easily infused in SBAE. The application of chemistry, biology, and zoology principles could guide studies in agronomy, crop science, animal science, forestry, natural resources, poultry science, and horticulture. Incorporating science concepts within SBAE engages students in hands-on learning, provides students with an applicable way to connect science to the real-world, and ultimately can foster higher levels of critical thinking (Hodge & Lear, 2011). Students are intrinsically motivated to learn science through an agricultural context and can transfer those skills to other courses (Chumbley, Haynes, & Stofer, 2015; Dailey et al., 2001).

Presently, Science, Technology, Engineering, and Mathematics (STEM) fields are predicted to have nearly 20,000 job openings annually between 2015-2020 (Carnevale, Smith, & Melton, 2011). As an applied science, agriculture has much to contribute to the STEM
movement and student preparation for STEM related careers (Despain, North, Warnick, & Baggaley, 2016; Myers, Washburn, & Dyer, 2004; Ricketts, Duncan, & Peake, 2006). Stubbs and Myers (2016) postulated agriculture teachers and agriculture teacher educators may potentially leverage the future of STEM integration. Teaching and learning science within an agriculture context is slowly gaining commitment and buy-in from agriculture teachers nationwide (Stubbs & Myers, 2016).

Some states, like Arizona, have expanded their SBAE programs to include science-focused courses to meet national demands. The Arizona Department of Education supports the integration of STEM into Career and Technical Education (CTE). Beginning in 1996, high school students in Arizona may consecutively complete the course, Introduction to Applied Biological Systems I (9th grade) and the course, Applied Biological Systems II (10th grade) to fulfill a biology requirement for high school graduation and college entrance (Arizona Department of Education, 2015). During the 2016-2017 school year, 79 of the 80 SBAE programs in the state of Arizona offered high school students the opportunity to complete their biology credit within their SBAE program (B. Masters, personal communication, October 19, 2016). However, despite offering these courses in SBAE programs, there are still doubts that agriculture teachers are truly being prepared to teach science content (Thoron & Myers, 2010).

**Literature Review**

Arizona agriculture teachers are certified to teach agriculture with a licensure in CTE, Agriculture 9-12. Traditionally certified agriculture teachers complete a bachelor's degree in agriculture or agricultural education and must pass Arizona Educator Exams, Arizona Educator Proficiency Assessments (AEPA), or National Evaluation Series (NES). However, licensure in CTE, with an emphasis in agriculture, does not automatically certify Arizona agriculture teachers
in science. Traditionally certified agriculture teachers who offer biology credit within their agriculture classes must also possess a license endorsement in biology. This requires both successfully completing an agriculture teacher preparation program and passing the Arizona state certification exams (Arizona Department of Education-Certification Unit, 2016). The Arizona Department of Education (2016) assumes teachers who complete an agriculture teacher preparation program, pass Arizona Educator Exams, and are endorsed in biology, provide equal science instruction as compared to teachers who are traditionally certified in biology secondary education 6-12 (Arizona Department of Education, 2016).

With expectations of agriculture teachers to teach science, it is important to investigate the evolution of science integration in SBAE and in conjunction with national content standard trends. Evaluation and improvement of teacher preparation programs within agricultural education has been on the forefront of university agendas for decades (National Academy of Science, 1988). The National Academy of Engineering and National Research Council (2014) set out goals for integrating STEM education into current subject matter areas. One specific goal, workforce readiness, can be achieved through integrating STEM education with CTE. These goals for agriculture teachers included increased STEM content knowledge (CK) and pedagogical knowledge (PK) to promote student success. (National Academy of Engineering and National Research Council, 2014)

Establishing how to expand coursework to prepare agriculture teachers for the challenge of teaching science has been a difficult and daunting task for agriculture teacher preparation programs. Arizona agriculture teachers are currently endorsed to teach biology without authentic science education training; including science CK and science specific pedagogical content knowledge (PCK). PCK is defined as a teacher’s understanding of the specific content they are
teaching combined with their knowledge on teaching (Shulman, 1986). Agriculture teacher preparation programs are currently comprised of content courses and pedagogy courses, but provide limited opportunities to integrate the two to facilitate the development of agriculture teachers’ PCK for teaching science. A lack of traditional training could send agriculture teachers into the classroom unprepared or deficient in their ability to integrate science concepts and principles into the agriculture curriculum. Thompson and Warnick (2007) reported agriculture teachers indicated the need for improved preservice and inservice opportunities to learn how to integrate science into the SBAE curriculum more thoroughly and effectively.

Once thought to produce competitive graduates, STEM secondary education has been described as idle in a report titled *Rising Above the Gathering Storm* (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2007). The report described the need for improved STEM education and how improvements would prepare the future workforce generation. Next Generation Science Standards (NGSS) were developed to respond to this issue. A document titled, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* included a vision, concept, and implementation plan for the national science standards. The framework encompassed the scope and nature of science education for kindergarten through 12th grade. NGSS were not meant to be a step-by-step approach to science education. Instead, NGSS were intended to serve as a guide to assist in curriculum development by science educators and administrators. Science disciplines focused within the curriculum standards included physical sciences, life sciences, earth and space sciences, and engineering, technology, and application of sciences (National Research Council, 2012).
The National Research Council (2012) cited two main reasons for the creation of NGSS. First, it had been 15 years or more since the last collective effort to create national science standards. Second, NGSS followed the national trend of common standards in mathematics and language arts that were being adopted by individual states (National Research Council, 2012). National standards continue to have a reputation for creating transparent and inclusive benchmarks for academic achievement. Ultimately benchmarks for science achievements are set to meet demands for career qualifications (National Research Council, 2012). In this study, NGSS were used to operationalize the necessary science CK needed by agriculture teachers. NGSS are national benchmark indicators for what science teachers should have as their CK foundation. Bybee (2014) recommended teacher preparation programs design coursework around NGSS and the framework created by the National Research Council (2012) to prepare the next generation of science teachers.

**Need for Study**

Teachers’ perceived self-efficacy for teaching NGSS could give insight to agriculture teacher preparation programs on whether they provide preservice teachers the opportunity to acquire the essential CK to teach science effectively. Understanding how agriculture teacher preparation programs must evolve to meet the needs of agriculture teachers could lead to the increased academic success of students. High attrition rates of novice agriculture teachers have been linked to low self-efficacy to teach agriculture in the classroom (Langley, Martin, & Kitchel, 2014). Specifically, for science content, McKim and Velez (2015) concluded agriculture teachers do not have enough experience to support high self-efficacy scores for teaching science. Myers, Thron, and Thompson (2009) recommended research be conducted on agriculture teachers’ efficacy to teach science content to enrich SBAE curriculum.
Science CK and general pedagogical knowledge contributes to teachers’ effectiveness, and overall confidence to teach science (Loughran, Berry, & Muhall, 2012). Without CK in combination with PCK, teachers do not have the tools to effectively teach their students (Ball, Thames, & Phelps, 2008). Thoron and Myers (2010) concluded preservice agriculture teachers felt the greatest barrier to integrating science into SBAE curriculum was a lack of science CK. Furthermore, preservice agriculture teachers suggested the need for more required science courses at the undergraduate level (Myers et al., 2009). Thus, raising the question: How efficacious are Arizona agriculture teachers in teaching science as a result of their previous sources of science CK?

**Conceptual Framework**

Originally described by Shulman (1986, 1987), PCK is the foundational knowledge base for teachers that combines CK and pedagogical knowledge. Käpylä, Heikkinen, and Asunta (2009) defined content experts as teachers who possess a full understanding of subject matter knowledge and are more sensitive to students’ academic obstacles. Teachers who were classified as content experts demonstrated a positive association with PCK and were better able to plan meaningful learning activities as compared to content novices (Käpylä et al., 2009). Both CK and PCK contribute to a teacher’s ability to be effective in the classroom (Shulman, 1986).

Rice and Kitchel’s (2015) conceptual framework, derived from an extensive literature review, illustrated the relationship between sources of agriculture CK and PCK (see Figure 1). Application of Rice and Kitchel’s (2015) model has transferability to agriculture teachers’ science CK within an agricultural context. Rice and Kitchel (2015) described seven distinct sources of CK that contribute to agriculture teachers’ PCK. Rice and Kitchel (2015) claimed teacher preparation programs are not the only sources of CK; years spent teaching, teaching
experience, internet and other media usage, professional development opportunities, agriculture jobs and internships, and high school agriculture program experience each influenced agriculture teachers’ PCK.

*Figure 1.* The relationship between sources of content knowledge and PCK (Rice & Kitchel, 2015)

The first source of CK Rice and Kitchel (2015) identify is teaching experience. Teaching experience can lead to more effective instruction through practice, analysis, and reflection (Hiebert, Morris, Berk, & Jansen, 2007); in simple terms, learning by doing. Teaching and re-teaching year after year are necessary components that contribute to a teachers’ PCK (Hashweh, 2005). A science content example of this source is when a teacher can successfully modify a
laboratory exercise for a specific topic (e.g. photosynthesis) based on previous student interaction in the classroom. The second source of CK contributing to PCK is the teacher’s participation in a traditional high school agriculture program as a student. Traditional SBAE programs include three components: classroom/laboratory instruction, supervised agricultural experience, and student leadership activities (National FFA Organization, 2015). Darling-Hammond and Bransford (2005) noted most teachers are likely to teach in similar ways they were taught; strengthening the need to further investigate SBAE programs as a source of CK. Teacher preparation programs was identified as the third source of CK. Teacher preparation programs typically include instruction in both CK and pedagogy, culminating in the student teaching experience. Haston and Leon-Guerrero (2008) studied preservice music teachers and found apprenticeship, methods courses, and mentor teachers were all contributors to teachers’ PCK. Specifically, in science education, this could include content area courses in animal science or biology and pedagogy courses that integrate laboratory skill development or address inquiry based learning.

A fourth source of agriculture teachers’ CK is previous jobs or internships related to agriculture content. For example, employment in a greenhouse or an internship in the agriculture industry can enhance agriculture teachers’ CK. Newcomb, McCracken, Warmbrod, and Whittington (2004) stated work experiences contribute to the CK necessary to successfully teach agriculture. An example related specifically to science CK could include employment as a lab technician on a college campus. The fifth source of agriculture teachers’ CK is professional development, which can be defined as additional educational opportunities for practicing teachers. One example of science specific CK professional development is agriculture teachers participating in Curriculum for Agriculture Science Education (CASE) institutes (Curriculum for
development can offer “targeted experiences to address significant needs” of agriculture teachers
(pg. 181).

The sixth source of agriculture teachers’ CK is internet and other media. Rice and Kitchel
(2015) discuss the millennial generations’ reliance on internet and technology as a source of
current and future CK. The millennial generation views technology as positive and are confident
in their abilities to find information online (Brown, Murphy, & Nanny, 2003). An example of
teachers using internet and technology would be online science curriculum resources such as
collaborative share groups found on Facebook or professional science organization websites.
Finally, number of years spent teaching is the last of seven sources of CK described by Rice and
Kitchel (2015). Years spent teaching is a separate CK source from the previously mentioned
teaching experience. Years spent in the classroom does not necessarily guarantee that a teacher
possesses PCK, but it does increase the likelihood this knowledge base is present. However, just
because a teacher has spent many years in the classroom does not guarantee that the quality of
those experiences were contributors to their CK (Bereiter & Scardemalia, 1993).

While Rice and Kitchel (2015) defined their sources of CK for teaching agriculture
specifically, these predictors are also applicable sources of science CK in an agricultural context.
Because agriculture is defined as an applied science, agriculture teachers who develop PCK in
various agriculture topic areas may also possess PCK in science content within an agriculture
context (Smith, Rayfield, & McKim, 2015). These sources of CK defined by Rice and Kitchel
(2015) were applied to various agriculture content areas in their study because the agriculture
teachers self-identified unit topics in agriculture when describing their own sources of CK.
Sources of CK may not be subject specific and could be applied to any topic within an
agricultural context (Rice & Kitchel, 2015). Rice and Kitchel’s (2015) framework guided this study by asking agriculture teachers to report which sources of science CK prepared them to teach science and the effectiveness of those sources.

**Theoretical Framework**

The theoretical framework that guided this study was Bandura’s (1977) theory of self-efficacy. Bandura (1977, 1997) defined self-efficacy as one’s belief in his or her ability to accomplish set goals. Self-efficacy is mirrored by confidence through the capacity of one to exercise control over their own motivation, behavior, and social environment (Bandura, 1997). Bandura (1977) described self-efficacy based on a theory for behavioral change. For one to expect a certain outcome, the individual must be willing to change their behavior to accomplish said desired outcome. Bandura’s (1977) model (see Figure 2) illustrated the process of behavioral change. Bandura (1977) defined efficacy expectation as one’s confidence to successfully achieve a given behavior to meet expectations. In contrast, outcome expectancy is defined as one’s own assessment that a given behavior will meet expectations. Outcome and efficacy expectation differ because an individual can believe an outcome is caused by a certain course of action, but their lack of confidence to perform the required activities does not impact their behavior (Bandura, 1977).

![Figure 2. Diagrammatic representation of the difference between efficacy expectations and outcome expectations (Bandura, 1977)](image-url)
Self-efficacy is influenced by four main sources: mastery experiences, physiological and emotional states, vicarious experiences, and social persuasion (Bandura, 1977, 1997). Bandura’s (1977) theory of self-efficacy can be adapted to examine teachers’ self-efficacy. Woolfolk (2007) defined teacher self-efficacy as one’s confidence that he or she can help even the most difficult students to learn. Teacher self-efficacy is positively associated with student achievement (Woolfolk, 2007). Teachers with low self-efficacy often do not believe they can help students who lack motivation and do not provide time for non-academic, administrative tasks. In contrast, teachers with high self-efficacy devote additional time to unmotivated students and utilize environmental resources including school and parental support (Bandura, 1997).

Previous SBAE research indicated quality teacher preparation programs were an important factor in agriculture teacher self-efficacy (Knobloch & Whittington, 2002; Ross, Cousins, & Gadalla, 1996). Wolf (2011) argued that agriculture teachers’ self-reported efficacy levels should guide the re-evaluation of agriculture teacher preparation programs to better prepare preservice teachers who express low confidence in specific CK areas. Bandura’s (1977) theoretical framework was used in this study to determine Arizona agriculture teachers’ confidence for teaching science content, specifically in the biological and life sciences. Teachers’ self-efficacy is important to study because it can give insight into where agriculture teachers feel confident and provide clues to why some do not feel confident in the content they are teaching.

**Purpose and Research Objectives**

The purpose of this study was to describe the relationship between sources of science CK and the perceived self-efficacy to teach science content among practicing Arizona agriculture teachers. This purpose aligned with priority four of the 2016-2020 National Research Agenda.
(meaningful and engaged learning in all environments) (Roberts, Harder, & Brashears, 2016). To achieve the purpose, the following research objectives were established:

1. Describe sources of science content knowledge for practicing Arizona agriculture teachers.
2. Describe perceived self-efficacy to teach science content among practicing Arizona agriculture teachers.
3. Describe the relationship between sources of science content knowledge and perceived self-efficacy to teach science content among practicing Arizona agriculture teachers.

**Methods**

The design of this study was descriptive-correlational research. Descriptive-correlational research attempts to define a relationship between two variables in terms of magnitude and direction (Ary, Jacobs, & Sorensen, 2014). The two variables studied were sources of science CK (independent variable) and perceived self-efficacy to teach science content (dependent variable). NGSS, and even more specifically the NGSS life science strands, were chosen to operationalize the science CK agriculture teachers should possess.

The target population was Arizona agriculture teachers who had taught at least one agriculture course for science credit (Introduction to Applied Biological Systems I or Applied Biological Systems II) during the 2016-2017 school year. Seventy-nine of 80 schools in Arizona have science integrated into their SBAE programs (B. Masters, personal communication, October 19, 2016). A census of 109 agriculture teachers in the state of Arizona for the 2016-2017 school year was attempted (Ary, Jacobs, & Sorensen, 2014).
The data collection instrument utilized for this study was an electronic questionnaire via Qualtrics. The questionnaire was comprised of two sections. Section one contained questions related to sources of science CK derived from Rice and Kitchel’s (2015) conceptual framework. The seven sources of science CK (teaching experience, high school agriculture program, teacher preparation program, agriculture jobs and internships, professional development, internet and other media, and years spent teaching) were measured on a 5 point Likert-type scale with 1 being “extremely ineffective”, 2 being “somewhat ineffective”, 3 being “neither effective or ineffective”, 4 being “somewhat effective”, and 5 being “extremely effective”.

Section two contained 31 questions related to agriculture teachers’ perceived self-efficacy to teach science content. Items regarding were grouped into the following five constructs based on the NGSS life sciences standards: (1) structure and function (SFO) (3 items), (2) matter and energy in organisms and ecosystems (MEOE) (6 items), (3) interdependent relationships in ecosystems (IRE) (6 items), (4) inheritance and variation of traits (IVT) (6 items), and (5) natural selection and evolution (NSE) (10 items) (National Research Council, 2012). Self-efficacy was measured using a 5 point Likert-type scale for each NGSS life science strand with 1 being “extremely unconfident”, 2 being “somewhat unconfident”, 3 being “neither confident or unconfident”, 4 being “somewhat confident”, and 5 being “extremely confident”.

The questionnaire was reviewed by a panel of five agriculture teachers who are each considered experts in their field to determine face and content validity (Ary, Jacobs, & Sorensen, 2014). Reliability was determined through a pilot test (Ary, Jacobs, & Sorensen, 2014) on both section one (sources of science CK) and section two (NGSS life science strands). The questionnaire was distributed electronically through Qualtrics to 30 agriculture teachers in Arizona. Arizona agriculture teachers were chosen to complete the pilot test because they were
comparable to Arizona teachers both geographically (southwest) and by agriculture teacher population. Coefficient of stability was calculated using SPSS® to determine the reliability of the instrument. Reliability coefficients for the five constructs were .88 or above.

Data were collected in February 2017. Dillman, Smyth, and Christian’s (2014) tailored design method was used to guide the data collection to maximize response. Five points of contact were implemented beginning with a pre-notice email inviting subjects to participate in the study. Subsequent points of contact contained the rational for the study along with a link to the electronic questionnaire. Because of the electronic nature of the data collection, approximately 48 hours were allowed between points of contact. Each email message was personalized to the subjects to maximize the response rate. Collectively, the five points of contact yielded a 63.3% (n = 69) response rate. Non-response error was not addressed because the response rate met the requirements for an exploratory study (Miller & Smith, 1983). Consequently, the data are limited to those who responded (Ary, Jacobs, & Sorensen, 2014).

Data for objectives one and two were analyzed using descriptive statistics (means and standard deviations) (Ary, Jacobs, & Sorenson, 2014). Data for objective three were analyzed using a multiple linear regression analysis to explain variance in perceived self-efficacy from sources of science CK (Berry & Feldman, 1985). Because of non-response error and non-inferential nature of this study, all references to statistical significance were eliminated from the findings and are not generalizable beyond the respondents.

Findings

Research objective one was to describe the seven sources of science CK for practicing Arizona agriculture teachers. The following sources of science CK for the respondents were found (see Table 1). Data were ordered from the highest mean to the lowest mean. The average
number of years spent teaching was 11.25 (SD = 10.10), ranging from 1-40 years of teaching experience. Sources of science CK were reported by respondents on a Likert-type scale from 1-5 ranging from “extremely ineffective” to “extremely effective”. On average, all sources of CK were reported as somewhat effective: teaching experience (M = 4.25, SD = 0.85), agriculture jobs and internships (M = 4.20, SD = 0.88), internet and other media (M = 4.04, SD = 0.85), professional development (M = 3.99, SD = 1.02), teacher preparation programs (M = 3.97, SD = 0.96), and high school agriculture programs (M = 3.90, SD = 0.91).

Table 1

<table>
<thead>
<tr>
<th>Source of Content Knowledge</th>
<th>n</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of years spent teaching</td>
<td>69</td>
<td>11.25</td>
<td>10.10</td>
</tr>
<tr>
<td>Perceived effectiveness of sources¹</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching experience</td>
<td>65</td>
<td>4.25</td>
<td>0.85</td>
</tr>
<tr>
<td>Agriculture jobs and internships</td>
<td>66</td>
<td>4.20</td>
<td>0.88</td>
</tr>
<tr>
<td>Internet and other media</td>
<td>69</td>
<td>4.04</td>
<td>0.74</td>
</tr>
<tr>
<td>Professional development</td>
<td>69</td>
<td>3.99</td>
<td>1.02</td>
</tr>
<tr>
<td>Teacher preparation program</td>
<td>60</td>
<td>3.97</td>
<td>0.96</td>
</tr>
<tr>
<td>High school agriculture program</td>
<td>58</td>
<td>3.90</td>
<td>0.91</td>
</tr>
</tbody>
</table>

¹Scale: 1 = Extremely ineffective, 2 = Somewhat ineffective, 3 = Neither effective or ineffective, 4 = Somewhat Effective, 5 = Extremely Effective

Research objective two sought to describe agriculture teachers’ perceived self-efficacy to teach science content. Respondents reported the following self-efficacy scores for NGSS life science strands (see Table 2) on a Likert-type scale from 1-5 ranging from “extremely unconfident” to “extremely confident”. Overall, respondents reported an average self-efficacy score of being somewhat confident to teach the NGSS life science strands. Ordered from the highest self-efficacy mean score to lowest, the metrics for each standard are: Inheritance and variation of traits (IVT) (M = 3.82, SD = 0.99) and natural selection and evolution (NSE) (M =
3.81, $SD = 0.89$) as highest average self-efficacy scores, followed by structure and function (SFO) ($M = 3.76, SD = 0.93$), matter and energy in organisms and ecosystems (MEOE) ($M = 3.74, SD = 0.84$), and interdependent relationships in ecosystems (IRE) ($M = 3.70, SD = 0.84$).

Table 2

<table>
<thead>
<tr>
<th>NGSS Standard</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVT</td>
<td>3.82</td>
<td>0.99</td>
</tr>
<tr>
<td>NSE</td>
<td>3.81</td>
<td>0.89</td>
</tr>
<tr>
<td>SFO</td>
<td>3.76</td>
<td>0.93</td>
</tr>
<tr>
<td>MEOE</td>
<td>3.74</td>
<td>0.84</td>
</tr>
<tr>
<td>IRE</td>
<td>3.70</td>
<td>0.84</td>
</tr>
<tr>
<td>All Life Science Strands</td>
<td>3.77</td>
<td>0.82</td>
</tr>
</tbody>
</table>

Scale: 1 = Extremely unconfident, 2 = Somewhat unconfident, 3 = Neither confident or unconfident, 4 = Somewhat confident, 5 = Extremely confident

Research objective three sought to determine the relationship between sources of science CK and the perceived self-efficacy to teach science content among practicing Arizona agriculture teachers. A multiple linear regression analysis was used to determine the relationship ($R^2$) (see Table 3). In conducting the regression analysis, two steps were applied to meet the assumption of the analysis. First, a bivariate correlation was calculated between all sources of science CK and the dependent variable (perceived self-efficacy). With the exception of teacher preparation programs, all sources of knowledge had an association with respondents’ perceived self-efficacy scores. Consequently, teacher preparation program was eliminated from the regression analysis. Second, researchers inspected data for multicollinearity (Berry & Feldman, 1985) by addressing tolerance factors and VIF’s among the remaining six sources of knowledge and revealed no concern of multicollinearity between constructs.
After meeting the assumptions of the analysis, a simultaneous multiple regression was chosen to analyze if \( Y \) (perceived self-efficacy to teach science content) can be predicted by \( X \) (sources of science CK) (Berry & Feldman, 1985). The results of the analysis yielded an \( R^2 (.37) \), and an adjusted \( R^2 (.29) \) (Field, 2009). Hence, analysis determined 29% of variance in teachers’ perceived self-efficacy can be explained by the linear combination of the sources of knowledge: teaching experience (\( \beta = 0.36 \)); high school agriculture programs (\( \beta = 0.28 \)); internet, textbooks, and other media (\( \beta = 0.22 \)); professional development (\( \beta = 0.03 \)); agriculture jobs and internships (\( \beta = 0.02 \)); and years spent teaching (\( \beta = -0.01 \)).

Table 3

<table>
<thead>
<tr>
<th>Source of Content Knowledge</th>
<th>( B )</th>
<th>Std. Error</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching experience</td>
<td>0.36</td>
<td>0.14</td>
<td>2.55</td>
</tr>
<tr>
<td>High school agriculture program</td>
<td>0.28</td>
<td>0.12</td>
<td>2.42</td>
</tr>
<tr>
<td>Internet, textbook and other media</td>
<td>0.22</td>
<td>0.13</td>
<td>1.64</td>
</tr>
<tr>
<td>Professional Development</td>
<td>0.03</td>
<td>0.11</td>
<td>0.24</td>
</tr>
<tr>
<td>Agriculture related jobs or internships</td>
<td>0.02</td>
<td>0.12</td>
<td>0.18</td>
</tr>
<tr>
<td>Years spend teaching</td>
<td>-0.01</td>
<td>0.01</td>
<td>-1.10</td>
</tr>
</tbody>
</table>

Note \( R^2 = 0.37, R^2_{Adj} = 0.29 \)

Discussion

Research objective one set out to describe sources of science CK. All sources of CK from Rice and Kitchel’s (2015) model (teaching experience, agriculture related jobs and experiences, internet and other media, professional development, teacher preparation program, high school agriculture program, and years spend teaching) were reported as somewhat effective contributors to respondents PCK, which is vital for dynamic classroom teaching. Teaching experience and agriculture jobs and internships on average were reported as the most effective sources of science CK, which paralleled Rice and Kitchel’s (2015) study. Respondents reported high school
agriculture program as the least effective source of science CK. Conclusions indicate respondents depend primarily on their experiences in the classroom to effectively teach science content. On average, respondents did not report any source of science CK as “extremely effective.” While Rice and Kitchel’s (2015) conceptual framework suggests applicability to science CK, it is possible additional sources of science CK were not captured in their conceptual framework.

Research objective two set out to describe perceived self-efficacy to teach science content, according to NGSS life science strands (IVT, NSE, SFO, MEOE, IRE). The majority of respondents reported they were somewhat confident to teach science content. Respondents reported on average, inheritance and variation of traits (IVT) as the life science strand they were most confident to teach. Respondents may lack self-efficacy as a result of doubting their own ability to teach science. Assuming respondent’s attitudes toward teaching science are inhibited by what they believe they can do, there is hope for improvement. Applying Bandura’s (1977) theory to this study, it can be concluded respondents do not feel particularly confident to teach NGSS life science strands, thus lacking the perceived ability to teach science. Individuals who trust in their ability to achieve a task will have greater success (Bandura, 1997). Assuming respondents want to be more efficacious, there is opportunity for continued development, specifically for respondents who are certified in biology and currently offer science credit to their high school students through agriculture courses.

Research objective three set out to describe a relationship between sources of science CK and perceived self-efficacy to teach science content. Respondents past high school agriculture program experiences, on the job teaching experiences, and past agriculture jobs and internships revealed a relationship with NGSS life science strands. All other sources revealed negligible
relationships. The CK source that had the weakest reported relationship with confidence to teach NGSS life science stands was teacher preparation programs, which paralleled Rice and Kitchel’s (2015) study.

Conversely, high school agriculture programs were reported as the least effective source of science CK (research objective one), yet revealed the strongest relationship with respondents perceived efficacy to teach NGSS life science strands. Additionally, respondents reported teaching experience as the most effective source of science CK (research objective one), but the amount of years spent teaching in the classroom was found to have negligible relationship with respondents perceived efficacy to teach NGSS life science strands. Perhaps respondents’ confidence is due to the quality of their teaching experiences, not the number of years spent in the classroom.

Twenty-nine percent of respondents self-reported confidence to teach science content can be attributed to six of the seven sources of CK (teaching experience, high school agriculture programs, internet and other media, professional development, agriculture jobs and internships, and years spent teaching). The CK source, teacher preparation programs, was expelled from the analysis because there was no relationship to NGSS life science strands. Again, high school agriculture programs were reported as the least effective source of science CK, yet was the second highest contributor to the explained variance. It should be noted that not all respondents surveyed were enrolled in a SBAE program as high school students. Perhaps, respondents who did have that experience developed greater confidence to teach science as a result. If only 29% of agriculture teachers’ confidence levels can be explained with the six sources from Rice and Kitchel’s (2015) conceptual framework, what sources contribute to the remaining 71% of unexplained variance?
Overall, two major questions arose based on the findings: (1) should agriculture teacher preparation programs require more science content courses and (2) why don’t respondents identify agriculture teacher preparation programs as an effective source of knowledge? From a content standpoint, agriculture teacher preparation programs should consider restructuring coursework to require more science content credits, but also offer science specific PCK courses. If requirements in Arizona encourage agriculture teachers to become certified in biology, agriculture teacher preparation programs should take an active role in preparing pre-service teachers to be successful science teachers as well as agriculture teachers.

**Recommendations for Practice**

Respondents are encouraged to continue to use effective sources of CK including their teaching experience, high school agriculture program experience and internet and other media, as each source was found to contribute to agriculture teachers’ overall confidence to teach science. Likewise, sources that contributed little to the variance (agriculture related jobs and internships, professional development, and years spent teaching) should be enhanced. Specifically, agriculture jobs and internships could be integrated into The University of Arizona agriculture teacher preparation programs by requiring preservice agriculture teachers to complete an agriculture industry related internship or job prior to student teaching (National Research Council, 2009). Not only would this provide preservice teachers with experience that is applicable to the classroom, but it could also contribute to agriculture teachers’ sources of CK. Additionally, professional development opportunities were lacking as an available and effective source of science CK for respondents. While there are many agriculturally related professional development opportunities available, science specific professional development is also necessary to keep up with national trends for science integration within agriculture. Arizona Agriculture
Teachers Association (AATA) should collaborate with Arizona Department of Education (ADE) and The University of Arizona to provide science specific professional development experiences to practicing agriculture teachers. Thoron, Myers, and Abrams (2011) recommended agriculture teacher professional development focus specifically on inquiry methods of teaching, which is critical for effective science instruction.

It is recommended respondents attend Curriculum for Agricultural Science Education (CASE) institutes as a science specific professional development opportunity. CASE is science curriculum developed by agriculture teachers that focuses on agricultural science and its applicability to SBAE programs. Agriculture teacher preparation programs are also encouraged to utilize CASE as a preservice professional development opportunity for student teachers to become CASE certified prior to graduation (CASE, 2011). Because of the negligible relationship between teacher preparation programs and perceived self-efficacy to teach science, agriculture teacher preparation programs are encouraged to re-evaluate current course work and consider additional required science courses. However, increasing the number of science content courses is not enough; science specific PCK courses and a focus on inquiry teaching methods should also be considered (Myers et al., 2009). It is recommended agriculture teacher preparation programs collaborate with science teacher preparation programs to be better prepare preservice agriculture teachers in science specific CK and PCK.

Seventy-one percent of the respondents’ confidence to teach science content was unexplained. Potentially, Rice and Kitchels’ (2015) conceptual framework may not have captured every knowledge source that contributes to science CK. Mentorship could be an additional source of science CK, especially in a close knit agriculture teacher community. Arizona agriculture teachers are encouraged to collaborate with and support each other through
the professional organization AATA, The University of Arizona, and Arizona FFA staff. It is recommended that additional sources of science CK are both identified and promoted for use for Arizona agriculture teachers.

**Recommendations for Research**

It is recommended that future research utilize qualitative methods to establish a greater understanding of how agriculture teachers apply various sources of CK when teaching science. Personal interviews could allow researchers to unpack what impedes or facilitates agriculture teachers’ efficacy for teaching science. Because this study was confined to Arizona agriculture teachers, future research should also expand to include other states to determine if findings are similar or different.

Results of this study suggest The University of Arizona agriculture teacher preparation program was an insignificant contributor to the perceived self-efficacy of agriculture teachers to teach science. The researchers recommend an examination of each component (e.g. CK courses, PK courses, and PCK courses, student teaching experience, etc.) of teacher preparation programs to determine why it is perceived as an ineffective source (National Research Council, 2009). Additionally, research comparing agriculture teachers and traditional science teachers’ perceived self-efficacy to teach science content and their actual CK in science topics is needed (Myers, Washburn, and Dyer, 2004). The biology certification exam scores could be an additional avenue for investigating agriculture teachers’ science CK. Finally, the researchers also questioned if the sources of science CK varied between novice and veteran agriculture teachers. Potentially investigating sources of CK by career stages of teachers may lead to increased confidence levels of agriculture teachers when teaching science.
References


doi:10.1177/0022487108324554


Dormody, T. J. (1992). Exploring resources sharing between secondary school teachers of


Washington DC: Committee on Agriculture Education in Secondary Schools, Board of Agriculture.


