SHAPING PEDAGOGICAL CONTENT KNOWLEDGE FOR EXPERIENCED AGRICULTURE TEACHERS IN THE PLANT SCIENCES: A GROUNDED THEORY

A Dissertation

presented to

the Faculty of the Graduate School

at the University of Missouri-Columbia

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

---

by

AMBER MICHELLE RICE

Dr. Tracy Kitchel, Dissertation Supervisor

MAY 2015

The undersigned, appointed by the Dean of the Graduate School, have examined the dissertation entitled

SHAPING PEDAGOGICAL CONTENT KNOWLEDGE FOR EXPERIENCED AGRICULTURE TEACHERS IN THE PLANT SCIENCES: A GROUNDED THEORY

Presented by Amber Michelle Rice,

a candidate for the degree of Doctorate of Philosophy in Agricultural Education and hereby certify that, in their opinion, it is worthy of acceptance.

Tracy Kitchel
Associate Professor and Director of Graduate Studies,
Agricultural Education and Leadership

Anna Ball
Professor and Department Chair,
Agricultural Education and Leadership

Jon Simonsen
Assistant Professor and Director of Undergraduate Studies,
Agricultural Education and Leadership

Kathryn Chval
Associate Dean for Academic Affairs,
Mathematics Education

DEDICATION

This dissertation is dedicated to my supportive husband Jim, my incredible parents Carrie and Rex, my best friend and sister Amanda, and to all of the agriculture teachers out there continuing to make a difference in the lives of students.

ACKNOWLEDGEMENTS

I would like to take this opportunity to thank the members of my committee for the countless hours they dedicated to my dissertation process. I could not have asked for more knowledgeable, supportive, and invested committee members. To Tracy Kitchel, I could not have accomplished this milestone without you. Thank you for the countless draft revisions, idea discussions, and most importantly for your unwavering faith in me. It is because of your excellent mentoring that I know I will go on to impact agricultural education with my teaching and research. To Anna Ball, thank you for instilling in me a love for qualitative research, for advice when I needed it the most, and for your thoughtful comments on my dissertation. To Jon Simonsen, thank you for being the smiling face that gave me courage to press forward and for always being available if I needed resources or advice. To Kathryn Chval, I am so grateful you were willing to serve on my committee. Your expertise in PCK research has been invaluable to both to my dissertation and to my future research agenda. To anyone else who was instrumental in my dissertation and graduate school journey- thank you.

TABLE OF CONTENTS

LIST OF FIGURES

Shaping Pedagogical Content Knowledge for Experienced Agriculture Teachers in the Plant Sciences: A Grounded Theory

Amber Michelle Rice

Dr. Tracy Kitchel, Dissertation Supervisor

ABSTRACT

The purpose of this grounded theory study was to conceptualize the pedagogical content knowledge (PCK) of experienced agriculture teachers in the plant sciences. The overarching theme that emerged during data collection and analysis was the influence of beliefs on participants' PCK. This finding guided subsequent data collection and analysis that focused on what was shaping the participants' PCK in plant sciences. Three major themes that shaped the participants' PCK were: integrated belief systems, experiences prior to and during in-service, and the context of the participants. The integrated beliefs system was the driving force in shaping the participants' PCK. A substantive level theory was developed that illustrated the relationships between the three themes on participants' PCK. These findings support further examination into what is shaping agriculture teachers' PCK, including investigation in other agriculture content areas such as animal sciences and further examination into views about the purpose of agricultural education.

CHAPTER 1: INTRODUCTION

Background and Setting

The most significant impact on student learning is the teacher and how they use their knowledge to teach (Darling-Hammond, 2006; Hattie, 2009). Research on teaching and learning has identified two primary knowledge bases important for all teachers to possess: subject matter expertise and pedagogical content knowledge (PCK) in a specific subject matter field (National Research Council, 2010). Shulman (1986) first coined the term PCK at an education conference in a speech on the 'missing paradigm' in education. In the decades prior to his speech, education research had focused primarily on pedagogy and less on subject matter knowledge or content knowledge. In his first article addressing PCK, Shulman (1986) discussed the historical emphasis on teacher content knowledge, describing exams used for teacher certification that focused primarily on content knowledge. He claimed research and reform efforts had since strayed away from the importance of content knowledge in teachers and challenged educators to reassess the importance of content knowledge in relation to pedagogy.

Shulman (1986) first described PCK as a separate knowledge base where both content and pedagogy combined to create professional knowledge specifically for teaching. He argued PCK is what separates a teacher of content from a mere expert in content (Shulman, 1986). After introducing the concept of PCK, Shulman (1987) elaborated on the many practices a teacher with PCK could accomplish including: clarifying materials, making representations, and navigating student difficulties. The definition of PCK has evolved over time; with the majority of researchers in agreement that PCK is more complex than Shulman originally conceived (Kind, 2009). The most recent definition of PCK came from a summit where current minds in science PCK research attempted to create a consensus definition. PCK was defined as the knowledge of, rationale behind, planning for, and act of teaching a piece of subject matter using specific methods for specific students to promote student learning (Gess-Newsome & Carlson, 2014). This definition of PCK highlighted its presence in both the planning stage of teaching and the in-the-moment action of teaching.

PCK allows teachers to transform their understanding of content for their students' understanding (Halim & Meerah, 2002) by enabling teachers to identify critical concepts, make connections between concepts and topics, and display the skills and methods needed to teach content (Chick, Baker, Pham, & Cheng, 2006). Teachers must comprehend how students think about particular content in order to create metaphors to explain that content (Kennedy, 1998). Effective teachers have an understanding of students' misconceptions and preconceptions of content and take into account students' strengths, weaknesses, and interests (Stronge, 2007).

Differences among students also necessitate the importance of teachers developing PCK (Enfield, 2012). Teachers must understand their content areas deeply and flexibly to effectively teach all students in a variety of ways (Solis, 2009). When one method of teaching or one representation does not work, teachers need to be able to call on alternatives (Ball & McDiarmid, 1990). If teachers do not possess PCK they are in danger of perpetuating student misconceptions, may be unable to promote student comprehension of content, and may be unable to provide explanations for material that result in student learning (Borko et al., 1992; Halim & Meerah, 2002; Van Driel, Verloop, & De Vos, 1998).

Today, PCK is widely accepted as a crucial knowledge base for teachers (Loughran, Mulhall, & Berry 2004); however, its specific components and how they interact together still varies amongst researchers (Ballantyne & Packer, 2004; Hashweh, 2005). In mathematics education research, PCK is commonly referred to as mathematical knowledge for teaching and components include: knowledge of content combined with knowledge of students, knowledge of content combined with knowledge of teaching methods, and knowledge of content combined with knowledge of curriculum (Hill, Ball, & Schilling, 2008). In science education, similar components of PCK include: knowledge of science curricula, knowledge of assessment of scientific literacy, knowledge of instructional strategies, and knowledge of students' understanding of science (Magnusson, Krajcik, & Borko, 1999). Based on a review of PCK literature, instruction, students, curriculum, and assessment knowledge within a subject matter context repeatedly appear as important components of the PCK in various education disciplines (Kind, 2009). However, discrepancies amongst developed models may lead to difficulties when examining PCK in largely non-researched education disciplines.

In addition to the debate between various components of PCK, another aspect of PCK research inquiries have dealt with the topic specific nature of PCK. Early research studies investigated PCK in a more generalized fashion by discipline; however, various researchers have now claimed PCK is topic specific (Etkina, 2010; Gess-Newsome & Carlson, 2014; Magnusson et al., 1999; Van Driel & Berry, 2012). In science education, a recent study examined the topic specific nature of teaching electrochemical cells and nuclear reactions (Aydin, Friedrichsen, Boz, & Hanuscin, 2014). When comparing two chemistry teachers, the researchers discovered teachers' knowledge of instructional strategies, learners, and curriculum were topic specific, but other areas such as knowledge of assessment and orientations were not topic specific. It is still unclear if PCK is topic-specific in general or if the topic specificity differs by components of PCK (Aydin et al., 2014).

Van Driel and Berry (2012) further described PCK as topic, person, and situation specific. The PCK definition and model from the recent summit of science educators also reflects the personal and topic specific nature of PCK, by including components such as beliefs, orientations, and personal PCK (Gess-Newsome & Carlson, 2014). Knowledge, beliefs, and experiences of individual teachers can shape their PCK (Van Dijk & Kattmann, 2007). PCK is constructed through an individual teacher's lens, and is described as idiosyncratic by Lee (2011) and Loughran et al. (2012). No one teacher will have the exact same PCK for a topic; however, there can be overlaps and similarities (Padilla & Van Driel, 2011). Friedrichsen, Van Driel, and Abell (2010) call for further exploration into the role of science teaching orientations on PCK. They proposed goals and purposes of science teaching, views of science, and beliefs should be specifically examined (Friedrichsen et al., 2010).

PCK is acknowledged as an important knowledge base for teachers to possess in many disciplines, including agricultural education (Roberts & Kitchel, 2010). Curriculum development recommendations in agricultural education include considering the prerequisite knowledge students need for learning particular content, the interests of students regarding content, and the readiness levels of students for learning content

(Talbert et al., 2005), all demanding PCK. Despite its espoused importance, little research has been conducted specifically on PCK's role in agricultural education. Instead, studies have primarily focused on needs studies of agriculture teachers and characteristics of effective agriculture teachers (Garton & Chung, 1996; Layfield & Dobbins, 2002; Mundt & Connors, 1999; Myers, Dyer, & Washburn, 2005; and Washburn, King, Garton, & Harbstreit, 2001), among others.

An example of agriculture teachers' PCK in the plant sciences, specifically within the area of greenhouse management and plant growth, could include knowledge of common student misconceptions. One student misconception related to this area is plants get their 'food' from the soil and thus need soil to grow (Driver, Squires, Rushworth, & Wood-Robinson, 1994). If an agriculture teacher is aware of this student misconception, they may choose to teach a lesson on hydroponics to demonstrate plants can grow without soil. They may also have students conduct experiments using different growing mediums in the greenhouse to see how they influence plant growth. Dispelling this misconception could pave the way for deeper conversations about photosynthesis. Knowledge of student misconceptions for a particular content area and the subsequent teaching strategies chosen to dispel those misconceptions are all grounded in agriculture teachers' PCK.

Despite the importance of PCK illustrated in the previous example, the agricultural education discipline does not know what PCK agriculture teachers have or need for any content area within agriculture. Without a clear picture of what PCK current teachers have, it will be difficult to anticipate where efforts for development should be focused. And without a model for PCK in agricultural education, how can the development of PCK in teachers be fostered? In addition to not knowing what PCK agriculture teachers possess, teacher education in agriculture is also unaware of what PCK agriculture teachers *should* possess to enhance student learning.

Investigating experienced agriculture teachers currently in the field is an important first step in articulating what PCK agriculture teachers possess. In science education, a field at the forefront of PCK research, experienced teachers were consulted to develop documents representing detailed PCK for specific science topics such as genetics or electrical circuits (Loughran et al., 2012). While experience in the field does not guarantee an individual will possess PCK, it does increase the likelihood PCK has been developed (Hashweh, 2005). According to Darling-Hammond and Bransford (2005) approximately five to eight years is when expertise begins to be developed in teachers. When examining teachers with expertise, these individuals are more likely to notice patterns of information, have a substantial amount of content knowledge (the foundation for PCK), and are more readily able to apply their knowledge and retrieve it with little effort (Bransford, Brown, & Cocking, 2000).

A recent study in agricultural education investigating beginning teachers' abilities to deconstruct content knowledge for student understanding concluded this process was impeded by teachers' lack of content knowledge and PCK (Rice & Kitchel, 2014a). This further substantiates the need to investigate more experienced agriculture teachers. Because this study is focused on providing a foundation for future research in PCK in agricultural education, it is also important to study teachers with not only teaching experience, but with expertise specifically in a content area of focus.

Content taught in an agriculture classroom can include a variety of subjects: agribusiness systems, animal systems, biotechnology systems, environmental service systems, food product and processing systems, natural resource systems, plant systems, and power, structural and technical systems (National Council for Agricultural Education, 2009). With this wide breadth of possible content, it was important to focus on one specific area of content. Plant science is a commonly taught content area for agriculture programs across the nation and is one of the eight career pathways (National Council for Agricultural Education, 2009). Within the state of Missouri specifically, plant science is an important part of agricultural science standards (Missouri Department of Elementary and Secondary Education, 2011). Due to the lack of research in agricultural education for any content area, there was a need to focus on a common area typically taught to provide a foundation for future research.

Additionally, a substantial number of teachers were engaged in teaching plant science content both across the nation and in the state of Missouri. I also recognized I needed to have both content knowledge and PCK experience myself to recognize it in the participants. I am a former high school agriculture teacher who taught both plant science and biology for four years. I also have a background working in greenhouses and landscaping for four years prior to entering the teaching profession.

Statement of the Problem

PCK is one of the most important knowledge bases a teacher can have for effective classroom teaching (Baumert et al., 2010; Diakidoy & Iordanou, 2003; Gess-Newsome & Lederman, 1999; Loughran et al., 2012; Solis, 2009). Teacher education in agriculture has acknowledged the importance of PCK as a knowledge base for quality teachers and its positive impact on teaching and learning (Knobloch, 2002; Roberts & Kitchel, 2010). PCK influences numerous teaching decisions related to student understanding of content such as selecting appropriate representations and examples of concepts, addressing student misconceptions of specific concepts, and integrating and sequencing ideas and concepts in the curriculum (Ball, Thames, & Phelps, 2008). Therefore, it is imperative teacher education in agriculture assists agriculture teachers in developing PCK. However, due to limited research in agricultural education, it is still unclear what PCK teachers possess, to what degree they possess it, to what degree they *should* possess it, and the influence it has on their teaching.

At this point, the agricultural education field does not have a conceptualization of PCK for any topic area. Therefore, it is critical to first examine experienced teachers who have PCK. Since PCK is topic specific (Etkina 2010; Hashweh, 2005; Van Driel & Berry 2012), it will also be important to examine PCK for specific agricultural education topics. This research study will specifically focus on the investigation of agriculture teachers' PCK related to the plant sciences. Creating a picture of experienced teachers' PCK could provide valuable information for teacher preparation programs and inservice professional development initiatives. This could help to insure the quality of agriculture teachers in the classroom and ultimately enhance student learning.

Purpose and Research Question

The purpose of this grounded theory study was to conceptualize PCK for a specific topic in agriculture to serve as a model for the investigation and conceptualization of additional topics. The following central research question guided the study: What is experienced agriculture teachers' PCK related to the plant sciences?

Definitions of Terms

Agricultural Education: School based agriculture instruction for students in grades 9-12. The agricultural education model includes three components: FFA, SAE, and classroom instruction (Newcomb, McCracken, Warmbrod, & Whittington, 2004).

Content Knowledge: The knowledge of a specific content area to be learned or taught (Mishra & Koehler, 2006).

Experienced Teacher(s): Teachers with at least five to eight years of classroom teaching experience (Darling-Hammond & Bransford, 2005).

Inservice Teachers: Teachers who are currently fully employed in a school system.

Pedagogical Knowledge: knowledge of the strategies and methods for teaching (Darling-Hammond & Bransford, 2005).

Pedagogical Content Knowledge (PCK): The combination of content knowledge and pedagogical knowledge to create knowledge specifically for teaching (Shulman, 1986).

Plant Sciences: The study of plant and plant systems, including areas such as horticulture, agronomy, landscape, and turf management (Herren, 2007).

Limitations of the Study

1. This study focused on one unit of agriculture content- plant sciences. Findings from this content may not be transferable to other content areas within agricultural education.
2. This study focused on a specific group of eight experienced agriculture teachers in the state of Missouri. Findings from these teachers may not be representative of other experienced teachers within the state of Missouri or other teachers in different states.
3. Despite two observations cycles of two days a piece, not every potential example of PCK emerging during the act of teaching the unit could be captured. To compensate for this limitation, teachers were asked to complete reflection questions after each lesson.
4. The time spent in the field was limited to the length of one unit. Due to the limited time, various data were collected including interviews, observations, artifacts, and reflection journals.
5. The influence of the researcher may have caused the teachers to alter their typical teaching curriculum and/or methods. Interviews and reflection questions were utilized to probe for further evidence of PCK by extending beyond the current lesson and exploring hypothetical situations and alternatives to methods used.

Basic Assumptions

1. PCK exists in agricultural education and plant sciences and can be codified.
2. The teachers possessed effective content knowledge in the plant sciences.
3. The teachers possessed effective PCK in the plant sciences.

4. The teachers were honest during their interviews and reflections.
5. The classroom observations represented what was typical of the participants.

Need for the Study

PCK research is one way to conceptualize the complexity of teacher knowledge necessary for teaching (Gess-Newsome & Lederman, 1999). PCK research can aid in creating a picture of what teachers do when teaching, relate teaching to student learning, and further establish content knowledge alone does not make an individual qualified to teach (Kind, 2009). Exploration of PCK in a variety of disciplines can contribute to a further understanding of the knowledge and skills that make teachers effective (Abell, 2008). Research has indicated ways to strengthen PCK in teachers could lead to increased student progress and student learning (Baumert et al., 2010; Hill, Rowan, & Ball, 2005), which is the ultimate goal of teaching.

Specifically, this study could provide a foundational framework for looking at PCK in agricultural education within a specific topic area. Subsequent frameworks could then be developed. This could lead to better teacher preparation at both the preservice and inservice levels. Examining teachers' PCK and how it influences their teaching practices can assist teacher preparation programs in preparing quality teachers (Ballantyne & Packer, 2004). Magnusson et al. (1999) suggested using the components of PCK in a developed model to explicitly guide preservice teachers as they develop their knowledge for teaching. The researchers also suggested inservice teachers could benefit from PCK research because PCK is developed and enhanced throughout the teaching process (Magnusson et al., 1999). And if PCK is indeed very specific to a topic of content, it is even more important information is provided to preservice and practicing teachers so they develop PCK for the variety of topics they teach. It is impossible to completely develop PCK for all topics at the preservice level (Magnusson et al., 1999); so, without a PCK framework to guide agriculture teachers beyond university preparation their development of PCK is uncertain.

CHAPTER 2: REVIEW OF LITERATURE

Purpose of Review of Literature in Grounded Theory

When grounded theory first emerged as a qualitative research methodology, it was recommended researchers wait until engaging in data collection and analysis to conduct a thorough review of literature (Glaser & Strauss, 1967). The purpose was to protect the integrity of the developing theory by allowing researchers to enter the field as 'blank slates'. It is now widely acknowledged researchers cannot come into research studies as 'blank slates' but instead bring the lens in which they view the world, previous experiences, and knowledge of the field (Corbin & Strauss, 2008). It would be naive to assume researchers could completely ignore all of the literature they have previously read in their field before conducting a study (Corbin & Strauss, 2008).

Over time, the practice of abstaining from an initial review of literature has been questioned and many current grounded theory researchers have now conducted reviews of literature prior to engaging in research (Charmaz 2006; Corbin & Strauss, 2008; Dunne, 2011). Specifically, Corbin and Strauss (2008) indicated that while a review of literature should not limit how researchers view their data, it can provide valuable insight into the data itself. A review of literature in grounded theory methodology can be used for comparison purposes, assistance in the identification of various aspects of a phenomenon, and enable researchers to more readily see the connections between concepts (Corbin & Strauss, 2008).

The purpose of this particular study was to conceptualize PCK for experienced agriculture teachers in the topic of plant sciences. While agricultural education is lacking studies investigating topic specific PCK, other disciplines such as science, mathematics, social studies, English, physical education, communications, religion, chemistry, engineering, music, and special education (Ball et al., 2008) have made great headway in PCK research. The following review of literature begins with a focus on content knowledge, arguably the foundation for PCK (Darling-Hammond & Bransford, 2005; Halim & Meerah, 2002; Van Driel, De Jong, & Verloop, 2002). It then expands to discuss the integrative versus transformative nature of PCK, common components of PCK, development and sources of PCK, experienced and novice teachers PCK, new research on measurement and student achievement in relation to PCK, and a final examination of the importance and impact of PCK research on agricultural education.

Content Knowledge as a Foundation for Pedagogical Content Knowledge

As the concept of PCK began to gain steam in the research community, much of the initial research focused on the importance of content knowledge. Possession of strong content knowledge in a particular content area is considered an important criterion for teacher quality (Kaplan & Ownings, 2002; Okpala & Ellis, 2005). In 2011, all 50 states reported state standards for teaching credentials, all of which included content knowledge (United States Department of Education, 2013). Teaching standards specifically for secondary grades in career and technical education (CTE), the umbrella over agricultural education, were also reported for 40 states (United States Department of Education, 2013). The importance of content knowledge for teachers seems to be a widely held belief by education researchers. Ball, Hill, and Bass (2005) stated teachers need to understand their content deeply in order to be successful. Tasks such as choosing materials, assessing student learning, and sequencing curriculum all require content knowledge (Ball, et al., 2005).

In a book chapter, Ball and McDiarmid (1990) discussed the importance of content knowledge for teachers, identifying it as a prerequisite for PCK. They claimed content knowledge is important to eliminate teachers passing on erroneous material to their students or perpetuating student misconceptions. Without appropriate levels of content knowledge, teachers will struggle to help students learn (Ball & McDiarmid, 1990). Kennedy (1998) further elaborated on how knowledge of content impacts teachers' abilities by discussing how teachers use this knowledge to create effective instructional strategies, answer student questions, and provide relevant examples of content. Etkina (2010) also maintained content knowledge is the foundation for PCK development.

The Hill et al. (2008) Mathematical Knowledge for Teaching (MKT) model included content knowledge as half of their model. Content knowledge (referred to as subject matter knowledge on the model) was further broken down into common content knowledge, specialized content knowledge, and knowledge at the mathematical horizon (Hill et al., 2008). Common content knowledge was described as the basic mathematics most adults should know and the content teachers will be teaching their students (Ball et al., 2008). Specialized content knowledge was described as content knowledge specifically for teachers, a step above the content known by the average adult (Ball et al., 2008). For example, instead of the teacher simply knowing if a student math problem is correct or incorrect (requiring common content knowledge), if they possess specialized content knowledge they should know *why* a student answer is correct or incorrect, requiring a deeper knowledge of content. Knowledge at the mathematical horizon was described as knowledge about how different concepts of mathematics fit together across units and courses (Ball et al., 2008).

One of the more compelling arguments for the importance of content knowledge for teaching rests in what happens to teachers when they attempt to teach a subject outside of their area of expertise. Teachers who are certified and well-qualified in their own fields of study have been found to be ineffective when teaching a subject for which they were not prepared (Stronge, 2007). However, teacher preparation programs may not be enough to develop strong content knowledge in teachers. Ball and McDiarmid (1990) discovered despite completion of required coursework, physics and mathematics preservice teachers had weak content knowledge. Other researchers also discovered preservice and beginning teachers did not possess enough content knowledge to make meaningful lessons (Borko et al., 1992; Floden & Meniketti, 2005; Gess-Newsome & Lederman, 1999). Beyond secondary education, a common issue for elementary teachers when designing lessons was insufficient content knowledge, resulting in a difficulty for novices to recognize student misconceptions due to their own content misconceptions (Kapyla, Heikkinen, & Asunta, 2009).

While there is a debate in the literature over whether content knowledge is included within or is a separate knowledge base from PCK (Kind, 2009), there is no denying its importance in shaping quality instruction. However, it is not the only knowledge base necessary for teaching (Monk, 1994). Lee, Brown, Luft, and Roerhig (2007), found a strong science background, while important, was not enough for development of science teachers' PCK. So what separates PCK from content knowledge? The next sections explore the nature of PCK and the various components of PCK.

Integrative versus Transformative Nature of Pedagogical Content Knowledge

Gess-Newsome and Lederman (1999), in a book examining PCK in science education, elaborated on different perceptions about the nature of PCK since its conception by Shulman (1986). Some models and studies were based on transformative philosophies and some on integrative philosophies. Transformative philosophies regard PCK as its own separate knowledge base that is transformed through a teacher's knowledge of content, pedagogy, and context (Gess-Newsome & Lederman, 1999). This philosophy asserts for teachers to most effectively gain PCK, content and pedagogy must be taught together (Steele, Hillen, & Smith, 2013). Viewing PCK as transformative in nature recognizes it as a completely separate knowledge base from content knowledge and pedagogical knowledge. This philosophy also maintains teachers possess PCK for all topics taught (Gess-Newsome & Lederman, 1999). An example of a topic in agricultural education would be sexual reproduction of plants or digestive systems of ruminant animals.

Integrative philosophies took a different approach and claimed teachers develop aspects of content knowledge, pedagogy, and context separately and then integrate them while teaching in the classroom (Gess-Newsome & Lederman, 1999). Teaching expertise in an integrated model is not possessing separate PCK for topics taught, but instead being able to fluidly retrieve and integrate knowledge bases for topics taught (Gess-Newsome & Lederman, 1999). Hashweh (2005) described PCK as pedagogical constructions that come about by using all of the knowledge bases for teaching in repeated planning, teaching, and reflection. An integrative philosophy implies knowledge components can be taught separately in teacher preparation (Gess-Newsome & Lederman, 1999).

Kind (2009) argued a transformative approach to PCK is most beneficial moving forward for science education. She also described Shulman's (1986) original description as based on a transformative philosophy. Other researchers with transformative philosophies regarding PCK have included Halim and Meerah (2002) and Van Driel et al. (2002). Based on careful review of the two philosophies, it was determined that PCK will be examined based on the transformative philosophy in this study.

Components of Pedagogical Content Knowledge

Since Shulman's (1986) description, the majority of researchers have added components to his initial conceptualization, demonstrating the complexity of PCK (Kind, 2009). Many early researchers examined PCK in a more generalized fashion by discipline (Kind, 2009). Grossman (1990), a student of Shulman, identified three general areas of teacher knowledge including pedagogical knowledge, content knowledge, and knowledge of context that are transformed into PCK. Knowledge of context was the first component discussed influencing PCK and can include factors such as culture, school environment, and knowledge of individual students (Grossman, 1990). Context is not always explicitly addressed in models or descriptions of PCK; however, it is mentioned as having a strong influence on teachers' knowledge bases in various studies (Beijaard, Verloop, & Vermunt, 2000; Kennedy, 2010; Lee, 2011).

Kennedy (2010) emphasized how much context can alter teachers' behaviors in the classroom and their PCK. Four contextual factors she addressed included: parameters of teachers' work including: time, materials, and work assignments; students; school incursions into classroom life including: announcements, fire drills, and field trips; and reform clutter which included new education initiatives (Kennedy, 2010). Kennedy (2010) cautioned models of teacher quality should include situational characteristics on equal par with teacher characteristics. While context is not specifically a knowledge component, it does emerge in PCK literature as having a substantial influence on PCK knowledge and development by influencing various resources and constraints available to the teacher (Kind, 2009). As a largely unexplored discipline, it was important to be aware of context in agricultural education and its potential influence on PCK for this study.

In science education, The Magnusson et al. (1999) model for science PCK is one of the more prevalent models in PCK research and has been utilized in many studies since its conception (Hume & Berry 2011; Lannin et al., 2013; Padilla & Van Driel 2011), among others. The Magnusson et al. (1999) model was based on a transformative philosophy of PCK and included five components that continuously appear in other research studies, though often under slightly different terms. The parts include: orientations towards teaching which shapes- knowledge of learners, knowledge of assessment, knowledge of instructional strategies, and knowledge of curriculum.

In the Magnusson et al. (1999) model orientations to teaching shaped all of the other knowledge components in PCK. Magnusson et al. (1999) described nine specific orientations to teaching science including: process, academic rigor, didactic, conceptual change, activity-driven, discovery, project-based, inquiry, and guided inquiry. For agricultural education this could be used to explore how a teachers' purpose of agricultural education affects their PCK. Research in agricultural education has demonstrated a discrepancy between teaching for the purpose of developing career preparatory skills and teaching for the purpose of developing agricultural literacy (Roberts & Ball, 2009), making this particular component worthy of further exploration.

The instructional component is a critical component of PCK because it combines pedagogical knowledge of how to teach with the specific content being taught. According to Magnusson et al. (1999) this component included subject specific instruction and topic specific instruction for a specific piece of material. Topic specific instruction is further broken down into knowledge of representations and activities for teaching (Magnusson et al., 1999). An example of knowledge for using inquiry-oriented instruction for teaching a specific science topic is given by Magnusson et al. (1999). For agricultural education, this could look at how teachers explain examples through representations and what activities they choose for instruction and the educational purpose for which they were chosen.

The knowledge of students' understanding of science component included knowledge of where students were at currently in terms of knowledge for a topic and knowledge of difficulty students might have with content (Magnusson et al., 1999). This emphasized the importance of knowledge of students' prior knowledge and knowledge of students' misconceptions and difficulties with content. Magnusson et al. (1999) also described teachers' specific learning styles (i.e. direct-transmitter of knowledge or facilitator of learning) could play a role in this component of PCK. Knowledge of students is one of the most frequently explored knowledge components in PCK research (Depaepe, Verschaffel, & Kelchtermans, 2013). Schneider and Plasman (2011) stated more PCK articles revolved around the concept of knowledge of students than any other knowledge component. In particular, science studies often focused on knowledge of student misconceptions and other areas including knowledge of: students' initial science ideas and experience, students' idea development, how students express science ideas, challenging science ideas for students, and appropriate level of science understanding for students (Schneider & Plasman, 2011).

The next component of the Magnusson et al. (1999) model was knowledge of science curricula, which referred to knowledge of specific science curriculum programs and specific requirements of the nation, state, or school district on curriculum. These specific requirements included goals and objectives of teaching science (Magnusson et al., 1999). An example of a specific curriculum programs for agricultural education would be Curriculum for Agricultural Science Education (CASE). For agricultural education, the influence of curriculum could be an important component of PCK because of the lack of defined curriculum in agricultural education (Talbert et al., 2005).

In addition to providing detailed descriptions of the previous PCK components, the Magnusson et al. (1999) model was the first to discuss knowledge of assessment as a component of PCK. In the Magnusson et al. (1999) model, the assessment component was described as knowledge of assessment of scientific literacy and included dimensions of science learning to assess and methods of assessing science learning. Proponents of the Magnusson et al. (1999) model often justified their decision to use the model for their study partially based in its inclusion of the assessment component (Hume & Berry, 2011; Lannin et al., 2013; Padilla & Van Driel, 2011). In fact, Padilla and Van Driel (2011) claimed research should put more focus on assessment and its role in PCK.

Another popular model utilized in PCK research, is the Hill et al. (2008) MKT model. As previously discussed, this model included content knowledge as half of the components of PCK. In addition to content knowledge, the other half of the model was PCK specific and included: knowledge content with knowledge of students, knowledge of content with knowledge of teaching, and knowledge of content with knowledge of curriculum (Hill et al., 2008). Knowledge of content and students is the combination of knowledge of mathematics content with knowledge of students' learning (Hill et al., 2008). Teachers who possess knowledge of content and students are able to respond to student questions, evaluate student claims, anticipate if a task will be easy or difficult for students, and interpret students' emergent mathematical thinking (Ball et al., 2008). Knowledge of content and students also included knowledge of student development sequences (Hill et al., 2008).

In the Hill et al. (2008) model, the instructional component was termed knowledge of content and teaching. Knowledge of content and teaching is described as the combination of mathematics content knowledge with knowledge of teaching (Hill et al., 2008). Tasks associated with knowledge of content and teaching include: linking representations to underlying ideas, adapting content from resources, modifying teaching tasks, choosing and developing useful definitions, using appropriate terminology, and distinguishing between instructional advantages and disadvantages of various methodologies (Ball et al., 2008). Additionally, instructional tasks such as redirecting discussion and engaging in effective classroom discourse depend on teachers' PCK (Walshaw & Anthony, 2008).

The Hill et al. (2008) model included the curricular component as its final component of PCK and termed it knowledge of content and curriculum. Knowledge of content and curriculum is defined as the combination of knowledge of mathematics content with curriculum knowledge (Hill et al., 2008). Teachers possessing knowledge of content and curriculum are able to connect topics and explain mathematics goals and purposes (Ball et al., 2008). In a review of PCK literature, Schneider and Plasman (2011) acknowledged trends in the curricular component of PCK addressing scope of instruction, use of standards, sequence of instruction, and curriculum resources. Knowledge of the curricular component is an area in which many preservice and early career teachers are lacking according to empirical research (Schneider & Plasman, 2011).

The assessment component was not addressed by the Hill et al. (2008) model. In a literature review, Schneider and Plasman (2011) found PCK had the least amount of empirical studies exploring the assessment component. Assessment was also the only PCK area where more studies were focused on experienced teachers as opposed to novice teachers (Schneider & Plasman, 2011). The Hill et al. (2008) model also did not include orientations as a component of the PCK model, which has invoked some criticism of other researchers and led to many returns to the original Magnusson et al. (1999) model (Kind, 2009).

In more recent studies, orientations had been a more dominant component of PCK research. In a study using the Magnusson et al. (1999) model, Lee (2011) reinforced the view that orientations are an important component to PCK. Padilla and Van Driel (2011) also addressed orientations in their research on quantum chemistry. In the literature orientations are termed differently depending upon the model, but may include teacher beliefs about learning, approaches to teaching in general, specific approaches to subject matter, and epistemologies. Grossman (1990) referred to orientations as purposes and described them as the overall goals for teaching a particular subject. This lack of consistency with terms and various definitions for what is influencing PCK has surfaced many issues surrounding the concept of orientations in PCK literature. Key concerns surfaced by Friedrichsen et al. (2010) after conducting various projects that investigated orientations included: various definitions and meanings behind the word orientations, weak or non-existent relationships between orientations and the rest of the PCK model, researchers simply assigning teacher orientations, and researchers simply not addressing this proposed component of PCK.

Some researchers investigated teachers' beliefs in place of or in addition to their orientations. Development of knowledge is influenced by teachers' existing beliefs and this can in turn influence their teaching and PCK. To develop PCK sometimes changes to beliefs are required (Veal, 2004). Hashweh (2005) also claimed PCK is influenced heavily by teachers' beliefs. There is evidence that these beliefs can emerge prior to entrance in a teacher preparation program (Kapyla et al., 2009). Often student teachers' teaching orientations were connected to their own educational backgrounds (Kapyla et al., 2009).

The role of orientations and beliefs on PCK, in addition to all of the previously described components, are reflected in the most current model of PCK developed at the PCK summit by various PCK researchers from across the world (Gess Newsome & Carlson, 2014). This consensus model of PCK attempted to combine many of the previous PCK models and included knowledge components such as assessment, students, instruction, curriculum, orientations and beliefs, and context. This model included the influence of topic specific professional knowledge, classroom practice, student outcomes, and various amplifiers and filters on teachers' PCK (Gess-Newsome & Carlson, 2014). These amplifiers and filters included the concepts of beliefs, orientations, and context of the teachers, and for the first time in the literature, student beliefs and personal PCK. This model demonstrated the true complexity of PCK and the various relationships involved between the components.

Pedagogical Content Knowledge Studies in Specific Topic Areas

Research at the turn of the century began to explore PCK in a more specific fashion, looking at topic areas within an education discipline and not simply the discipline as a whole (Kind, 2009). This research was designed to capture the more nuanced aspects of PCK, and one field at the forefront of this type of research is science education (Kind, 2009). Loughran et al. (2004) developed a framework for PCK called Content Representations (CoRes) used to investigate teachers' PCK of specific topics. In collaboration with over 50 experienced science teachers, CoRes in topic areas such as genetics, acids and bases, and chemical reactions were developed (Loughran, et al., 2012). The CoRes framework was designed as a tool for teachers to fill out as they plan and for already completed CoRes to be used by existing teachers to guide teaching (Loughran et al., 2012). Questions from the CoRes framework included: what did you intend students to learn about this idea, why do you think it is important to know this, what difficulties or limitations are connected with teaching this idea, what else do you know that you don't intend students to know yet, and knowledge of students' thinking that influences your teaching of this idea, among others (Loughran et al., 2012).

In addition to the CoRe framework, Pedagogical and Professional experience Repertoires (PaP-eRs) were developed as an expansion of CoRes allowing for an even more specific look at a piece of content. Through a cumulative expert teacher narrative, PaP-eRs examined how the thinking of CoRes is put into practice by teachers (Mulhall, Berry & Loughran, 2003). Loughran et al. (2004) stated until their development of CoRes and PaP-eRs much PCK research had focused on various parts of PCK instead of the PCK as a whole for a particular topic. Since the development of CoRes, Hume and Berry (2011) have utilized the framework as a way to introduce PCK in teacher preparation with proclaimed success; however, Kaplya et al. (2009) caution PaP-eRs may be too complicated for initial teacher preparation.

Other studies have examined PCK for specific topics (Chick et al., 2006; Diakidoy & Iordanou, 2003; Padilla & Van Driel, 2011; Usak 2009; Van Driel et al., 1998). Schneider and Plasman (2011) called for more studies to examine PCK within a specific topic area. They claim this would be a useful way to move forward in understanding and enhancing teacher knowledge (Schneider & Plasman, 2011). However, Loughran et al. (2004) attest to the difficulty of capturing and portraying topic specific PCK. The detail that topic specific investigation of PCK can provide guided the plant science topic specific investigation of experienced agriculture teachers' PCK in this study.

Sources and Development of Pedagogical Content Knowledge

While the focus of this literature review has rested primarily in the area of conceptualization of PCK, it is also important to address literature in the area of PCK development. Research focused on development can provide insight into the nature of PCK and how it is acquired by teachers at all stages in their careers. Grossman (1990) described four sources of teachers' PCK including: coursework, observations, teaching experience, and professional development workshops. In a study of preservice music teachers, there was not one dominant source of PCK but instead apprenticeship of observation, methods courses, and cooperating teachers were all reported as effective sources by participants (Haston & Leon-Guerrero, 2008). These sources do not result in an instant accumulation of PCK; instead, PCK is continuously developed throughout a teachers' career (Lee, 2011) in a complicated non-linear process (Van Driel, 2010). Guidance and reflection are essential for the development of PCK (Schneider & Plasman, 2011).

There is also evidence for explicitly teaching PCK in teacher preparation programs (Kapyla et al., 2009), often through instruction about what it is and tools for continued development (Van Dijk & Kattmann, 2007). PCK fits with the teacher preparation model from Darling-Hammond and Bransford (2005) which includes: knowledge of learners and their development in social contexts, knowledge of subject matter and curriculum goals, and knowledge of teaching which includes content, pedagogy, and assessment. Magnusson et al. (1999) asserted development of PCK can begin during teacher preparation. However, students often leave programs with few tools to integrate their content knowledge, pedagogical knowledge, and context knowledge (Gess-Newsome & Lederman, 1999). Teachers in the first three years of music education teaching expressed a desire to receive more preparation on PCK in their methods courses

(Ballantyne & Packer, 2004). Borko et al. (1992) also claimed more opportunities to develop PCK should be provided to preservice teachers through university coursework.

Models specifically conveying PCK development have been created by researchers (Abell et al., 2009; Lee, 2011). The Abell et al. (2009) PCK development trajectory includes development long after teacher preparation. Professional development interventions have been found to impact the PCK development of novice teachers in chemical demonstrations (Clermont, Krajcik, & Borko, 1993). Loughran et al. (2012) recommend introducing CoRes as a framework for PCK to assist teachers in thinking about the complexity of teaching. Halim and Meerah (2002) suggested PCK be more readily incorporated into practicing teacher professional development. Van Driel (2010) stated the development of PCK can be strengthened by colleague interaction as teachers leave preparation programs and enter the field. This research supported the investigation of inservice versus preservice teachers for this study.

Experienced and Novice Teachers' Pedagogical Content Knowledge

Due to the cooperativeness of preservice and beginning teachers, and the increased ease of access, the majority of PCK research has focused on novices (Schneider & Plasman, 2011). However, there have been some studies comparing novice and experienced teachers' PCK and studies that have tapped into experienced teachers' PCK to conceptualize the knowledge component. In a study by Clermont, Borko and Krajcik (1994) interviews were utilized to uncover teachers' PCK for chemistry. In comparison to novices, experienced teachers possessed a wider array of representations, increased ability to adapt content, and had a better grasp of the complexities of chemistry, including how those complexities could interfere with student learning (Clermont et al., 2006). Practicing science teachers were also found to more accurately predict student preconceptions and misconceptions than preservice teachers (Diakidoy & Iordanou, 2003).

Beginning teachers typically possess fewer of the knowledge bases necessary for teaching as compared to expert teachers (Clermont et al., 1994; Gudmundsdottir & Shulman, 1987; Turner-Bissett, 1999). In fact, many studies have indicated novice teachers lack PCK in a variety of disciplines (Ballantyne & Packer, 2004; Borko et al., 1992; Van Driel et al., 1998). Halim and Meerah (2002) discovered novice science teachers lacked PCK in the student learning component, specifically related to knowledge of student misconceptions. Based on the complexity of PCK, development trajectories, and studies indicating PCK is lacking in novice teachers, experience has been deemed crucial for PCK development (Baxter & Lederman, 1999; Hashweh 2005; Kind, 2009; Lee, et al., 2007; Van Driel et al., 2002).

Experienced educators are more efficient, create better flowing lessons, and are better able to improvise than novice teachers (Stronge, 2007). Collaborating with experienced teachers led to the development of CoRes and PaP-eRs in science education (Loughran et al., 2004). In a review of PCK literature, Schneider and Plasman (2011) declared a need for a greater focus on experienced teachers in future studies because of the important information this research could provide for preservice and inservice teacher education. For these reasons, experienced agriculture teachers were chosen as the participants for this study.

New Research in Pedagogical Content Knowledge Measurement

At the recent PCK summit, the focus of future PCK research was directed to areas of measurement and connection to student achievement (Gess-Newsome & Carlson, 2014). As early as 2001, Rowan, Schilling, Ball, and Miller demonstrated it was possible to measure PCK in specific areas of mathematics and language arts. Phelps and Schilling (2004) created content knowledge for teaching reading measurement items in a multiple choice test form. The field of mathematics has covered the most ground in regards to PCK measurement by creating MKT items with the help of experts in the field (Ball et al., 2005). This has resulted in the Educational Testing Service (2011) introducing a multi-year pilot study of new exams on the Praxis certification test to measure teachers' PCK in mathematics.

An example of a PCK exam item related to knowledge of content and students involved a situational question that asked the test taker which strategies they would expect elementary students to engage in when solving a multiplication problem. The question listed four strategies to achieve the correct answer and then gave the test taker the option of selecting yes, no, or maybe for each strategy if they believed it was a strategy they would expect elementary school students to engage in for that particular problem (Hill, Schilling, & Ball, 2004). Similar application problems are found throughout example MKT test items

Connecting PCK to student achievement has been an even greater challenge in the literature, but arguably one of the most important (Kind, 2009). Ball, Hill, and Bass (2005) stated increasing teachers' MKT could address the student achievement gap and help with social justice initiatives for high-risk students. In an early study, Hill et al. (2005) discovered teachers with stronger MKT produced higher student achievement gains in first and third grade students' mathematics knowledge. More recently, Baumert et al. (2010) also found a positive effect of teachers' PCK on student learning gains. Future research addressing the connection between teachers' PCK and student achievement is needed within all education disciplines (Gess-Newsome & Carlson, 2014).

Impact of Pedagogical Content Knowledge Research in Agricultural Education

In agricultural education, the focus on teacher knowledge has historically been limited to need studies and characteristics of effective agriculture teachers (Garton & Chung, 1996; Layfield & Dobbins, 2002; Mundt & Connors, 1999; Myers, Dyer, & Washburn, 2005; and Washburn, King, Garton, & Harbstreit, 2001), despite the proclamation from teacher educators of the importance of PCK (Roberts & Kitchel, 2010). Agriculture teachers are expected to have both breadth and depth of content knowledge and are often looked to as the content experts in the communities in which they teach (Barrick & Garton, 2010). However, Houck and Kitchel (2010) caution variability in content preparation for preservice teachers at the university level may lead to unprepared teachers in agriculture content upon entering the teaching field. Teachers acknowledged that effective agriculture teachers need to be able to: plan for instruction, evaluate instruction, determine students' learning needs, use a variety of teaching techniques, demonstrate knowledge of teaching and learning, and demonstrate excellent knowledge of subject matter (Roberts & Dyer, 2004). Many of these teaching tasks require both content knowledge and PCK in agriculture topics.

PCK specific studies in agricultural education have been limited. In a quantitative study investigating the impact of sources of content knowledge on practicing teachers' PCK, Rice and Kitchel (2014b) discovered all seven sources of content knowledge from the literature (teaching experience, high school agriculture experience, teacher preparation program, agriculture jobs and internships, professional development, internet and other media, and years spent teaching) were perceived by teachers as effective sources of PCK. Additionally, teachers perceived their ability for all six constructs of PCK, using the Hill et al. (2008) model, to be at least a fair extent (Rice & Kitchel, 2014b). Rice and Kitchel (2014a) explored beginning agriculture teachers' ability to deconstruct content knowledge for student understanding. The beginning teachers revealed feeling deficient in content knowledge for various agriculture subjects. A model was developed to describe their coping strategies for content knowledge deficiency and underlying influencers were identified. Due to the deficiency barrier, it was recommended future research focus on experienced agriculture teachers' PCK (Rice & Kitchel, 2014a), which guided this study.

Further research in PCK can set a basis for how teachers are taught and increase the likelihood teachers will use that knowledge in the classroom (Ball et al., 2008). For teaching to be better valued as a profession, including the field of agricultural education, research in PCK needs to be done to uncover the complexity of teaching and establish the importance of professional knowledge (Phelps & Schilling, 2004). Conceptualizing PCK for a specific topic in agriculture can provide a foundation for future research and findings can inform teacher preparation programs and professional development initiatives.

Summary of Review of Literature

In summary, possessing PCK enables teachers to unpack content into usable forms for student learning, requiring a knowledge base different from content experts (Phelps & Schilling, 2004). Components of PCK are still widely disputed, but models often include five components: student component, instructional component, curricular component, assessment component, and orientations to teaching (Kind, 2009). The teachers' individual contexts can also play a role in PCK (Gess-Newsome & Lederman, 1999). PCK develops continually over time (Lee, 2011) and experience in the field is one of the most effective ways to obtain PCK (Baxter & Lederman, 1999; Hashweh 2005; Kind, 2009; Lee, et al., 2007; Van Driel et al., 2002). Research in PCK has focused on primarily on conceptualization and development with the majority of studies involving novice and preservice teachers (Schneider & Plasman, 2011). More recent research has begun to explore measurement of PCK and the connection between PCK and student achievement (Ball et al., 2005; Hill et al., 2005). PCK research in agricultural education is virtually non-existent, yet it is regarded as an important knowledge base for agriculture teachers to possess by teacher educators (Roberts & Kitchel, 2010). The topic specific nature of PCK (Etkina, 2010; Gess-Newsome & Carlson, 2014; Van Driel & Berry, 2012) warrants further examination of topic specific PCK in the field of agricultural education.

CHAPTER 3: METHODOLOGY

Purpose and Research Question

The purpose of this grounded theory study was to conceptualize PCK for a specific topic in agriculture to serve as a model for the investigation and conceptualization of additional topics. The following central research question guided the study: What is experienced agriculture teachers' PCK related to the plant sciences?

Research Design

The emergent design of grounded theory was chosen as the approach for this study because of the exploratory nature of the research question. Agricultural education research in PCK has been limited and the field does not have a conceptualization of PCK for any topic area within agriculture. Generating a substantive theory in one particular subject area, plant sciences, can serve as the foundation for future PCK research in agricultural education. PCK is the knowledge teachers use as they plan for and go through the teaching process (Kind, 2009) and investigating a concept associated with a process is a defining tenant of grounded theory methodology (Corbin & Strauss, 2008). Specifically, this study was guided by the work of Corbin and Strauss (2008), who view grounded theory as a way to understand complex social situations and experiences.

Pragmatist Epistemology

This grounded theory study was approached from a pragmatic lens. The epistemological roots of grounded theory rest in pragmatism and interactionism (Strubing, 2007), making this lens appropriate for the methodology. The purpose of grounded theory is to generate theory from data and data are treated as reality under construction (Strubing, 2007). Key assumptions of grounded theory, according to Corbin and Strauss (2008), such as the importance of actions and interactions in developing meaning, have roots in early pragmatist philosophers John Dewey and George Mead. Pragmatists view reality as something that cannot be separated from the researcher because reality exists as experienced through people. The actor and the environment determine each other and truth is what is known at the time but is subject to change (Corbin & Strauss, 2008).

Positionality Statement

In addition to my epistemological lens, it is also important to disclose my postionality because of its influence on my research (Creswell, 2013). My identity as a former high school agriculture teacher has shaped both the research topics I choose to pursue and the way I view agricultural education, content knowledge, and PCK. As a high school student I was enrolled in agriculture classes, but did not grow up with a traditional farming background like many of my peers. Instead, my agriculture content background was focused on plant science due to my employment at a landscaping and greenhouse company throughout high school. When I entered college to pursue a degree in agricultural education, I realized my content knowledge in other areas of agriculture such as animal science or agricultural mechanics was very limited. I assumed I would learn the content knowledge in college; however, the agriculture content classes I was required to take were designed primarily for students majoring in that content area, not prospective teachers. Additionally, my teacher preparation program focused more on general methods than methods for teaching specific content. I often felt like agriculture teacher preparation programs were not designed for someone like me who lacked production agriculture experience and had limited content knowledge.

During my four years teaching high school, I struggled to teach content in some subject areas within agriculture. I naively assumed my teaching peers with traditional agriculture backgrounds had stronger content knowledge and PCK in agriculture. I later discovered many agriculture teachers find themselves knowledgeable in one or two content areas, but few would consider themselves a master in all areas of agriculture, despite teacher preparation and professional development. My passion for agriculture teachers' content knowledge led to my master's thesis which explored the influence of content knowledge preparation on teacher knowledge. I believe knowledge of content and most importantly knowledge about how to teach content is a crucial part of teacher effectiveness. The goal of my research is to conceptualize the PCK of expert agriculture teachers so this information can be used to better prepare future teachers and assist practicing teachers. My desire is for more agriculture teachers to feel they have the skills necessary to adequately understand and effectively teach agriculture content.

Participants

Participants in this study included eight high school agriculture teachers in the state of Missouri with a minimum of eight years teaching experience. This specific experience range was chosen based on literature stating expertise begins to be achieved for teachers after they have spent approximately five to eight years in the field (Darling-Hammond & Bransford, 2005). Experienced teachers were specifically chosen to increase the likelihood they would possess PCK. Recommendations from teacher educators regarding teachers' quality and possession of PCK in the plant sciences were used in the purposeful selection of teachers to participate in this study. All recommended experienced teachers had professional development experiences in plant science and a reputation as an effective teacher by their peers and teacher educators. Additional criteria for participation included teaching within a 120 mile radius of the university so field work could be conducted and specifically teaching a plant science unit in fall 2014. See figure 3.1 for a chart that includes more specific characteristics of the teachers in this study including: pseudonyms, gender, years spent teaching, number of teachers in school agriculture program, and education and experience beyond the bachelors of science degree in agricultural education. Pseudonyms will be used throughout the description of the findings to protect the identities of the participants. Additionally, all participants signed a consent form to participate in this study (Appendix A).

Pseudonyms	Years Spent Teaching	Gender	Number of Teachers in Program	Education and Experience in Plant Science Beyond Agricultural Education Degree
Jane	11	Female	2	Additional classes inservice
Dawn	12	Female	2	Dual major in plant science Former business owner
James	28	Male	2	Professional development inservice
Kelly	12	Female	2	Worked in a flower shop in high school Worked in garden department in college Plant science minor
Allison	9	Female	2	Horticulture concentration Horticulture minor
Cora	18	Female	3	Professional development inservice Additional classes inservice
Clint	8	Male	2	Background in crop science from farm Plant science minor
Ashley	18	Female	2	Dual major in plant science

Figure 3.1 Chart of Characteristics of Participants

Plant Science Content Focus

As mentioned earlier in chapter one and more recently above, the specific agriculture content that was focused on for this study was the plant sciences. The topic specific nature of PCK (Etkina, 2010; Gess-Newsome & Carlson, 2014; Magnusson et al., 1999; Van Driel & Berry, 2012) created a need to examine one particular area of agriculture for this study. The particular area of plant sciences was chosen because it is a commonly taught agriculture area in Missouri schools (Missouri Department of Elementary and Secondary Education, 2011), there were ample experienced agriculture teachers in Missouri in the plant sciences, and I, as the researcher, had familiarity with this content area in order to recognize and study PCK. After participants agreed to participate in the study one of the first tasks was to identify the plant science unit to isolate for the study. This unit had to be taught in the fall of 2014. Figure 3.2 details a chart of additional information about the plant science unit for each participant including: the title of the unit, the number of lessons within the unit, and the number of students enrolled in the class.

Pseudonyms	Name of Unit	Number of lessons in unit	Number of students in class
Jane	Plant Processes	7 lessons	15
Dawn	Plant Identification	5 lessons	11
James	Plant Processes	7 lessons	16
Kelly	Floral Industry	3 lessons	5
Allison	Plant Reproduction	2 lessons	11
Cora	Plant Reproduction	2 lessons	13
Clint	Forages	3 lessons	17
Ashley	Plant Science Overview	3 lessons	15

Figure 3.2 Chart of Characteristics of Participants' Plant Science Units

Data Sources

Teachers can demonstrate PCK in different settings. At a recent PCK summit, a consensual PCK definition was developed by science education researchers and included two distinct parts. PCK is the knowledge of, reasoning behind, and planning for teaching a specific topic, and the actual act of teaching a specific topic (Gess-Newsome & Carlson, 2014). This demonstrates PCK's emergence in both the planning and in-the-moment phases of teaching. Additionally, reflection is a key piece of PCK development (Schneider & Plasman, 2011; Van Driel & Berry, 2012), with the summit definition identifying knowledge, reasoning, and planning as explicit reflection *on* action and the act of teaching as explicit or tactic reflection *in* action (Gess-Newsome & Carlson, 2014). To adequately capture agriculture teachers' PCK in plant sciences, it became important to explore data sources spanning those various settings in which PCK can occur. Hashweh

(2005) asserted experienced teachers develop PCK as a result of planning, teaching, and reflecting on teaching. Therefore, planning, teaching, and reflection all provided different opportunities to capture agriculture teachers' PCK.

For example, addressing student misconceptions, a commonly agreed on component of PCK (Depaepe et al., 2013), may surface during all three settings: planning, teaching, and reflection. During planning, a teacher may plan ahead of time to use a specific example because they know students typically struggle with a concept. During teaching, a teacher may react in-the-moment in response to a student misconception by explaining an example in a different way. Finally, during reflection, a teacher may reflect on the incident and contemplate a different teaching strategy or representation to use when teaching this concept again. All three of these examples are instances of a teacher demonstrating their PCK during different parts of the teaching process.

Six sources of qualitative data were collected for this study including: pre-observation interviews, classroom teaching observations, field notes, lesson artifacts, teacher journal reflections, and post-observation interviews with stimulated recall. Each data source occurred during one of the three settings above and provided a unique contribution in creating a complete picture of agriculture teachers' PCK in plant sciences. A multi-method approach is best when investigating PCK (Kapyla et al., 2009; Loughran et al., 2004). A review of mathematics PCK literature revealed when PCK was examined within a specific context, classroom observations supplemented with interviews, artifacts, and reflections were most typically used as data sources (Depaepe et al., 2013). Using various data sources served to capture as much data as possible in the short time frame of a single unit to achieve saturation of the data and develop a substantive theory (Creswell, 2013).

Pre-observation Interviews

Pre-observation interviews were conducted to capture PCK emerging during the planning phase of teaching. PCK is partially an internal construct (Baxter & Lederman, 1999), making interviews an integral part of data collection (Padilla & Van Driel, 2011). One-on-one semi-structured interviews were conducted and lasted between 45 minutes to an hour for each participant. All pre-observation interviews were conducted prior to teachers beginning classroom instruction for the plant science unit. Questions during the pre-observation interviews included having the teachers describe the context of the unit, their teaching goals and objectives, teaching strategies for the content, assessments of student learning, curriculum resources for the unit, and knowledge of student preconceptions, misconceptions, or difficulties that affected their planning of the unit. A full list of preliminary questions utilized for the pre-observation interview can be found in Appendix B. A chart connecting the different components of PCK to the interview questions can be found in Appendix E. These questions evolved throughout the grounded theory process to meet the needs of the concepts being investigated (Corbin & Strauss, 2008). All interviews were audio recorded for transcription purposes.

Classroom Teaching Observations

Classroom teaching observations were conducted to capture PCK emerging during the in-the-moment teaching phase. For example, if a student displays difficulty grasping a concept during a lesson, the teacher may or may not demonstrate PCK in response to addressing that difficulty by explaining the problem in a different way as the lesson unfolds. Additionally, people are not always aware of what they are doing or unable to recall what happened in a given situation (Corbin & Strauss, 2008), making researcher observations an important piece of this study.

PCK may not be evident from one single lesson observation (Loughran et al., 2004); therefore, two observation blocks were conducted each lasting two days in length. This time frame was chosen because the length of class periods in many Missouri schools lasts approximately 50 minutes. With this shorter class period length, often lessons took more than one day to cover. To increase the likelihood of capturing various facets of PCK, it was important to see some lessons in their entirety. Observations were video recorded for two purposes. First, I wanted the opportunity to replay parts of the video to search for instances of PCK. Second, clips from the videos were used for stimulated recall (to be described later in more detail) during the post-observation interview. Loughran et al. (2004) utilized observations in conjunction with stimulated recall for their PCK research on the development of CoRes for specific science topics.

Field Notes

Field notes were written to capture PCK emerging during the in-the-moment teaching phase of teaching not evident on the video recording. Additionally, field notes were used to record any instances of PCK emergence that could be used for the stimulated recall portion of the post-interview. At least three instances of PCK emerging during each lesson were noted in the field notes and select instances were later utilized in the post-interview with stimulated recall.

Lesson Artifacts

Lesson artifacts were collected to capture PCK emerging during both the planning phases and in-the-moment teaching phases of teaching. Hume and Berry (2011) also collected and analyzed classroom documents as a data source in their PCK research. Artifacts from the participants related to the lesson: handouts, PowerPoints, and worksheets, captured PCK from the planning phase as the teachers designed their lessons. Artifacts related to the students: student completed work without identifiers, captured PCK from the in-the-moment teaching phase. The purpose of examining student work was not to assess students' understanding of the material, but instead to provide evidence of participants' PCK. This was in the form of participant comments on student work or participant assessment of a correct or incorrect answer and their resulting actions based on that knowledge. Additionally, the type of assignments utilized, the content of the PowerPoints, and the exams all provided more evidence to create a complete picture of the participants' PCK.

Teacher Journal Reflections

Teacher journal reflections were used to capture PCK emerging during the reflection phase of teaching. The knowledge behind PCK is often hidden within a teachers' thought process making it difficult to identify (Kind, 2009). The limited time in the field and the complex nature of PCK led to a desire to capture the participants' thoughts as the unit progressed. After each lesson was complete, the participants responded to five reflection questions corresponding to that particular lesson. Questions were limited to five to be conscientious of the teachers' time. Participants could complete this reflection by typing their answers or voice recording their answers and submitted them via e-mail. All voice recorded reflections were transcribed verbatim. To compensate the participants for their time, participants who completed all of their lesson reflections were given a gift card. Reflection questions (also see Appendix C) included:

1. What student misconceptions or difficulties surfaced (if any) during this lesson and how did you address those misconceptions or difficulties? You may describe multiple instances if applicable.
2. What representations, illustrations, or analogies related to content did you utilize during this lesson and why did you choose those particular strategies? You may describe multiple representations, illustrations, or analogies if applicable.
3. How do you know the students learned the concepts for this lesson? What assessment strategies (formative or summative) did you utilize and why?
4. How did this lesson connect to or build from your other lessons in this unit?
5. What could you have done differently to improve the content of this lesson?

Post-observation Interviews with Stimulated Recall

Post-observation interviews with stimulated recall were used to capture PCK emerging during the reflection phase of teaching. The use of interviews and video clips for reflection knowledge is an effective way to measure PCK (Nilsson, 2008). Interviews were conducted one-on-one in a semi-structured format lasting between 45 minutes to an hour and half in length. Participants were asked questions to reflect on the plant science unit they had just completed. An example of a post-observation interview question would be: what changes (if any) would you make to this unit if you were to reteach it again?

Again, these questions evolved throughout the process to meet the needs of the concepts being investigated (Corbin & Strauss, 2008).

In addition to general reflection questions based on the unit, a minimum of three video clips from the two teaching observation blocks were used to engage the participants in stimulated recall. Stimulated recall is an introspective technique designed to allow participants to explain their thought processes and decision making after hearing or viewing a stimulus to prompt recollections (Mackey & Gass, 2005). Meade, McMeniman, Wilson, Kanes, and Davey (1991) indicated stimulated recall can be effective for examining knowledge bases of quality teachers that underlie their classroom actions. Stimulated recall techniques have been utilized in PCK specific studies to revisit a situation and explore the nature of PCK (Haston & Leon-Guerrero, 2008; Lannin et al., 2013; Loughran et al., 2004).

Video clips from the observations were played back for participants and they were asked to elaborate on the incident. Examples of questions during the stimulated recall portion of the interview included: I see you used X strategy in this video clip, what other strategies might you have used and why? I see you dealt with X student misconception in this video clip, what other student misconceptions have you observed related to this topic and how did you address those? A complete list of post-observation interview questions can be found in Appendix D. The goal of the stimulated recall portion was to have the participants give insight into their in-the-moment teaching decisions in hopes of uncovering additional PCK not evident in their actions alone. All post-observation interviews were audio recorded for transcription purposes.

Data Collection

Data were collected fall 2014 over the course of a single plant science unit for each participant in the study (see Figure 3.3 for data collection timeline). Pre-observation interviews with the participants were the first point of data collection and were conducted prior to the beginning the plant science unit in the classroom. The first classroom teaching observation blocks were conducted after at least three days had passed from the beginning of the unit. This decision was made to avoid unit introductions because possibly less teacher PCK would be evident due to the introductory material. The second classroom teaching observation blocks were conducted at least one week after the first observation in an effort to capture a wider array of plant science PCK. Field notes were taken in conjunction with each of the two observation blocks.

Artifacts related to the lessons were collected throughout the study, either in person or via e-mail, as they became available from the participants. Teacher journal reflections were completed at the end of each lesson and submitted via e-mail. The number of reflections per participant varied related to the number of total lessons in their unit and the length of each individual lesson. Post-observation interviews were conducted to reflect on the unit and stimulated recall was used to prompt the teachers to think more deeply about their PCK. This final interview occurred as soon after the completion of the unit as possible so experiences were still fresh in the minds of the participants. Finally, follow-up questions were asked of the participants to clarify emerging concepts during data collection and analysis (Appendix F).

Figure 3.3. Data Collection Timeline

Data Management

Data in a grounded theory study, particularly a study with six separate data points, could be overwhelming. To manage the data, the NVivo 10 qualitative software program was used. Beginning with the first interview, all audio recordings, video recordings, field notes from observations, lesson artifacts, and teacher journal reflections were loaded into the NVivo software program. These items were organized within folders for each participant in the study. Transcriptions of the pre and post interviews were completed as soon as possible after each interview occurred and then were loaded into the NVivo software program.

The NVivo software program was utilized not only to organize the data, but also to code, create memos, establish connections, and organize relevant literature. It is important to note that NVivo, or any other qualitative data software program, does not do the thinking for the researcher (Creswell, 2013). However, having all of the data for each participant in one place made it easier to code the various data sources, trace the codes back to their original data source with ease, manipulate code names and category names as more data became available, and link memos to the data as the study progressed. Additional features of NVivo that were utilized included searches of key words in the data as concepts began to be developed and word clouds to see what was emerging from the data in early stages of analysis. NVivo was updated on a weekly basis as more information became available to avoid overlooking any valuable data that could contribute to the study.

Data Analysis

Collection and analysis were conducted simultaneously due to the nature of grounded theory methodology (Corbin & Strauss, 2008). All six data sources including pre-observation interviews, classroom teaching observations, field notes, lesson artifacts, teacher journal reflections, and post-observation interviews were used in data analysis. Data were analyzed using a constant comparative process where data is compared against data, beginning with the first piece of data collected to search for similarities and differences (Corbin & Strauss, 2008). All interviews were transcribed verbatim. I followed the three step coding process of open, axial, and selective coding (Corbin & Strauss, 2008). The purpose of open coding is to develop categories, the purpose of axial coding is to connect categories, and the purpose of selective coding is to create a story ending in a developed theory (Corbin & Strauss, 2008).

Open Coding and Changes to Central Question

To begin the open coding process, I first read through the text and made notes to form initial codes. The purpose of open coding was to look for categories supported by the data (Creswell, 2013). Using the constant comparative approach, I examined all data sources as they became available for initial codes and adapted my data collection and analysis based on information needed to saturate a particular idea (Creswell, 2013).

Various analytical techniques as described by Corbin and Strauss (2008) were used throughout the data analysis process including: the use of questioning, making comparisons, drawing upon personal experiences, and examining language. Once an initial set of categories had been developed, I identified a pervasive phenomenon to focus on for this study that served as the central piece of my theory (Creswell, 2013).

It became apparent after the first three interviews that plant sciences was not specific enough of a topic to be able to adequately describe the participants' PCK in a way that allowed for comparisons between participants and ultimately the development of a theory. While all of the participants taught a plant science unit, the actual topics that they covered within that unit varied. Some of topics covered by the participants in the study included: sexual and asexual reproduction of plants, plant processes (i.e. photosynthesis, respiration, and transpiration), utilizing forage plants, the floral industry, and plant identification and classification. Additionally, while all of the units occurred during the same fall 2014 semester, they spanned from mid-September to late December. The current point that the participants were at in their classes during the time I and the participants were available to coordinate observations affected the unit I was able to witness and utilize for the study.

Simultaneously with my realization that conceptualizing PCK for plant sciences was not emerging from my data, a different phenomenon began to surface. Beginning with the first pre-observation interviews, the participants discussed their beliefs regarding agricultural education, plant science, and pedagogy. This was particularly interesting because my questions regarding orientations were purposefully left for the post-observation interviews. When I open coded the first teacher journal reflections, I also noticed this emerging theme of beliefs that seemed to shape teacher knowledge. Corbin and Strauss (2008) discuss how there are many different stories that can be told from a single set of data and how determining the central phenomenon in grounded theory methodology is partially a gut feeling on the part of the researcher. My gut feeling was that this phenomenon of beliefs was pervading the data in my study and could provide important knowledge to the field of agricultural education about how the PCK of agriculture teachers is shaped.

In grounded theory a wide net is cast in the form of a research question to see what truly emerges from the data (Creswell, 2013). Sometimes once the central phenomenon emerges it makes sense to alter the research question to reflect the new direction of the study. My original research question was: What is experienced agriculture teachers' PCK related to the plant sciences? Upon emergence of the central phenomenon the new central research question to guide the study became: What shapes experienced agricultural teachers PCK in the plant sciences? Using this question as my guide, I recoded existing data and applied the new research question to all subsequent data collected and analyzed.

Axial Coding

The next step in the coding process was axial coding. Utilizing my central phenomenon as a guide, I continued to analyze the data using the strategies mentioned above. The purpose of axial coding is to identify causal conditions influencing the central phenomenon (Creswell, 2013). Corbin and Strauss (2008) describe open coding as breaking the data apart and axial coding as bringing the data back together in a new way.

I analyzed the data for context, conditions, and consequences (Corbin & Strauss, 2008); to better understand the central phenomenon and how the categories interrelated. This process helped me to see how beliefs shaped the PCK of my participants. Through this process I discovered beliefs were not the only thing shaping PCK, experiences and context were also instrumental in shaping the PCK of experienced agriculture teachers in the plant sciences. Figure 3.4 provides an example of my coding scheme for a portion of the beliefs theme.

Overarching Theme	Category	Sub Category	Code
Integrated Belief Systems	Beliefs about Plant Science Education	Utilization of the School Greenhouse	-GH as a lab -GH as a business -GH for dual purpose -Hands-on application -Plant science isn't solely about GH -Expense of GH -Community expectations on GH -Purpose of agricultural education and its connection to GH
		Level of Science Integration	-Applied science -Traditional science -Responsibility for science content -Not covering plant science in biology -Science taught in the fall -GH manual work in the spring -Influence of 3 for 1 science credit -End of course assessments

Figure 3.4 Coding Scheme for a Portion of the Integrated Belief Systems Theme

Memos were kept throughout the entire process and reflected upon during data collection and analysis. Memos were used in the research process not to simply record information but also to analyze information, making memos a crucial part of the data analysis process (Corbin & Strauss, 2008). Memos can assist the researcher in exploring the data, developing preliminary relationships, asking questions of the data, and creating meaning from the data. My memos in particular were helpful in establishing my central phenomenon. They were also crucial in the process of connecting the PCK of my participants to what was influencing that PCK both inside and outside of the classroom. Figure 3.5 provides an example of a memo during collection and analysis.

Data Excerpt	Further Dissection of Data
Dawn: Well, some of the kids like I have one boy in particular that he knows he wants to go into turf grass. Um, ever since last year, uh, we went to Simpson Field Day. He's a big baseball player and likes to go off and do those types of things. And he knows he wants to go into turf grass. I mean I think that's the thing. I have some students that go through and they know they want to go into that area. So, if they can grasp the concepts now they're employable through college. It's easier for them once they get into college.	The characteristics of the students in Dawn's class seemed to shape her views about the purpose of agricultural education. This is partially based on the contextual factor of Dawn's location in an area career center. She expressed previously that students from her classes will sometimes get careers in the plant science field. Additionally, the community she is located could be a contextual factor to look for in future data.

Figure 3.5 Memo Connecting Views about Purpose of Agricultural Education to Context

Selective Coding

The final step in the coding process was selective coding. This phase was integral in developing the theory for this study. During selective coding, the researcher attempts to create a story from the data by interrelating categories related to the central phenomenon (Creswell, 2013). I was able to establish linkages between my core categories and how they influenced PCK of the participants. During the selective coding phase I asked follow-up questions of my participants in an attempt to answer any questions that still remained regarding the context and dimensions of my theory. Once no more new data emerged saturation had been achieved (Corbin & Strauss, 2008). Diagrams were utilized to display how the theory fit together and changed throughout the process. I attempted to reach a level of abstraction from the data (Corbin & Strauss, 2008) and tie together the different elements of the theory. The final result was the development of a substantive theory that explained the central phenomenon. This theory developed over time with assistance from participants, various models being developed as the study progressed, and follow up questions were asked of the participants to refine lingering questions about connections in the data.

Validation Strategies

Throughout the study I engaged in various validation strategies described by Creswell (2013) for general qualitative work. I utilized six separate sources of data to provide detailed evidence of the phenomenon being investigated. Triangulation was achieved by using various data sources to corroborate evidence and validate the study (Creswell, 2013). Rich, thick description was used to explain the findings from this study to aid the reader in both understanding how the theory was developed and to aid in transferability (Creswell, 2013). Memoing was utilized throughout the entire research process as a way to ask questions of the data, develop connections between concepts, and document my thoughts as the theory emerged (Corbin & Strauss, 2008). I also engaged in reflexivity by examining my own position within the data and how my position was shaping data collection and analysis (Creswell, 2013). Finally, in order to confirm the credibility of the findings, I engaged in member checking of the findings and interpretations (Creswell, 2013).

In addition to the validation measures of the research process mentioned above, Creswell (2013) also mentions evaluation measures specifically for a grounded theory study. These measures include: study of a process, coding process emerges from the data to the theory, theory is presented in a figure or diagram, a story line connects the categories, memoing is used throughout the process, theoretical sampling is conducted, and reflexivity and positionality are addressed. To meet the process criterion, a research question associated with a process was chosen. Additionally, the pervasive concept that served as the central point to the theory was based around a social process. To meet the coding process criterion the process of open, axial, and selective coding (Corbin & Strauss, 2008) was followed. Additionally, rich thick description of the data itself demonstrated how the theory emerged from the data. The theory was presented as a diagram and a story line was used to connect the concepts of the theory in the findings for this study. Memoing was used throughout the research process and was instrumental in surfacing the central phenomenon, establishing connections between categories, and establishing and refining the theory over the course of the study. Theoretical sampling was not utilized in the traditional sense of sampling additional participants to contribute to the developing theory but instead was used as a means of sampling the existing data and focusing on events, incidents, and scenes that contributed to the developing theory (Fassinger, 2005). Reflexivity and positionality were addressed throughout the study as I continuously reflected on my own previous experiences with content knowledge and

PCK to prevent my own biases from shadowed the emerging data collection and analysis process.

CHAPTER 4: FINDINGS

Purpose and Revised Central Research Question

The purpose of this grounded theory study was to conceptualize PCK for a specific topic in agriculture to serve as a model for the investigation and conceptualization of additional topics. The initial central research question that guided the study was: What is experienced agriculture teachers' PCK related to the plant sciences? After data collection and analysis, the central research question was altered to focus on the emergent central phenomenon for the study. The revised central research question became: What shapes experienced agriculture teachers' PCK in the plant sciences?

Outline for Findings

Throughout the description of the findings, I elaborated on each of the three main themes (integrated belief systems, experiences, and context) in more detail including major categories and sub-categories descriptions, connections between the three themes and the influence of those connections on the participants' PCK, the influence of each theme on shaping participants' PCK directly, and finally how the three main themes coalesce to explain the overall substantive theory behind what shapes experienced agriculture teachers' PCK in the plant sciences.

The integrated belief systems theme was presented first because it was the most emergent theme in the study. This theme included: beliefs about the purpose of agricultural education, beliefs about plant science education, and beliefs about teaching and learning in agricultural education. These three components comprised the participants' overall integrated belief systems. Within each of these components, I described their linkages with the other two themes in the study- context and experiences. I then described how each of the three components in the integrated belief systems shaped the PCK of the participants. Next, I described the experiences theme. This theme included experiences of the participants prior to inservice and experiences of the participants during inservice. For the experiences during inservice category, I described in detail how the context directly influenced those experiences. For each of the two experience categories, I then described how they shaped the PCK of the participants. Next, I described the context theme. This theme included the influence of the agriculture and school context on the PCK of the participants. Finally, I described how all three themes amalgamated to create the substantive theory.

Integrated Belief Systems

The first major theme shaping the PCK of experienced agriculture teachers in the plant sciences was integrated belief systems. Integrated belief systems were comprised of three main components: beliefs about the purpose of agricultural education, beliefs about plant science education, and beliefs about teaching and learning in agricultural education. These three components interacted with each other to form the participants' integrated belief systems (see Figure 4.1).

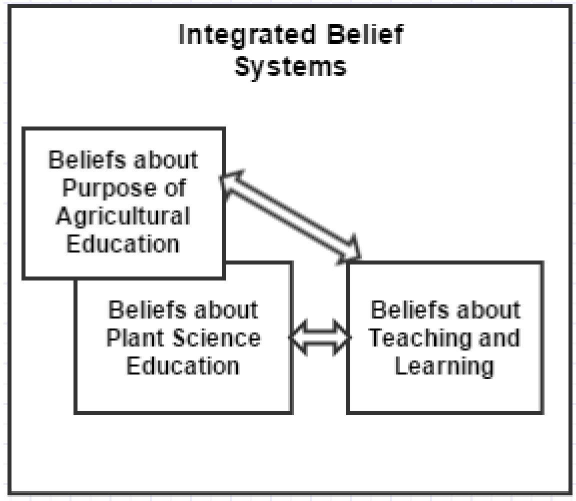

Figure 4.1 Integrated belief systems of experienced agriculture teachers

Beliefs about Purpose of Agricultural Education

Integrated belief systems emerged as the driving force shaping experienced agriculture teachers' PCK, but specifically, participants' beliefs regarding the purpose of agricultural education emerged as the key belief system. After some contemplation and discussion with participants, it began to emerge that their individual beliefs regarding the purpose of agricultural education in general (not plant science specific) seemed to directly influence their other beliefs within the integrated belief systems. The participants' specific beliefs about plant science education and beliefs about teaching and learning mirrored their overall belief about the purpose of agricultural education. For this reason, the beliefs about the purpose of agricultural education category was discussed first.

The four main purposes of agricultural education that emerged from the data were: career preparation, college preparation, agricultural literacy, and practical life skills. The majority of participants in the study held multiple views about the purpose of agricultural education for their students, but some expressed more of an emphasis on specific views than others. A fifth view labeled individualization, based on individual student need, was surfaced by one participant as the purpose of agricultural education as he attempted to combine all of the purposes to best meet the needs of his various students and classes as a whole. Figure 4.2 described the primary and secondary views of the participants regarding the purpose of agricultural education.

Pseudonyms	Primary Views	Secondary Views
Jane	Literacy	College
Dawn	Literacy	Life Skills, College and Career
James	Literacy	Life Skills, College and Career
Kelly	Life Skills and Literacy	Career
Allison	Career and College	Literacy and Life Skills
Cora	Career	Literacy and Life Skills
Clint	Individualization	N/A
Ashley	Literacy	Life Skills

Figure 4.2 Participants Beliefs about the Purpose of Agricultural Education

Primary and secondary views for each participant were determined through a series of steps. To begin, I read through the pre-observation interviews as data became available to see how the participants framed their teaching. During the open coding process specific views quickly emerged as codes. These codes were then utilized to code subsequent data. Next, I observed to see if these views emerged in the classroom during my unit observations. Then, I clarified each participant's views by asking questions during the post-observation interviews. Secondary views included any views that were mentioned by participants and were evident in their teaching but were not their primary views about the purpose of agricultural education. The majority of participants had one primary view that guided them, with the exception of Allison and Kelly who expressed equal importance on two views. Two of the participants discussed that they held multiple views about the purpose of agricultural education, but attached numerical values to their importance. For example, James provided specific percentages for each of his views about the purpose of agricultural education, clearly demonstrating which views were primary and which views were secondary. One of the participants did not express secondary views and this was indicated in figure 4.2 as not applicable.

Career preparation purpose.

Many participants viewed the purpose of agricultural education to be career preparation and skills development. Cora, however, was the only participant in the study with career preparation as her sole primary view. “My goal is to teach kids to be successful when they leave here so they could go to work in a greenhouse or they could raise their own plants.” Due to the uniqueness of career preparation as her sole primary view, I asked Cora if she thought other agriculture teachers were operating under similar beliefs. Her response was, “Unfortunately, not enough. I truly believe that we need to teach kids by doing.”

Allison, who viewed career preparation as one of her primary purposes of agricultural education said, “We’ve also done careers in the greenhouse industry because I feel like part of my job is to prepare them.” Allison even specifically identified the next step for her students upon graduation. “I either want to prepare them to be able to enter college knowing what horticulture degree they want, or for them to go straight into the workforce where they could run a small greenhouse with little guidance.” Dawn may not have had a primary career preparatory view like Cora or Allison, but she also recognized career preparation as a secondary purpose of agricultural education. When asked for her overall goal for students in her course, Dawn stated, “I want them to be educated citizens of society and be able to take knowledge that they can use in a future career.”

The type of outcomes they focused on developing within their students varied amongst participants. Some focused on manual greenhouse skills such as dividing plants for asexual reproduction, and some focused on manual skills more closely related to traditional farming such as growing crops to feed livestock. The focus largely depended on the careers students were being prepared for and the agricultural industry within the community. Cora, who focused more on skills specific to the greenhouse, said the following:

> You know, I mean, I physically want them to be able to look at a plant and be able to determine, this is how it would be best to reproduce it, and then be able to do that, not just tell me how, but them be able to go through the steps and do it.

Clint, who focused predominately on farming related skills in the plant sciences, said, “Our program’s goal is to have career-ready graduates who are educated about agriculture and are going to be able to someday manage a small farm and be successful.”

This particular participant had an uncharacteristically high amount of farmers in his community and was located at an area career center.

If the participants did not a hold a career preparatory view it was most often because it didn't fit their audience (students). To explain why she didn't have career preparation as one of her views, Jane stated, "But a lot of our students, you know, they're in our programs not to learn career preparation, but they are in it for everything else." Later in the interview, Jane clarified that the majority students in her greenhouse class had taken agriculture leadership courses previously and enrolled in greenhouse to avoid taking an agriculture mechanics class. She expressed that many of these students simply wanted to remain in the agriculture program, but didn't have an invested interest in plant science. Ashley described the limited number of students in her program that pursued a career in the greenhouse industry in her 18 years in the field. "Right now I have one current student with a greenhouse and two formers students with greenhouses. The rest of them don't, so right now it's not real applicable."

Often, the career preparation view was influenced by the context participants were in, including the general agricultural industry in the surrounding area, greenhouse or other plant science related careers available for students in the area, and most importantly, if the agriculture program was located in an area career center or a comprehensive high school. Three of the participants were located at area career centers separate from the local high school. These career centers were typically comprised of other career and technical education subjects such as family consumer sciences and business education and some also included industrial arts facilities. Being located in a career center increased the expectation for the agriculture department to teach career skills because of an explicit and implicit focus on career readiness. The remaining five participants had agriculture facilities such as a school greenhouse but were located in comprehensive high schools with other content area subjects such as English and mathematics.

The career preparation view was also influenced by experiences the participants had both prior to and during inservice. Participants with this view had experienced students in their classroom who left their agriculture programs and found employment in the plant science industry or at least expressed interest in finding employment in the plant science industry. This is illustrated by a comment from Allison, “I have a student who actually works for greenhouses and from day one he was able to move really quickly through because he already knew how to do everything I needed him to do.” Cora also stated, “I’ve got kids that want to either have a garden that they’re going to sell or do a farmer’s market with, or eventually they want to have a greenhouse or floral shop.” This also related to the focus on students that was prevalent through an overwhelming majority of participant interactions, observations, interviews, and reflections. The participants who did not focus as much on career preparation in their programs commonly stated this purpose did not fit their students’ needs, interests, and abilities.

Allison discussed how a career preparation primary view assisted her in reaching the majority of the students in her classes:

> I also want to prepare them if they want to leave here; they could jump on somewhere as manual labor, as a grower, and work their way up through the system. I try to do a healthy balance of all of it, but I think taking that

> production standpoint does that for me, because they need to understand how they grow and why they grow for them to understand what to do in a greenhouse.

Allison's excerpt demonstrated how a career preparation focus could serve as the foundation for other secondary purposes and that is why she chose to let this primary view guide her teaching.

Some participants even transformed their focus overtime, beginning with a career preparatory view and transitioning to include college preparation, agricultural literacy, and/or practical life skills as purposes of agricultural education. This is illustrated through a comment from James, who had been in the classroom for 28 years, "I used to be a person that trained people to go into production agriculture. That's what I started out doing… but now agricultural literacy has probably gone from maybe 5% to about 50%." Kelly, who had been a high school agriculture teacher for 12 years, also surfaced a shift in the purpose of agricultural education. "Just basic ag literacy, life skills, I think that's important for now. And I think in the past it wasn't that way, but I think now it's becoming more that way."

College preparation purpose.

A second view participants' held about the purpose of agricultural education was the college preparation of their students. This view included both specific content knowledge they wanted their students to acquire in plant science (or another agriculture subject area) in preparation for college and general college readiness skills such as note taking, synthesizing information, and critical thinking.

Jane explicitly explained to her students how the content she taught in her classroom will prepare them for college. “Things you hear in my classroom you’re going to see on college entrance exams. It’s my job to go over the most stuff I can; it’s preparation for those other tests and courses they are going to be taking.” Dawn described how career and college preparation overlap in her secondary views about the purpose of agricultural education, “Well some of the kids, like one in particular, he wants to go into turf grass. He’s a big baseball player. So, if they can grasp concepts now. They’re employable in college. It’s easier for them in college.”

Sometimes the college preparation purpose was not predominantly rooted in developing students’ plant content knowledge or other agricultural content knowledge for college, but instead was focused on developing general skills for learning and success in college. Dawn described how she developed general college preparatory skills within her students:

> When you get into college, those [PowerPoints] aren’t really provided to you, or a lot of times they weren’t provided to me and I had to figure out how to make my own outline...If they can figure out how to organize their own notes correctly and properly, it’ll help them in the future.

This conversation with Dawn was substantiated by my classroom observations where I witnessed her talk through content not written on PowerPoint slides and subsequently tested students on content she discussed in class. Dawn described her strategies further, “In my greenhouse class, I had them write down bulleted items. And they took a quiz today over it and they’re like, ‘we didn’t….You didn’t…This wasn’t on our note sheet.’ And I go, ‘But we talked about it.” James also discussed how he is preparing his students for college, “I’m teaching to those kids wanting to go to school, you know, you need to be able to take notes and pullout information, and you need to set time aside and study.” I observed James give multiple quizzes during my classroom observations. He described that part of his assessment strategy of frequent quizzes was to prepare students for a college education.

The current context the participants were operating within also influenced the college preparation view. This context included: the message their schools were sending about the amount of college preparation necessary for students, the demand for students to go on to pursue a college degree in their community, and the characteristics of students in the agriculture program and within specific agriculture classes. Just because a school had many students interested in pursuing college degrees, didn’t necessarily mean agriculture students were representative of the entire school. If school administrators felt like the agriculture department bore responsibility for preparing students like James expressed, then participants were inclined to include more college preparation in their agriculture curriculum.

The similarity between college and career preparation views on the purpose of agricultural education was they both focused on an ultimate career outcome for students. This included careers in the plant science industry directly out of high school, returning to traditional production farms and raising crops for livestock, employability in college in the plant sciences industry to earn money and gain experience, or preparation for a college degree in agriculture or another field. Most of the participants who held a college preparation view also held a career preparation view about the purpose of agricultural education. The exception to this phenomenon was Jane, who had a primary agricultural literacy view but also held a secondary college preparation view. However, when Jane discussed her beliefs about college preparation, she emphasized entrance exams (i.e. ACT) and how to study and take notes and less about finding a career in an agricultural field.

Agricultural literacy purpose.

Every participant, even the individuals who held career and/or college preparation as their primary views, discussed agricultural literacy as a purpose of agricultural education in some capacity. This is reflected in figure 4.2 that displayed every participant with a primary or secondary view of agricultural literacy. The difference between the participants was how much of an emphasis they placed on agricultural literacy. Allison, who incorporated skills and science in her classroom, said this to her students about agricultural literacy during a classroom observation, "…we are going to talk about the technical aspects, but you also have to be able to answer the how and the why. I want you to be a good consumer." This quote illustrated how even with a focus on other purposes of agricultural education, agricultural literacy was still important to Allison.

When I asked Jane what the purpose of agricultural education was, her immediate response was, "Its literacy. It's literacy." Jane discussed literacy throughout both of her interviews and multiple journal reflections. She stated, "I feel like that's my job, I was put into the position that I am in now, for ag literacy purposes." The experiences that shaped Jane's agricultural literacy view stemmed partially from the characteristics of students involved in her agriculture program. She said, "A lot of it would be ag literacy because the kids are just getting much farther removed from the farming operation. So, they're starting to not see the relevance of it anymore like I got to see growing up." Jane viewed agricultural literacy as having a ripple effect and discussed how her students would educate others, even their future children. Clint also discussed how his students took information back to their parents, grandparents, and other members of his local community.

Similarly to Jane's comment that she felt her job was to teach agricultural literacy, other participants believed teaching agricultural literacy was a moral responsibility. This is what Clint said about his students:

> I believe that as contributing members to our society, they need to have a background in some sort of agriculture. The kid who is going to leave here and do nothing agriculturally that's okay, but still that person's a voter. That person is going to be approached with hot topics and hot button items and if that person went through this program and has an understanding of why we have forages, just the background behind why we do the things we do in ag, that's what it's all about. That's what's going to save our industry to be honest with you.

Even Cora, who had a heavy career preparation focus to her program, saw the value of an agricultural literacy purpose for agricultural education. She said, "As a consumer or as a grower they are going to need to understand those principles." Some of the participants even second guessed their agricultural literacy focus. After describing her agricultural literacy and practical life skills related views Kelly said, "Maybe that's the wrong way to think about it." It is possible agriculture teachers feel guilty for not pushing agriculture professions or specific career skills when they adopt a more general agricultural literacy purpose. Overall, agricultural literacy was the only purpose of agricultural education mentioned by all participants in some capacity.

The context the participants were operating within had a profound influence on their views about the purpose of agricultural education. For participants with an agricultural literacy view, this was often determined by their student makeup (background in agriculture, aspirations beyond high school, year in school when they entered the agriculture program), local community, and the current state of the overall agriculture industry. When I asked Clint about the role of agricultural literacy in his classroom he responded, "Why? You've said one because of the community. The other reason I want to have that [agricultural literacy] is because I believe as contributing members to our society, they need to have a background of some sort in agriculture." The age and year in school of their students also influenced the participants' emphasis on agricultural literacy. Kelly indicated her freshman agriculture class was primarily agricultural literacy focused. Ashley also discussed an agricultural literacy purpose for her entry level classes. Participants typically made this decision because they felt it was important to develop base agricultural literacy knowledge in their students. Many participants expressed that it would be difficult to begin an introductory class with specific career skills when their students had zero background in the agriculture industry.

Part of the need for agricultural literacy was for the students' benefit, but a secondary reason was because of the influence educated individuals can have on the agricultural industry. Multiple participants mentioned a desire for students to be informed voters. This was less about the students' development and learning and more about the impact that students could have on the agriculture industry through legislation. This is an important distinction because agricultural literacy was the only focus in which participants mentioned the outcome explicitly extending beyond the needs of the student.

Experiences of the participants also influenced the agricultural literacy view as the purpose of agricultural education. This connects to the students in individual schools not pursuing agriculture careers. If the students in the participants' classrooms were not focused on attending college, entering a trade after high school, or going back to the family farm; then the participants were more inclined to adopt an agricultural literacy based purpose or a combined purpose of agricultural literacy and practical life skills.

Practical life skills purpose.

The fourth view held by participants about the purpose of agricultural education was practical life skills. This view shared similarities with agricultural literacy (development of general knowledge and awareness about agriculture); but the life skills view took it a step further than mere literacy to focus on students developing tangible skills such as being able to grow a garden, create a weld, or operate a chainsaw. Some participants even mentioned some soft skills as practical life skills such as being able to conduct a meeting or communicate to a group of individuals. Originally, the practical life skills view was included within agricultural literacy, but upon further reflection it became apparent there were distinct differences between the two purposes.

To parse out the differences, a follow up question was asked of the participants to establish their personal definitions of agricultural literacy. The definition of agricultural literacy has adapted over time within agricultural education research (Hess & Trexler, 2011). Since agricultural literacy definitions may vary, it was important for me as the researcher to be confident about what the participants meant when they described agricultural literacy as a purpose for agricultural education. A representative definition provided by Ashley was, "Educate the students and the public in common knowledge of basic agriculture." The words consumers, voters, knowledge development, basic knowledge, and general knowledge were all used in participants' definitions of agricultural literacy. After this clarification from participants, it became clearer that their agricultural literacy view was focused primarily on knowledge and awareness about agriculture. Therefore, a new purpose, practical life skills, was a necessary descriptor for those participants who discussed developing tangible, practical skills within their students not directly related to career outcomes.

Kelly described the role of practical life skills development in her classroom:

> A lot of these kids just have no clue. And introducing them to basic ag ed, basic how to use a drill, how to use a chop saw, how to use a welder, how to plant a plant correctly, are all life skills. Just basic ag literacy and life skills I think are important.

Kelly further described how her practical life skills view would benefit her students. "They're probably all going to garden or have flowers or landscape. So, it's more important to me to teach them life skills than think they are really going to be a greenhouse owner when they grow up." Dawn also mentioned practical life skills gained from her plant science content for students not pursuing a career or attending college in the area. “It’s productive for them because if they have their own house someday they can select the right trees, shrubs, and then save money…” An interview with Cora, whose primary view was career preparation, revealed how important the application of skills in some capacity was to her. “…when they [students] leave here they could go to work in a greenhouse or they could raise their own plants or they could take it and use it in real life. I want it to be applicable.” Cora gravitated toward practical life skill development because of the importance of hands-on application and physical skills to her.

The practical life skills Kelly described in her classroom went beyond plant science content, even within her plant science classes. As a component of her floral industry unit, she had the students complete a wedding project. When we discussed her purpose of this particular assignment Kelly indicated that in addition to skills related to the floral industry, she was also assisting students in developing basic math skills and communication skills. Cora also discussed the importance of practical life skills in the form of soft skills. “Maybe they’re not learning plant science, but they’re learning life skills. Citizenship, cooperation, they’re learning so many skills that will make them productive citizens because of what I have taught them.” Soft skills were not explicitly mentioned as a purpose of agricultural education by participants, but evidence of soft skill development occurred in the majority of the classrooms I observed.

Cora’s view that practical life skills were a secondary purpose of agricultural education was partially influenced by the context of the intracurricular nature of agriculture programs, specifically FFA. FFA is a national youth organization that is an integral a part of the overall agricultural education model (National FFA Organization, 2015; Newcomb et al., 2004; Talbert et al., 2005). The FFA motto, adopted in 1928, is:

Learning to Do, Doing to Learn, Earning to Live, Living to Serve (National FFA Organization, 2015). Historically, FFA and agricultural education as a whole has prided itself on the hands-on component to education, evidenced from the previous motto (Newcomb et al., 2004). Since FFA is such an essential part of agricultural education, it made sense the “doing to learn” philosophy would also influence how the participants viewed the purpose of agricultural education. Practical life skills appeared to be an avenue to maintain the hands-on instruction most participants felt necessary and effective for agricultural education, while still catering to their students’ current needs and interests.

Another contextual factor that influenced the practical life skills view was the elective nature of agricultural education. Students choose to sign up for agriculture courses. Many of the participants expressed they needed to teach in a way that catered to students’ interests, needs, and goals. This was partially because students are not typically required to take agriculture courses. If students expect hands-on education vastly different from their core content area classes, then they may react negatively to a class that doesn’t focus on skill development or hands-on activities. Consequently, if students don’t fill classes, then it is possible teachers’ jobs could be in jeopardy. Finally, experiences with the students in their classroom and the future goals of those students had a profound influence on the practical life skills view, just like all of the other views about the purpose of agricultural education. Many of the participants discussed altering their views based on the characteristics of students enrolled in their classes.

Practical life skills and agricultural literacy are overlapping views because they both focus on knowledge and awareness about agriculture. However, practical life skills could be regarded as an application or an additional step beyond agricultural literacy, just like college preparation could be regarded as an additional step beyond career preparation. For this study, if a participant viewed the purpose of agricultural education as practical life skills they also viewed the purpose as agricultural literacy. However, there were participants who held an agricultural literacy view but not a general practical life skills view as their purpose for agricultural education.

Individualization purpose.

While all of the views about the purpose of agricultural education mentioned previously were rooted in what the participants thought their students needed, one participant took it a step further. Clint developed a new view, which encompassed all four of the different views mentioned previously (career preparation, college preparation, agricultural literacy, and practical life skills). Clint and I described this combined purpose as individualization, because it focused on meeting the needs of each individual student. Clint discussed this:

> I believe it's per kid, I really do. I know someone would say, well you can't say that. Well I do. Ultimately, it's about student success. That's because I really pride this program on its ability to prepare a student to go to a 4 year college while that student is sitting right next to someone who is only going to graduate.

Clint felt an underlying obligation to meet the needs of all of his students which was influenced by some of his previous experiences. Clint shared with me what he heard from a former agriculture teacher, "He said your job, as an ag teacher, is to take your students as far as the most limiting factor. He said that limiting factor is either going to be your intelligence or their intelligence." Clint went on to discuss how the scenario would play out for him if the limiting factor was his own intelligence, "If it's your intelligence, then it's your job to get them some where they can get more."

Clint felt an obligation to teach to each student individually. He expressed this when he stated, "I believe it's my job, it's this program's job, to fit the needs of each student. You can't just take a sweeping brush and say this is going to be a science based program." He went on to describe a student with aspirations of being a welder who was also diagnosed with autism. Clint described the education he planned to provide to this student, which included a mixture of manual welding skills and soft skills related to communication and resume construction. He also stated he did not feel it was necessary to teach this particular student from a scientific standpoint because he wouldn't have a use for extensive scientific knowledge. Clint summed up his belief with this comment, "Could I say well 51% of my students are going to benefit from a scientific based agricultural curriculum so we're going to do it. So I just leave out 49% of my students? I'm not doing that." The individualization view was a very strongly expressed purpose from Clint.

In summary, Clint's individualization view overlapped with all of the other views regarding the purpose of agricultural education including: career preparation, college preparation, agricultural literacy, and practical life skills. Career preparation and college preparation views commonly overlapped and agricultural literacy and practical life skills views commonly overlapped. Figure 4.3 illustrated the overlapping beliefs about the purpose of agricultural education for the participants in this study.

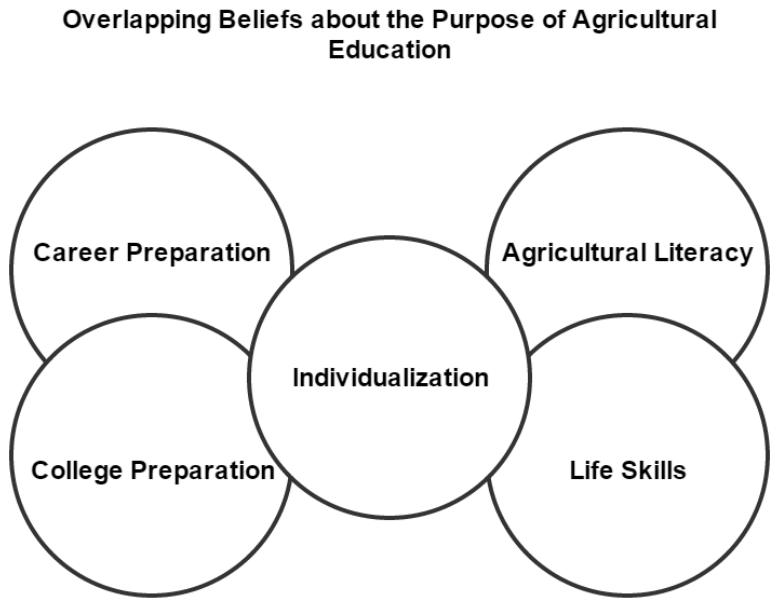

Figure 4.3 Overlapping Beliefs about the Purpose of Agricultural Education

Summary: Beliefs about the purpose of agricultural education and its connection with teachers' pedagogical content knowledge.

Participants with career preparation as their primary view developed PCK that included more manual skill outcomes such as: dividing plants, greenhouse maintenance, treating plant diseases, greenhouse sales, and greenhouse management so they could develop those skills within their students. Participants with a career preparation view also gained knowledge more often related to authentic assessments because they wanted the students to physically show them they had mastered a skill versus memorization of information. Allison and Cora, who both had career preparation as a primary view for the purpose of agricultural education, groomed students to be greenhouse managers. Thus, they utilized more inquiry based teaching methods and engaged students in thinking about potential issues from a business owner's perspective. Cora's career preparation view influenced how she chose content and what content she chose. For example, Cora emphasized the need for sanitation in the greenhouse and instructed her students on the proper ways to sanitize greenhouse tools and pots. This practice was not strictly followed or taught to students by many other participants in the study.

Viewing career preparation as the purpose of agricultural education also influenced some of the experiences the participants engaged in for their CK and PCK development, including seeking knowledge and assistance from other agriculture teachers in the field. The participants with a career preparatory view all had a heavy incorporation of the greenhouse into their classroom, which increased the participants' need to attend Hummert professional development (a greenhouse company) to learn practical manual greenhouse operation skills. Cora commented teacher preparation did not prepare her to operate a greenhouse and this terrified her when she first began her teaching career. She expressed professional development workshops and classes and talking with professionals (both in the agriculture industry and other agricultural teachers) were her primary avenues for PCK development because of her lack of background knowledge on greenhouse operations after completing her teacher preparation program.

Participants with the career preparation view stressed hands-on learning and skill development. One of the biggest complaints about a popular curriculum source (Instructional Materials Laboratory) IML, stated by Jane, was it did not include enough activities or hands-on applications. All of the participants in the study were familiar with IML, a company that developed curriculum packages through the University of Missouri for various career and technical education disciplines, including agricultural education. IML curriculum covered a variety of content areas in agriculture, including plant science. All of the participants incorporated IML curriculum into their classrooms to some degree. IML curriculum included the content information, study questions and objectives, and instructor and student workbooks, but it did not include many activities to reinforce the content. If participants viewed the purpose of agricultural education as a career preparation that necessitated hands-on application and skill development, they would most likely need more than the IML curriculum alone to achieve this purpose. This would expand the possibility of a teacher with this view having developed a vast knowledge of plant science curriculum by exploring other curriculum resources.

In contrast, participants with a primary agricultural literacy view were more likely to focus on developing knowledge and less likely to focus on developing skills. This altered the type of assignments given to the students and the teaching methods utilized to deliver material. Agricultural literacy focused participants tended to utilize classroom discussion, reading, and writing assignments more heavily than participants whose views were focused on other purposes of agricultural education. Jane illustrated how her primary view of agricultural literacy influenced her classroom assignments. “They are the future consumers of our food; do they understand why that is important? And so we do writing assignments to make sure they understand it and we do a lot of discussion.” During classroom observations, I witnessed Jane engage in open dialogue with her students regarding photosynthesis.

The agricultural literacy view also influenced the type of content the participants deemed important to teach, and subsequently the knowledge they developed on how to best teach that content. Dawn summed up how she chose the content she covered in her classroom, “If the students can’t use it in the future, what’s the point?” This illustrated a direct connection between her views about the purposes of agricultural education, the content she felt was more important to learn about, and the subsequent PCK she developed.

Clint stood out from the rest of the participants by having a student individualization view as his purpose of agricultural education. He discussed the responsibility he felt to take each student as far as they could go, which caused him to have to know the content he was teaching “pretty dang well.” This view influenced Clint to seek out various knowledge and teaching strategies to fit with the needs and interests of all his students. He commented that he needed to teach the same agriculture content on different levels depending on the abilities of his students and for different purposes depending on the end goals of his students after high school.

Beliefs about Plant Science Education

There were many emergent beliefs specifically for plant science education that influenced the participants’ PCK. Beliefs about plant science education included: the utilization of the greenhouse in plant science education, the level of science integration in plant science, the influence of students’ prior knowledge on the teaching of plant science, and the perceived dry/boring nature of plant science content.

It is important to surface the beliefs about plant science education as a whole mirrored the beliefs about the purpose of agricultural education for all of the participants in the study (see figure 4.1). For example, Cora held a primary career preparation view and consequently believed the school greenhouse should be utilized to develop career skills and run like a business, the level of science integration should focus on applied science, and the nature of plant science was only dry or boring if you didn't engage in hands-on activities in the greenhouse. This phenomenon could be different for another agriculture content area other than plant sciences.

Utilization of the school greenhouse.

The most prominent plant science education belief surfaced from the participants revolved around the purpose of the school greenhouse. All of the participants discussed the importance of hands-on learning in agricultural education, which was often enacted in the school greenhouse. Kelly said, "My advanced greenhouse class is so hands-on that we're hardly in the classroom." This belief about hands-on education is explored further in the teaching and learning beliefs in agricultural education section. However, the difference between the participants utilization of the greenhouse was some of them viewed the purpose of school greenhouse as a laboratory, others saw it as business, and some had dual purposes for their school greenhouse. This specific plant science education belief was also the most heavily influenced by the context of school and community.

James, who had a primary agricultural literacy view, saw the school greenhouse as a laboratory. When asked what he thought the purpose of a school greenhouse was he responded, "To me, a school greenhouse is primarily a lab where students can practice skills learned in the classroom and a place where they can conduct plant science related experiments." Kelly reflected on the beliefs of her former high school agriculture teacher in relation to the use of the school greenhouse in the plant sciences. "His theory on it was that he didn't spend all semester in the greenhouse because he didn't think that was what the kids needed to learn, that was just repetitive." However, one of Kelly's own reservations with viewing the greenhouse solely as a lab was the students' pride in their work. "But I don't think the kids take as much pride in it when they don't plant it; when you just buy it from somewhere."

Some of the participants in the study viewed the school greenhouse primarily as a business whether that was because they had a career preparatory focus or because the school or community put additional pressure on the viability of the greenhouse. Cora demonstrated the impact of her location on her utilization of the school greenhouse. "When I moved from [city] I went from a small greenhouse that was hobby and we just used it for classroom projects, to actually having a production facility where we had to have plant sales and grow things." Allison evidenced her business utilization of her greenhouse operation with: daily chores for all the students, displaying recent greenhouse product catalogs, and side conversations that were heavily related to the sales portion of the greenhouse.

Dawn's views about the purpose of agricultural education, which included both agricultural literacy and career preparation, were also reflected in her belief about the utilization of the school greenhouse:

> It is an extension of the classroom learning environment. The greenhouse will provide the student the opportunity to apply lessons learned in the classroom into a real life situation. The greenhouse also gives students the ability to gain skills which could lead to employment or future careers.

Her dual use of the school greenhouse as both a lab and a business combined characteristics of both greenhouse purposes and reflected her overarching views about the purpose of agricultural education. The hybrid business purpose of a school greenhouse acknowledged the current set up many agriculture teachers had for incorporation of the school greenhouse. Currently, the majority of participants in the study spend the fall in the classroom and the spring in the school greenhouse. When participants believed purpose of the school greenhouse was at least partially a business, the content taught to students was focused primarily on information they would be able to directly use in their school greenhouse. Allison discussed how the sexual propagation lesson I observed in her classroom led to her students growing plants in the greenhouse in the spring.

The amount of responsibility given to the students in the school greenhouse differed based on the participant. Dawn, whose beliefs about the purpose of agricultural education included career and college preparation views, gave the students more responsibility in the school greenhouse. She explained, “They are the managers and caretakers of the greenhouse. As a teacher, I select and order materials and treat the plants with chemicals, but the students do everything else under my direction and supervision.” Ashley had an agricultural literacy primary view with a secondary practical life skills view regarding the purpose of agricultural education. She allowed the student their own tables of plants to completely take care of once they entered her advanced greenhouse classes, also reflecting the bearing of the age of the students on the amount of responsibility they were granted in the school greenhouse.

The school greenhouse can be an expensive component of an agricultural program. Some schools expected it to simply be self-sustaining; some expected it to raise money for fundraising purposes. James said, “Now in the ‘real world’ school greenhouses are generally expected to carry their own weight financially which usually means producing crops for sale to the public each spring and fall.” Allison acknowledged the responsibilities of the greenhouse for the student and the teacher extend beyond the classroom. Allison said, “I think their primary role is to be students and learn the ends and outs, but I also think they obviously have to be the labor force behind everything you grow.” Allison discussed her need to balance having the students work in the school greenhouse so they could raise plants to sell and having the students work in the school greenhouse to learn new plant science concepts.

If there are specific growing expectations of the school or local community, the purpose of the school greenhouse can shift. As the purpose of the school greenhouse shifts, so does the knowledge teachers need to run the greenhouse. James explained how he taught some of his plant science classes differently than others simply to keep up with the external demands of the greenhouse. “My greenhouse and operations management classes operate the greenhouse like a business which fits our class objectives perfectly. They learn how to plan for, schedule, grow, and sell various crops and go out and do it in the greenhouse.” This utilization of the school greenhouse allowed him to balance educational demands of the greenhouse with school and community demands of the school greenhouse. However, James acknowledged navigating individual beliefs about utilization of the school greenhouse with community and school expectations is not easy. He discussed how his different classes had different purposes and while not every class gets to experience every part of the process, they each played an important role in the overall school greenhouse. His freshmen classes used it more as a lab for experiments, his floriculture classes focused more on sales, and finally his greenhouse classes attended to overall management.

Allison illustrated just how important the context of school and community can be on the utilization of the school greenhouse:

> I think that depends on where you are at. At my first school they paid for all my supplies and I was not supposed to have a sale because they did not want me competing with the local greenhouse. The purpose was solely educational. Here, I have to make enough to pay for what I do out there so the greenhouse has two purposes- the first to be educational the second to make enough money to continue funding it and the class.

Allison also emphasized the influence the community could have on how the school greenhouse was utilized. “In the greenhouse, the community is the sole factor in what I choose to grow. If I cannot sell it, it does me no good to grow it.” Later, in a conversation during a classroom observation, she expressed additional pressure for growing for the community. “100 of them [poinsettias] are already contracted to our grocery store, so this year I’m like these have to be right.”

Finally, some participants were quick to say, even in courses titled greenhouse, that greenhouse was not the only part of plant science they taught. In fact, some of the units I observed such as forages with Clint, while they were plant science in nature, had nothing to do with greenhouse. This decision was influenced by Clint’s context that included students in his classes primarily living on production farms and the community he was based in having a need for forages content over other plant science areas. When I asked Kelly if there were any negative approaches to teaching plant science in her post observation interview, she replied, “Maybe a class where you only learn about one type of plant science because there are so many sections and divisions. I don’t want kids to think the only thing out there is greenhouse.”

Level of science integration.

All of the participants believed science integration was a component, at least to some degree, of teaching plant science. Many of the participants in the study viewed agriculture in general as an applied science and this influenced their level of science integration. Allison elaborated on her belief that she is teaching an applied science course in the following journal reflection. “I think it’s important that they get the science content behind plant science (the processes, factors, etc.) but I also feel my job is the practical application of that science.” Dawn and Ashley also expressed a view of agriculture as an applied science. Dawn stated, “The majority of the classes are applied science. We are not focusing on the memorization of the extreme technical aspects. We’re focusing more on the application aspects and the use for future applications.” This belief that agriculture is an applied science fits directly with the hands-on experience component many participants relayed to me as the hallmark of agricultural education. Kelly, who had a primary agricultural literacy and practical life skills focus, acknowledged the influence of science in her classroom. “So I think a good mix of the sciences and the practice is a good combination.”

The belief agriculture was an applied science influenced the depth of content the participants deemed important to address in their classrooms. Many of the participants discussed not duplicating and instead complimenting biology and other science curriculum. Allison explained, “Our science teachers do a great job of going in-depth on the concepts so there is no need for me to rehash it. We should build off of what each other are doing in our classrooms.” However, the content addressed by science teachers and the overall quality of science teachers differed depending on the school context. Some of the participants in the study actually felt they needed to cover more science, not less, because of what was being taught in current biology courses in their respective schools. Kelly stated, “Honestly, photosynthesis, we get into because they don’t cover that a lot in biology anymore.” If the participant felt science integration was important for teaching plant science then many felt an obligation to cover science concepts in their courses.

James stated that behind the ability to work, the second most important skill his students learn is scientific inquiry. Within the realm of science integration, many of the participants organized their content to include heavy science based curriculum in the fall and more manual skills based content in the school greenhouse in the spring. This related to the previous category about the utilization of the school greenhouse. If the purpose of the school greenhouse focused more on business then this served as an additional reason for focusing on science concepts in the fall.

Part of the participants’ reasoning for a strong belief in science integration related to context, specifically the desire of their students to acquire science knowledge. Cora said, “I try to get the plant science stuff. That’s why they’re here. They want to learn about the plant science.” Another contextual factor that influenced the belief of science integration was three for one science credit. Kelly, Dawn, and James all mentioned their schools participated in this program. This program granted students one science credit if they took three approved agriculture courses. This type of program can influence the level of science taught in an agriculture course. The more science that is expected to be taught the more science content knowledge and methods of teaching science content the participants needed to know.

Another contextual factor related to the three for one science credit program was end of course assessments. In a follow up question, James discussed how he felt responsible to contribute to students' performance on the biology end of course assessment as a direct result of his participation in the three for one science program. "We offer three ag science classes for one regular science credit so we must ensure that our 'science' classes are rigorous enough to help student when they take science eocs [end of course assessments]." When assessments and science credit became a bigger contextual influencer on agriculture programs, the influence of science integration appeared to increase.

Clint cautioned teachers to examine the degree of science integration in their agriculture classrooms. Despite going as far as using science based extension research articles in his classroom, Clint still maintained having too much of an emphasis on a science based program goes against his student individualization view about the purpose of agricultural education. "…you can't just take a sweeping brush and say- this is going to be a science based program." Allison also closely monitored her level of science integration in the classroom:

> I want them to understand basic science principles and I want them to be able to go into their science [classes] and already know it. I want it to have that rigor that we are constantly talking about, but I also think we have to remember that many of the kids taking my class aren't going to be science majors.

In contrast, Ashley had the most direct focus on science integration. She was one of two participants in the study who followed a text book regarding curriculum. She provided me with a copy of her unit exam and it was one of the more difficult content exams in terms of depth of content than any other participant in the study. The amount, depth, and type of content that Ashley addressed were more akin to a traditional biology course.

Plant science education is primarily building on students' prior knowledge.

One interesting belief related to plant science education was that plant science was different than other agriculture content areas regarding the amount of prior knowledge of students. This prior knowledge of students can be traced all the way back to elementary school according to the participants. In reference to his unit on plant processes James said, "This first lesson is just a review of information that students have learned since 2^{nd} grade." Participants also believed students' prior knowledge of plant science was developed in middle and high school years. I observed Ashley describe the unit to her students as a review from previous agriculture and science classes.

James discussed the influence of student prior knowledge of plant science on his teaching throughout the interviews, reflections, and most noticeably in dialogue with students during my classroom observations. Many of the participants mentioned to students during their lessons that much of the material they learned was just building on previous knowledge. James said, “Because I always tell them that I can never teach them anything they don’t already know. When I ask them questions, you already know the answer. It might not be the best answer, but you already have some idea.”

Jane also indicated awareness of prior knowledge of her students in plant science. “Most of them should have the background knowledge already of biology, plants, photosynthesis, and generic things like that.” Sometimes this belief about prior knowledge in plant science influenced the pace at which the participants taught the content as evidenced from an interview with Jane:

> My kids always get onto me about how fast sometimes I go through things. And I say, ‘I’m trying. We are using knowledge. We’re just recalling previously learned knowledge. So this should not be something that we’re going to spend a whole month over like you did 2 years ago.

James also commented that plant parts haven’t changed since second grade and he was going to review that material and reinforce those concepts, but add a little more to it. James said, “They’ve got the parts down, we’ll add a few things to that. Instead of just talking about roots we’ll talk about osmosis, we’ll talk about root caps. We’ll take those parts and expand on those.” James mentioned the knowledge his students learned in elementary and middle school related to plant science across multiple data sources and multiple times throughout the course of the study.

Part of James' strategy was to make the content more accessible to students. He described how he passed around his daughter's 4th grade science test to the students in his classroom to demonstrate that they had learned the content previously. James referred more to elementary and middle school prior knowledge because he didn't feel like his particular school covered much plant science for students' freshmen year in high school. This is evidence for how the context of the school, combined with the beliefs of participants and knowledge of the students, can influence PCK. Kelly also expressed concern for the level of science her students were receiving in middle and high school.

Kelly had been an inservice teacher for 12 years, yet she surfaced changes in the amount of content students learned prior to entering her classroom just within her time in the field. Cora, who had been teaching 18 years, also seemed surprised by some of her students' lack of prior knowledge. "I would say probably my biggest shocker is what they don't know coming in." When the students' prior knowledge regarding plant science was limited, some of the participants chose to relate the content to humans or animals if it was applicable. Cora explained that she related plant reproduction with humans because it helps the students to trigger background knowledge. Clint often related his plant science knowledge to animal science as a way to invoke the prior knowledge of his students. This knowledge was partially developed based on the contextual influence of the agriculture in the community and the needs of his students.

Experiences of the participants were also influenced by the belief that plant science education is primarily building on students' prior knowledge. Some participants did not feel obligated to seek out additional information on the base knowledge of some plant science concepts because they assumed students already had the knowledge. This was particularly evident with Jane who commented she didn't know how to elaborate more on photosynthesis after discussing the formula and the function of chloroplasts. On the other hand, if participants believed students didn't have as much knowledge coming into their classes, they spent more time in the review stage like I observed in Ashley's unit where she recapped crucial plant science concepts. The participants' belief about how much prior knowledge their students held in the plant sciences influenced the participants' development of their own new knowledge to effectively teach students at their current level.

Plant science content is believed to be dry/boring by nature.

Many of the participants viewed plant science as one of the more boring agriculture areas for students to learn about at the secondary level. This generally did not reflect their own feelings about plant science, which were generally positive, but instead reflected what they believed students thought about the subject area. In a journal reflection James wrote, "It may sound juvenile, but we talk a lot about the 'circle of life' and the role plants play in it. Again, I am trying to get students to think about boring, old plants and how they grow." Jane also discussed trying to utilize a variety of teaching techniques to keep plant processes content from being dry/boring. "Obviously that stuff [plant science] can be pretty boring material if you make it boring."

Cora speculated teachers might feel like plant science was boring or their students thought it was boring because they underutilized the greenhouse. Whenever she spoke about the greenhouse, she visibly lit up, and she constantly expressed the value of having a greenhouse to engage students in hands-on activities and skill development they could use in their future careers. Cora commented, “I could take kids and get out of the classroom. They hate these four walls, they get bored. But if you can walk them down and go into the greenhouse, whole new environment. I loved that.” She strongly believed any negative feelings about plant science on the part of students directly stemmed from their agriculture teachers’ lack of ability to immerse them in the plant science content through experiential learning.

The participants who didn’t utilize the greenhouse as much in their classes were consequently the same participants who struggled to incorporate more hands-on activities in their classes and were more likely to hold the belief that plant science is dry/boring for students. All of the participants acknowledged hands-on applications were one of the best ways for student to learn; however, the participants varied in their ability to incorporate hands-on activities in the classroom. Particularly Kelly and Jane, participants with 12 years’ experience and 11 years’ experience in the field respectively, struggled to develop meaningful activities. They also discussed how IML, a popular curriculum resource mentioned previously and an important agriculture specific contextual influencer, lacked activities and expressed a strong interest in further curriculum resources to develop hands-on activities and applications to plant science content.

Clint took a different approach to the belief plant science could be boring and dry. Unlike many teachers that attempted to either utilize the greenhouse or incorporate activities such as making models of the parts of a flower, Clint approached plant science from an animal science perspective. This method was also chosen because of his individualization view about the purpose of agricultural education and because of his agriculture in the community. Clint said, “We try very hard to approach this from an animal science standpoint because that is very prevalent in our area. If I approach this [forages] from a plant science standpoint it won't work."

Summary: Beliefs about plant science education and its connection with teachers' pedagogical content knowledge.

Beliefs regarding the utilization of the school greenhouse influenced the PCK of the participants. When the participants wanted students to take away specific manual skills, then the participants themselves had to possess those skills. Cora said, "Especially the hands-on pieces, you have to be five steps ahead of every kid. You've got to know what you're doing though. That's not something that you can fake with them." The specific plants the community wanted participants to grow in the greenhouse also influenced the participants' PCK. Allison discussed how she had to learn how to grow poinsettias and learn how to teach students to grow poinsettias because it was something her school and community demanded from her agriculture program.

Believing the purpose of the school greenhouse was primarily business also influenced the structure and sequence of the content for some participants. Many at least partially based their lessons around preparing students for greenhouse work, which occurred primarily in the spring. Allison said, "We needed the sexual propagation lesson as well as the plant part lesson to really understand this lesson. It then helps us when we start growing plants in the greenhouse." Cora also followed a similar structure in her classroom, which was reflected in one of her journal entries. "This lesson connected to the plant parts and functions lesson as well as builds on tasks that will have to be accomplished next semester (planting from seeds, taking cuttings to establish hanging baskets)."

Another way participants' beliefs about plant science education influenced their PCK is in the area of science integration, in particular the use of research in the classroom. Clint consistently utilized research articles from land grant university extension systems evidenced through observations, reflections, and lesson artifacts from the unit. For the forages unit I observed, Clint taught a lesson that discussed the nutrients different forages needed to grow and incorporated a university soil test into the discussion of how to grow the most successful crop. Additionally, participants who had a practical life skills or career and college preparation as their primary view about the purpose of agricultural education gained more PCK in science related to applied science principles. Allison communicated she didn't want to delve too deep into difficult science content because she believed her purpose was to stay more application based.

A quote from James demonstrated how his assumption of prior knowledge of his students influenced his PCK. James stated, "The biggest hurdle in this lesson is getting them to understand respiration. So far in their education, they have focused on how plants make food, not how they use it. That's where we start with this lesson." This quote demonstrated to me just how much assumed student prior knowledge was influencing what content the participants decided to teach, what level they decided to teach it at, what content they needed to review, and what content they could assume students already knew.

Assumption of student prior knowledge also influenced Dawn's PCK. She described to me that she didn't teach students how to use dichotomous keys in her identification unit because they had experience in biology class with the tool. Dawn also knew her identification of plants backwards and forwards because of her double major in plant science. When I asked Dawn how she knew that a particular strategy was the best way to teach a concept, her reply illustrated the consideration she gave to student prior knowledge in her development of teaching methods for plant science. Dawn said, "I don't [always know the best strategies]. It's just more understanding and having prior knowledge of my students, prior knowledge of my class and seeing how they are obtaining the information as you work through."

Finally, beliefs about the nature of plant science content influenced the participants' PCK. If the participant felt like plant science content was inherently dry and boring to their students, then they sought out resources for more engagement activities. Jane described her desire for more activities in plant science education, but was also one of the participants who utilized the greenhouse more as a laboratory and less as a business due to her agricultural literacy focus.

Beliefs about Teaching and Learning in Agricultural Education

The final component of the integrated belief systems was the participants' beliefs about teaching and learning in agricultural education. These beliefs were separate from plant science education specific beliefs and delved more into general pedagogical beliefs that could apply across content areas in agriculture. The context of the agriculture and school community influenced these beliefs as well as experiences the participants engaged in, particularly in the classroom. Specific beliefs related to teaching and learning that shaped participants' PCK in this study were: teacher as a lifelong learner and reflector, students have a role in determining content taught, and students learn best through hands-on experience and real life application. It is also important to surface the participants held many beliefs about teaching and learning in agricultural education, but these were the most influential in shaping the participants' PCK.

Teacher as a lifelong learner and reflector.

The most influential belief about teaching learning in agricultural education on the participants' PCK was the belief it is the teachers' responsibility to be a lifelong learner and reflect on practice. This belief was held by all of the participants and emerged in various interviews, journal reflections, and classroom observations. It is possible this specific belief is why those individuals were recommended as experienced plant science teachers with PCK to participate in this study, as reflection is a crucial component of PCK development (Hashweh, 2005; Schneider & Plasman, 2011). Holding the belief that a teacher is a lifelong learner was especially apparent with Clint, who viewed student individualization as his purpose of agricultural education. He described previously how he felt the need to continually develop knowledge to meet the needs of each of his students.

The belief agriculture teachers should engage in lifelong learning was connected to experiences of the participants. Participants expressed they sought out additional professional development experiences because they believed it was their responsibility as teachers to seek out additional knowledge. Ashley described her beliefs, "Don't ever quit learning. Keep your eyes open. Pay attention. Read the magazines…If they're [students] learning, they're making you learn. You've got to keep up with those kids. I think that makes a big difference. Ashley continued that regardless of the level of individual content preparation, all agriculture teachers can benefit from more classes in the areas they teach. She stated, "I came out with a masters and so technically I didn't have to do any more classes, but I did. I still do." Ashley had been in the field for 18 years and still mentioned various professional development experiences she had engaged in within the last five years alone. Asking other teachers for assistance was again mentioned as a way to develop new knowledge. Allison described that when she didn't know how to teach specific content she asked questions of other agriculture teachers in her area, even mentioning some of the other teachers in the study with more experience than her inservice as sources.

Participants believed agriculture teachers should not only engage in lifelong learning but they should also reflect on their knowledge and experiences in the classroom. Clint discussed the influence of reflection on his knowledge, "Through reflection, I've learned which ways some things work and some don't." Many of the participants engaged in deep reflection evidenced from their journals and post-observation interviews. Utilizing stimulated recall, the majority of participants described a variety of instructional strategies for the same piece of content and all the participants expressed numerous aspects of their lessons they would like to alter to improve the overall lesson. James discussed in a post-observation interview that his students were not effectively grasping the content of plant diseases and contemplated utilizing a disease triangle handout in the future to increase student comprehension.

Clint voiced that he engaged in continuous reflection. “I reflect at every spare opportunity I get. Sometimes that’s driving home. Sometimes I reflect here when I eat lunch.” Cora and Clint both strongly stated it was the responsibility of the agriculture teacher to find time for reflection because it was a part of their job. Clint claimed all teachers had time to reflect. “No time to reflect, I don’t buy that. That’s someone who is disconnected I believe.” However, both Kelly and Jane stated it was often difficult to reflect on their experiences in the classroom due to time constraints related to FFA involvement, other professional related duties, and their personal lives, such as having children. Clint summed up his beliefs on agriculture teachers being lifelong learners and reflectors with the follow journal reflection excerpt:

> As a young first year teacher, I asked an old retired principal for teaching advice; he told me the following: ‘A good teacher teaches 30 years over his career; a bad teacher teaches 1 year and repeats it 29 times.’ I truly believe sincerely practicing daily reflection of the educational process leads to pedagogical growth as a professional. Without sincere daily reflection of the day’s activity, I believe educators are ignoring the needs of their students and merely ‘repeating’ their lessons. Therefore, it is extremely important to be a true lifelong learner and reflect daily.

Students have a role in determining agriculture content taught.

The second belief participants held about teaching and learning in agricultural education was the belief students had a substantial role in determining the agriculture content they were taught in the classroom. Many of the participants chose content based on their students' interest. Ashley claimed, "I look at where those kids' interests lie and adjust accordingly." Cora described how student interest directed her content choices. "If I have kids who are really interested in something we'll go that direction. One year I had kids who were really interested in grafting." Grafting was a subject Cora did not typically delve into during her plant science class primarily due to context constraints of time and resources. However, if her students were interested in the subject she was willing to explore that content further.

A contextual component influencing the belief that student interest plays a role in the content taught in the classroom is the elective nature of agricultural education. This was mentioned previously in the practical life skills view about the purpose of agricultural education section. Because agricultural education was not a mandatory course for students in the majority of these schools, enrollment was critical for teacher employment. If students did not enroll in agriculture courses, the participants expressed their jobs could be in jeopardy. Participants who felt students should have a stronger role in determining the content taught also typically felt more of a need to engage their students in the content.

In addition to student interest, many participants chose content based on student need and what they thought was important to teach. Allison stated, "I can pull in things that are necessary based on time of year, what interests the students, and what I think is important in the industry." Much of this theme is related to the student first mentality that pervaded the entire study. When I asked Clint what type of knowledge guided his teaching he replied, "Knowledge about my students." Considering Clint described his view about the purpose of agricultural education as individualization for students, it made sense that students had a key role in the content he chose and how he presented that content in the classroom. Clint also considered what content his students needed within the context of his community. He said, “My role would be to deliver instruction on forages that are pertinent to our local community and to my students.”

Students learn best through hands-on experience and real life application.

The final belief about teaching and learning in agricultural education was students learn best though hands-on experience and real life application. This belief was related to a common emphasis on student engagement from all of the participants. All of the participants voiced student engagement was at least partially the responsibility of the teacher. This emphasis on student engagement also reflected the belief that plant science content was dry/boring by nature. If participants believed content in plant sciences was inherently boring, or was perceived that way by students, it stands to reason that they would feel more of a need to engage their students in the classroom or school greenhouse. According to the participants, the best ways to engage students were hands-on experience and real life application.

Cora described how she felt engaging in hands-on application was essential for student learning to occur. She said, “We in agricultural education want to be the ‘learning to do piece’. You know and ‘doing to learn.’ Without those activities, they’re not doing it, so, consequently, how much are they learning it?” In her journal reflections, Cora frequently discussed hands-on ways to improve her teaching and address student difficulties and misconceptions. Allison simply stated, “I know hands-on and everything is best." Clint explained how he felt engaging in experiential learning also aided in student comprehension of content:

> I think through logically, how do I believe my students will learn best? Is it best for me to teach them welding standing up here in front with a welder in this classroom and not turning it on and showing them how we're going to make a bead or would it be much better for them to come outside and I'll get on a welding helmet and they can actually watch me run a bead and then practice running a bead? I just think through in my mind, 'what's the best way for them to learn that?'

I observed the participants use hands-on applications and activities in many classroom observations. The participants with a career preparatory view as their purpose of agricultural education completed a lot of hands-on application in the school greenhouse setting. Cora described how she utilized the school greenhouse, "Having that ability to go and show them and let them do something solidifies what they're learning." Participants with an agricultural literacy view created more hands-on applications for the classroom setting. For example, Jane had her students create models of perfect and imperfect flowers, flower parts, seeds, and plant cells. One of the reasons she mentioned for utilizing these activities in her classroom was to engage her students in the content through hands-on application. Jane stated, "Just to keep them engaged because that's the world we live in." Kelly also utilized hands-on and real life application by incorporating a wedding project in her floral industry unit. However, the length of time spent on these activities in comparison to what the students learned was questionable, even according to the participants themselves.

If the participants couldn't physically show a manual skill to the class or incorporate a hands-on activity, they often utilized real life examples because they felt that was another way students' learned best. Dawn said, "My philosophy is the more they see it the better off they will remember it." I observed Dawn utilize multiple examples during her lesson, both planned on her PowerPoints or with plants she brought in or in response to further student inquiry. Ashley utilized many real life examples in her teaching, "I really like doing a lot of the diagram and samples. For these kids around here I can pull in real life situations and tell them- what about Bob Smith's corn?" When I asked her if the close knit community she was a part of made it easier to engage the students in real life situations and examples she responded, "yes, very much."

Just because the participants valued student engagement and real life examples did not mean that they didn't view lecture as a useful teaching method for student learning. In fact, many of the participants utilized lecture in their classroom and claimed this was another way to foster student learning if used appropriately. Clint stated, "When we go to ag class, we discuss, we listen, we ask good questions, we write our notes, and that's just my philosophy on how students learn." However, in a later interview when I asked Clint if he had infinite resources and time would a hands-on approach always be best, after a few minutes of contemplation he responded with, "yes, nothing is better than the real thing." It is important to surface Clint was under unique circumstances at his school because the class periods were significantly shorter than the rest of participants, making hands-on activities more difficult to complete.

Jane and James both referred to lecture as storytelling and a way to relay some of those real life examples they believed were critical for student learning and understanding. These participants both had agricultural literacy as a primary view about the purpose of agricultural education and were located in comprehensive high schools, not area career centers. James, in particular, was a master storyteller evidenced by classroom observations where he would talk for most of the period, but the students would be completely captivated the entire time. This natural strength of James could also play a role in his utilization of this method. Despite claiming students learned well through lecture, James still alluded to the hands-on component of teaching agriculture as superior, at least for the plant sciences. He stated, “I know other teachers that do a lot more hands-on stuff, and are really more plant science kind of people who utilize more resources.” This quote, and the previous quote from Clint, demonstrated the emphasis on hands-on application and activities as superior to most of the participants, regardless of their primary teaching method.

Experience played a role in the amount of student engagement that participants felt was important in their classroom. If their students had a history of being bored when sitting in their classrooms then the participants developed a variety of ways to teach the material. Cora said, “A lot of it came from networking and from having taught it a bajillion times, sitting down and going what can I do? If I’m bored the kids are bored. Now what can I do to make this better.” When I asked Kelly if she knew of any ineffective ways to teach plant science content she replied, “I think never doing hands-on would be a bad way to teach plant science and sad for those kids that take that class because I think they take it because it is a hands-on class.” This quote demonstrated how the context of the types of students in her program and their expectation of the class influenced her instructional methods.

Summary: Beliefs about teaching and learning in agricultural education and its connection with teachers' pedagogical content knowledge.

The participants' beliefs about teaching and learning in agricultural education also had a profound influence on their PCK. The belief that teachers should be lifelong learners and reflectors heavily influenced the type of experiences participants sought out, particularly during inservice. All of the participants expressed it was the responsibility of the agriculture teacher to engage in reflection and learning, even if some of the participants did struggle with making time to engage in this activity. The participants who expressed a struggle with finding time to reflect consequently struggled more than other participants come up with other ways to teach material when prompted during the stimulated recall portion of the post-observation interview.

James is an example of a participant who, despite teaching inservice for 28 years, still engaged in professional development because he believed it was important to continue to learn. In fact, during the timeframe I observed the plant science unit in his classroom, he spent a few days at a professional development workshop specifically related to teaching students about photosynthesis utilizing fresh methods. This professional development influenced James' PCK about photosynthesis. As a teacher nearing the end of his career this was not something he was required to attend by his school district, instead this decision was based on his belief that it was important to seek out new knowledge and teaching strategies.

The belief that students should play a role in determining the agriculture content taught, also influenced participants' PCK. Participants presented many examples of researching information specific to an area their students desired to learn more about. Ashley discussed how in her classroom, she would often elaborate on questions students asked or take a different turn in the lesson based on student inquiry. This often required her to seek out additional knowledge. Allison also discussed how she incorporated student interest into her curriculum. She stated, "They are taking classes of practical application. That is what they wanted so I'm going to give them as much as possible." The student first mentality drove many of the teachers' beliefs and subsequent PCK development, and perhaps more importantly the amount of personal effort they put into their PCK development.

Beliefs about the importance of student engagement on student learning also influenced participants' PCK. Clint, who was piloting a Google classroom, discussed how he utilized a specific computer program partially because the students enjoyed it as a form of assessment and they were both looking forward to using it more in the future. Ashley also commented, when I observed her students utilizing a computer based testing program, one of her reasons for seeking out more information on technology use with her content was because students enjoyed it, were engaged, and learned more as a result.

The strong belief in hands-on learning led to many participants attending professional development, such as the Hummer institute, to develop those greenhouse manual skills such as maintenance. Participants who utilized the greenhouse more frequently and who held career preparatory views also attended more of these types of professional development opportunities. If these were not available due to context, many of the participants tried to increase the number of examples and visuals that they had for the content. Dawn discussed growing plants in her own yard to have as examples for her students and having to refresh herself on how to care for certain landscape plants. Participants who felt hands-on activities and real life examples were crucial for effective teaching had to seek out additional examples beyond the basic IML curriculum. This curriculum was limited in the activities that it included to reinforce the content. This led to participants developing PCK beyond what was presented in the IML curriculum.

Overall Summary: Integrated Belief Systems and their Connection to the Substantive Theory

The three belief systems: beliefs about the purpose of agricultural education, beliefs about plant science education, and beliefs about teaching and learning in agricultural education, formed an integrated belief system for each of the participants. Within the integrated belief systems, there was overlap between the beliefs about the purpose of agricultural education and beliefs about plant science education. It appeared beliefs about plant science education mirrored the beliefs about the purpose of agricultural education for all participants. Finally, beliefs about teaching and learning in agricultural education also influenced the other two belief systems. The integrated belief systems as a whole influenced the participants' PCK for teaching plant sciences. The participants' PCK in turn influenced their integrated belief systems. Experiences during inservice directly influenced the integrated belief systems. Experience prior to inservice also influenced the integrated belief systems, but through their continually evolving PCK. Finally, the influence of agriculture and school context played a role in shaping the participants' integrated belief systems.

Experiences Prior to and During Inservice

Beliefs of the participants were not the only influencers that shaped their PCK. Experiences, prior to entering the field and after the participants began their inservice careers, directly influenced the PCK of participants. For this reason, experiences are the second main theme in this study. Some of these experiences may seem typical of the average agriculture teacher, but the focus is on how these experiences shaped the participants' PCK. Clint said this about the power of experiences, "My personal experiences have really really helped me perform as an agriculture teacher dramatically." Clint described various experiences both before he began his inservice career and during his inservice career that influenced his PCK in the plant sciences.

Experiences Prior to Inservice

Experiences prior to inservice set the stage for PCK development and for the development of integrated belief systems that will continually evolve and shape PCK. While there were many experiences of participants that may have shaped their PCK, the experiences that emerged multiple times throughout the data were: high school experiences, involvement in the agriculture industry and previous job experiences, and teacher preparation experiences including student teaching.

High school experiences.

High school experiences, for many participants, were their first exposure to plant science content. Participants were shaped by the teaching of plant science content by their high school agriculture teachers and participation in career development events in plant science during high school because of the intracurricular nature of career development events in agricultural education. Career development events are competitions that serve to develop career skills in students through the FFA component of agricultural education (National FFA, 2015). The majority of the participants utilized career development events within their current plant science curriculum including: nursery and landscape, floriculture, and grasslands competitions. When I inquired about their sources of knowledge for teaching plant sciences, the majority of the participants began with knowledge gained during their high school years. Clint stated, "I'll start back in high school. In high school, my ag teacher taught me a lot about forages and grasslands." Clint went on to highlight his career development event involvement in high school, "I was on the grassland contest all four years and traveled to state all four years." Ashley also gained knowledge about plant science from her high school career development event involvement. "I had five contests in the four years. Floriculture and nursery and landscape were my junior and senior years and I loved it."

Beyond simply gaining content knowledge, the methods participants' agriculture teachers utilized for teaching plant science content was another way high school experiences influenced participants' PCK. Clint showed me his problem solving format and IML curriculum and explained how he was taught plant science with this same curriculum and methods as a high school student. This demonstrated how being taught content utilizing specific methods influenced the participants' knowledge on the best methods for teaching that content, especially if the participant had a positive learning experience. Clint went on to say the following:

> Everything I have ever known or seen as an ag student has been based on this, both as a high school student and when I got to college and started

building lesson plans. I was trained to do it this way. I did this as a high school student. I did it through college. I did it when I student taught. I do it now.

Allison traced her experiences back to her time as a high school student, particularly greenhouse related content, which is a primary focus of her current agriculture program. James, who had been in the classroom the longest at 28 years, also still reflected on his experiences as a high school student. “To be honest with you, I don’t know how I remember this, but I know some of the things we are talking about in plant science that I teach my kids, my ag teacher taught the same way.” He followed up with this comment, “I tend to think that I teach like my ag teacher taught.”

High school was also the time many of the participants developed their passion for plant science content. Jane discussed how a high school greenhouse management class she took as a student and participation on the floriculture career development team contributed to her interest in plant science. She stated, “I was on the floriculture team actually three different years because in the [district] we never made it. So I really found a passion for the floriculture contest by learning plants.” This passion for content contributed to the participants’ motivation to seek new knowledge and new methods of teaching that knowledge in the classroom. Clint discussed, during a classroom observation, that it was easier to seek out knowledge about content when he had personal interest in that content, like he did with the plant sciences.

When the participants reflected on what they gained from their high school agriculture classes it wasn’t always simply content knowledge, for example, knowledge about the concept of photosynthesis. Instead, it was also effective ways to teach photosynthesis in the classroom or recalling confusion when learning about photosynthesis as a student themselves. This phenomenon occurred within college classes, as well. Allison described her experience:

> I had two professors that I just thought were amazing professors in terms of the way they taught things. In fact, I use some of them. Like when I teach taxonomy. He [professor] made students pull shoes off in a college class and then we were taxonomists with the shoes. I do that too.

Allison went on to say, "I think part of it is I had some really great professors so I was able to see how they taught it and I understand what I liked and what helped me as a student." Allison was prepared at an out of state university different than the majority of the other participants in the study. The biggest difference that she surfaced between her teacher preparation university and her fellow agriculture teachers' preparation in Missouri was the requirement of an emphasis area for her agriculture degree program. This meant she had to pick an area of agriculture to focus on during college (i.e. plant science, animal science, or agricultural mechanics).

Involvement in agriculture industry and previous job experiences.

Another type of experience that shaped the participants' PCK was involvement in the agriculture industry or previous job experiences in the plant sciences. Some participants had production experience on a farm related to plant sciences like Clint. Some participants had job experience at a floral shop or greenhouse like Kelly and Dawn. These experiences could occur before high school; however, the experiences that resonated most with the participants and had a lasting effect on their PCK did not typically occur prior to high school.

Clint had been involved in a livestock and forage operation for his entire life growing up on a farm. He directly connected that experience with his current PCK. “That background knowledge that I have provides opportunities to tell students and relate to students, when you’re on the farm this is what it’s like type scenarios.” Specific job experiences in plant science were more common amongst participants. Kelly mentioned working in a flower shop throughout high school and then a garden department throughout college. Clint also mentioned working for [farm] during his time in college and how that contributed to his knowledge for teaching plant science. Dawn had one of the most profound business experiences that occurred within plant science:

> I’ve actually been owner, and now my dad owns it, of a fruit and vegetable business since 1995. We’ve been raising plants, cut flowers, fruits and vegetables and selling them directly to consumers at farmer’s markets. If I wasn’t teaching ag I’d probably be owning my own horticulture business or working in the horticulture industry.

Dawn and Kelly both had agricultural literacy as one of their primary views about the purpose of agricultural education. Clint held a student individualization view about the purpose of agricultural education, which also included an agricultural literacy component. It is possible the participants’ experiences in industry contributed to their belief that it was important to inform their students about the agriculture industry as a whole and create literate consumers of agriculture.

Teacher preparation experiences.

Teacher preparation experiences in college were comprised of content specific courses, agricultural education specific courses, and the most influential teacher preparation experience- student teaching. Multiple participants who attended the same university mentioned a specific professor who assisted with their PCK development. Clint even served as a teaching assistant for this professor to further develop his knowledge about home horticulture, an area in which he did not have a previous background within the plant sciences. Allison mentioned the PowerPoints she currently used in her plant science classes were developed utilizing some of her college material. Dawn also described specific college courses she still utilized resources from in her classroom, including pictures of plants for the identification unit I observed her teach.

Clint discussed how his own high school agriculture teacher served as a mentor in guiding his college course selection, and how that had a profound influence on his ability to teach plant science. “I minored in plant science. When I say minored in plant science, I made sure that the plant science I learned wasn’t plant science I was familiar with. That would be my suggestion to them.” This quote demonstrated how one experience (mentor influence) can influence beliefs (I need to work on what I am weakest in and it is my role as a teacher to seek out new knowledge) and can influence other experiences such as the college classes taken and the amount of attention participant gave to the content.

While all of the participants were required to take some plant science content courses for their agricultural education degrees, some of the participants took it a step further and received a minor or double major in plant science. Dawn and Ashley double majored in plant science and agricultural education. Kelly, Allison, and Clint minored in plant science. Allison connected her more extensive plant science content background with her ability to interpret resources. She stated, “I think my background has helped me. I can understand the text because sometimes if you don’t have a background you are not going to understand.”

The student teaching experience was the single most impactful teacher preparation experience of the participants. Student teaching was the time when the participants were able to take their budding PCK and put it into practice in the classroom with real students. At this juncture in their college careers, the participants were also better equipped to effectively analyze and interpret their cooperating teachers’ actions, adding to their content knowledge and PCK. Cora discussed the influence her cooperating teacher had on her PCK in the plant sciences. “He just taught me the little things of doing this and hands-on activities. I’m like that was so much fun. I could take kids and go out of the classroom.” How the participants were exposed to plant science teaching initially, whether that was high school, college, or student teaching, seemed to have a lasting influence on how the participants taught in their own classrooms.

Allison described how her student teaching site was focused on horticulture and that is where she gained some of her valuable horticulture teaching skills. Allison’s student teaching experience was such a powerful shaper of her PCK she wished to pass that knowledge onto her own student teachers:

> What I do with the students teachers I have, when we actually do something in the greenhouse, the first class that does it I teach the class

> and my student teachers watches. This is what she [my cooperating teacher] did with me. Then the student teacher of the next class that's doing it would teach it. If I only have one greenhouse class, I will probably teach them after school how to do it and then have them teach it.

Cora described how teacher preparation did not give her enough plant science knowledge to make meaningful lessons. When I asked her what she would recommend a new teacher teaching plant science do she replied. "I guess if they're doing specifically a plant science class I hope they've gotten some background in the university other than just the required six or nine hours."

Summary: Experiences prior to inservice's connection with teachers' pedagogical content knowledge.

Many of the participants' experiences prior to inservice directly influenced the participants' PCK in the plant sciences. One participant in particular, Clint, was able to express throughout his interviews the direct connections between those experiences and his knowledge development. While many of the participants shared similar experiences, the majority of the direct quotes are provided by Clint because he was better able to articulate how those experiences influenced his PCK. Clint stated:

> When I think back to not only high school but also college, I think back to how I learned best under what teachers. I can name them off to you. What is it those teachers did in that class that made it easy for me to learn then? If I model that to these students, and then check for success obviously, then their chances of having success I guess are much higher.

This quote from Clint surfaced a connection between his experiences with learning content and how those experiences influenced his beliefs about learning. Then he discussed how those beliefs subsequently influenced the type of instructional methods and knowledge he sought from other sources. Clint also connected his experiences in the classroom with assessment through his comment on assessing to see if learning occurred. Clint provided justification for relying heavily on his high school experiences. “I believe the way I learned in high school, or still learn, is not much different than the way these students are learning….. I was a run of the mill average student.” Since Clint considered himself the “average” student, he felt the way he learned best was also the way his students learned best. Consequently, he felt a need to develop strategies to teach content in that way.

When Clint discussed with me the best ways students learn and how he decided what method to utilize when teaching certain content, he kept referring back to the principles of teaching and learning card that he was given during his teacher preparation experience in college. He said, “What do I use as my basis for that? Right here- principles of teaching and learning. It works, it really works.” This comment from Clint directly connected his experiences in college with his PCK development, specifically his development in the area of knowledge of content combined with knowledge of his students and knowledge of content combined with knowledge of instructional strategies.

Experiences prior to inservice, particularly teacher preparation, did not always have the influence on PCK the participants expected. For example, my first question in my pre-observation interview with Cora was, “Tell me a little bit about your background as a plant science teacher." Cora's answer to this question took an unexpected turn when she voiced her lack of preparation in the plant sciences after college:

> When you come out as an ag teacher you feel overwhelmed in that you have so many different areas you have to teach, you have not been able to specialize. So yes I had a crop science, yes I had a horticulture class, and I had soils. But really that was it. Along with what I learned in high school which do you really-I hate to say that as a high school teacher, but basically you're reviewing that in college and building a little bit on it. There wasn't really a lot of depth of knowledge that I learned.

This quote from Cora acknowledged that while experiences prior to inservice could influence participants' PCK, they may not always have the influence teacher preparation programs expect. This could have interesting implications for the role of experiences prior to inservice on future agriculture teacher PCK development.

Experiences During Inservice

Experiences during inservice also influenced participants' PCK in the plant sciences and were heavily influenced by the context of the agriculture in the community and the specific school setting. Specifically, experiences in the classroom emerged as the primary experience that influenced PCK during inservice. Professional development experiences, including structured workshops and unstructured consultation of experts and personal research, also emerged as experiences that shaped the participants' PCK.

Classroom experiences.

All of the participants indicated changes to the way they presented, assessed, sequenced, and adapted content for students' understanding based on their own classroom experiences during inservice teaching. This was evident in the interviews, journal reflections, and even through live observations. Sometimes the participants focused on discussing past experiences and sometimes we discussed experiences that had just occurred in the unit I observed. Dawn described how classroom experiences influenced her PCK:

> It's just more of a learning experience seeing what students can accomplish in previous years or in previous lessons and then adding some tips and tricks, like some of the identification factors, or some things that students have said in the past that's helped them. And I try to integrate those.

Classroom experiences had a substantial influence on participants' knowledge of student misconceptions. This type of PCK was revealed primarily in classroom observations and post-observation interviews. Participants had a difficult time recalling student misconceptions in the pre-observation interviews, but were better able to identify them in the post-observation interviews. Classroom experiences also influenced the participants' abilities to anticipate student difficulties. In a journal reflection, James addressed how he adapted his methods to address student difficulties with content he had observed in his classroom. "Students always seem to have trouble with the steps of germination and emergence. I use handouts and pictures to take them step-by-step through the process."

Many of the participants commented that trial and error experiences in the classroom were a common way they developed PCK. Clint stated, "Some of what I have done is trial and error. As I have progressed as a teacher I'm able to look back and say, that worked or that would have worked better if I would have done this." It is important to note that reflection, which was included in beliefs about teaching and learning in agricultural education, was an important component influencing these types of experiences. A specific example of trial and error I observed in Kelly's classroom involved her switching the sequencing of her content on floriculture arrangements in her floral industry unit. When I asked Kelly why she re-ordered the sequence, she commented that after seeing the confusion from her students she adjusted the sequence for future years.

Professional development experiences.

Professional development experiences for the participants were not limited to inservice, and certainly occurred during teacher preparation and student teaching. However, when the participants discussed professional development that influenced their current PCK, they almost always referred to professional development completed during their time inservice. All of the participants in the study indicated participation in some professional development during their time in the field.

Jane, Kelly, James, and Dawn all mentioned summer conference workshop opportunities in the plant sciences. Ashley, Cora, and Clint all mentioned a short course at the [University] that was beneficial for developing greenhouse knowledge. Dawn expressed the rationale for the focus on professional development related to greenhouses in Missouri. She stated, “Most of our professional development focuses on greenhouses. It’s an expensive part and most people don’t know how to run it.” As previously stated, James mentioned a workshop on photosynthesis and respiration that occurred during my unit observation window. In response to follow up questions, he mentioned there were many new strategies he learned as a result of this professional development experience that he hoped to try next year in the classroom. This, again, related to the belief the role of the teacher was to be a lifelong learner and reflect on practice. James still attended professional development, despite the fact it is common knowledge in his school and community that he would retire in just a few years.

Dawn, who had a tremendous amount of greenhouse experience with her double major in plant science and business background, expressed a need for more professional development surrounding landscape, turf grass management, and other plant science topics that are not specifically greenhouse related. Allison and Dawn both expressed a strong desire to be DuPont agriscience ambassadors soon in their careers to expand their technical plant science knowledge. Due to the varied backgrounds in plant science content, it appeared formal professional development workshops and classes were not meeting the needs of some of the more advanced participants. Ashley mentioned traveling on her own as a way to develop new knowledge:

> I think about the experiences that I’ve had and the travels that I’ve done. Even when we go on our summer vacations my husband and I like the agricultural part of it and doing coffee plant tours and chocolate places. I

> think when I can learn something from those I can bring it back in and apply it directly to whatever lesson.

This quote from Ashley also tied back into the desire many of the participants had for real life examples and application. Professional development experiences of individual participants were truly tied back to their integrated belief systems.

Clint and Cora both emphasized the importance of seeking out good professional development for new teachers to build PCK. Clint specifically explored the de-emphasis on content specific professional development:

> The other thing would be to attend professional development on content. Often as teachers we think professional development; the first thing that we think of is how to be a better teacher. Let's go listen to Harry Wong. There is nothing wrong with turning in professional development to go to the state grazing conference. That is good professional development if you need to better yourself in the grazing field.

A common reason Clint surfaced that many agriculture teacher do not engage in professional development was teachers not wanting to leave their students during the regular school day. Clint stated he believed, "bettering yourself as a teacher" was more important than being gone from the classroom for a day or two. When scheduling my unit observations, I had to work around many participants' schedules that included fall professional development outside of their respective school districts, demonstrating how often the experienced teachers in this study engaged in professional development.

However, there are contextual factors that influenced the type and length of professional development for a given participant. One of the participants described how their former school district discouraged content specific professional development. Other school districts had different requirements on the quantity of professional development hours a teacher could take during a regular school year. Funding was also another contextual influencer that influenced professional development. Some school districts were willing to pay for more professional development than other school districts. Seeking out professional development on the part of the participant again returned to beliefs about a teacher being a lifelong learner and reflector. This belief gave many participants drive to seek out additional PCK development opportunities.

As a direct consequence of the information age, personal research experiences could not be discounted in shaping participants' PCK. Dawn stated, "A lot of times, I look for ideas. Like the Jenga review I am using for this unit. I found it on Pinterest." Most of these types of experiences were not exclusively plant science related. When asked, the participants either said yes they were already referring to all agriculture areas with their statements or they weren't but they agreed that they employ those same strategies in other agriculture content areas. When she is uncertain about how to teach in a given area, Allison employed this tactic, "If it's an area I don't know as much, I'll call people. I'll do research on my own." Cora mentioned utilizing her advisory council and director at her area career center for PCK development. Clint also discussed contacting experts for new content information. He identified multiple research scientists at land grand universities he had obtained information from related to plant science, specifically forages. He also displayed numerous professional journals that he used for content references during my classroom observations. Finally, Clint mentioned reading industry publications in a journal reflection.

Summary: Experiences during inservice's connection with teachers' pedagogical content knowledge.

Experiences in the classroom directly influenced participants' PCK. Specifically, classroom experiences developed knowledge about student misconceptions with the content and ways to present material to counteract student misconceptions. In a journal reflection, Dawn described how her classroom experiences with student misconceptions altered her teaching strategies for approaching that content:

> Students were having a difficult time understanding basic plant science concepts and plant parts. The 2nd day of the lesson, I brought in cuttings so students would have visual representations of the various plant parts such as a petiole, leaf surface textures, buds, internodes, etc.

Experiences in the classroom directly related to the participants' knowledge of content and students. Many of the participants described the use of visual examples and real life applications as effective ways to teach agriculture content. Dawn said, "I try to make analogies which would relate specifically to students' home situations or items they can relate to outside of the school setting." Experiences in the classroom learning about students were necessary for the participants to be able to apply the content to their specific students' lives. Because students can enroll in agriculture courses for multiple years, agriculture teachers may have more of an opportunity to get to know their students than other education disciplines.

An important influence of experiences on PCK development is simply the experience of teaching the content. Cora described how she sequenced the content for her greenhouse class, and why she sequenced the content in that particular way. When I asked where she developed the knowledge to complete this task, she replied with experience. “It’s just kind of an experience. I didn’t teach that and I had to go back and reteach that. So sometimes it really is just experience. I know that’s not what you want to hear.” Specifically, when it came to knowledge of sequencing curriculum, multiple participants expressed their related knowledge came either from a set curriculum source like IML, experiences in the classroom, or a combination of the two.

Professional development experiences also directly influenced participants’ PCK. Cora illustrated just how important a course on managing a greenhouse and engaging with experts in the content was on her plant science PCK:

> I knew that I was going to get a greenhouse and so I made sure to sign up that summer to take that class. And I had a lot of really great mentors I could go to and ask questions. If I had not had that, where they literally walked me thorough, here is what you do, here is how you mix your soil, and I would have been lost. I would have been absolutely lost when I went to teach it.

Cora went on to describe how she utilized experts to help her gain the necessary PCK to teach students how to raise poinsettias.

> I walked in and I had 500 poinsettias that were going to arrive in a month and a half when I got this job. I’d never raised poinsettias in my life. I was

> scared to death. Luckily the teacher came back. He retired and lived in the community and was able to come back and walk me through it.

It is important to point out while Cora had the advantage of having the former agriculture teacher still available in her community, many teachers may have to look farther for sources of PCK development when they being their teaching careers.

Professional development for mid-career teachers was also a concern of participants. Dawn, Kelly, and Allison all mentioned a desire for professional development that focused on teachers with over 5 years' experience. Allison commented, "I don't typically go to professional development for greenhouse or things like that because most of the time it's lower than what I need." The point in time that the participant learned the content in their career was another contextual component that influenced participants' PCK. Cora reflected on her experiences taking a greenhouse class as a beginning teacher. "I wish I had time to go though as a refresher because there are so many things now that I took away as a beginning teacher that would be totally different from what I would take away now." She went on to postulate separate courses, one for beginners and one for experienced teachers for future professional development.

Overall Summary: Experiences and Their Connection to the Substantive Theory

Experiences prior to inservice and experiences during inservice both shaped the participants' PCK in the plant sciences. Experiences prior to inservice influenced the participants' PCK primarily during high school introduction to plant science content and during teacher preparation in college. Within teacher preparation, the most impactful experienced was student teaching. Some of the participants had experiences prior to inservice in the agriculture industry that also influenced their PCK. Experiences during inservice also shaped the participants' PCK and influenced the participants' integrated belief systems. The context of the agriculture and school for each participant had a substantial influence on their experiences during inservice.

Contextual Influencers

Context is the third and final theme that influenced the shaping of participants' PCK. All of the participants' experiences and beliefs were influenced in some way by the context the participants were in at the time. The influence of the context is threaded throughout and elaborated on within the previous two themes- beliefs and experiences. This section was focused more specifically on how context directly influenced participants' PCK. The context varied for each participant, but there were many similarities. Some of the contextual influencers were specific to agricultural education and some were general contextual influencers of the school.

Community Context

The most emergent contextual influencer specific to agricultural education was the role of the community. Because agriculture can change from community to community and because the needs of communities can differ (Talbert et al., 2005), there were varying degrees of influence on participants' PCK. The type of agriculture in the community (i.e. forages production or local greenhouses) was an important contextual influencer. Clint summarized its influence, "To be successful I believe you have to have a needs assessment, know what the needs of this community are agriculturally, and that's what you teach." He then described how his areas of interest within agriculture are not his primary reasons for selecting important content to teach his students:

> It depends on your community. If I had a big strength and love for corn production and I spent let's say a month and a half on corn production I'm doing a disservice to my kids. Do they need to know about corn production? Sure they do. Do we need to spend a month and a half on it? No.

Allison and Dawn mentioned their advisory councils, which are bodies of community stakeholders that meet periodically and advise the local agriculture teacher(s) and department (Talbert et al., 2005). These councils can also influence the PCK a teacher develops because of their potential direct influence on the agriculture program. Sometimes the community had specific expectations. Clint who had a substantial community influence on his program said, "Parents, alumni, community members, ag community, they expect students to leave this program knowing about forages." This attention to the livelihood of the community altered the quantity, quality, and depth of PCK participants developed for a topic area.

Often, the community was a central pillar of support for local agriculture programs. This was evidenced through monetary support and resources. Clint recommended new agriculture teachers find out who the agriculture leaders are in their community and make friends with them early on in their induction to the community. Cora mentioned a recent out of state tour of an agriculture department she attended that was 85% locally funded. “But its local based. So it’s what does their industry need? They’re filling that local need. But isn’t that awesome too because your kid can get a job right out of school.” Also, utilization of the school greenhouse was largely dictated by agriculture community influence, and to a lesser degree school influence. Dawn stated, “The plants we select for the spring sale are determined by the community. With multiple greenhouses in town I don’t want to compete with them, but I also want to make available the plants that community members will purchase.” Growing different plants in the school greenhouse and teaching students how to grow various plants in the greenhouse influenced participants to expand their CK and PCK.

IML Curriculum Context

The next agriculture specific contextual influencer was the type of curriculum the participants were exposed to, in particular the IML curriculum which was described in previous sections. James and Jane in particular utilized IML curriculum heavily. IML curriculum began each section with objectives and study questions. I observed James and Jane utilize this format to present information to their students and they covered much of the content in the IML curriculum verbatim. They utilized worksheets and tests from the IML curriculum package as evidenced from their lesson artifacts. The order of the content in the unit I observed for Jane and James was also laid out in the same order in the IML curriculum.

Dawn, Clint, Kelly, Allison, and Cora all also utilized IML curriculum but with their own additions and adaptations. For example, I observed Allison go from a PowerPoint, based on IML curriculum content, to a PowerPoint from another resource during my second teaching observation on plant reproduction. In Dawn's classroom, I asked her if her handouts were from IML and she told me that while she used some objectives and content from the IML curriculum, she created the majority of her handouts herself. She said, "Sometimes I'll use the handouts and then other times I don't like what they have in there, I don't think it's complete enough, then I'll make my own." Ashley utilized IML curriculum the least of all the participants and instead let her plant science curriculum be guided by an agricultural science text.

Many of the participants trusted and relied on IML curriculum. Jane said she was encouraged to use IML curriculum in her teacher preparation program. When I asked James why he used IML curriculum he replied, "Because it's what we grew up with and it works really well. I love the problem-solving approach. I have not wavered from that because it still works." Kelly stated she used IML curriculum more as a younger teacher and over time had developed more of her own curriculum by compiling various resources. Despite relying heavily on IML curriculum in her classroom, Jane told me she felt the plant science IML curriculum was outdated. Clint also acknowledged that yes some of the facts were outdated, but also pointed out some of the information is still relevant to his students.

Allison recognized the pitfalls of using one curriculum resource, "Teachers who use strictly IML, I'll even go as far as to say strictly just one text, are going to give the basics that the students need but it is all going to come from one perspective." Even Clint who was a moderate user of IML curriculum acknowledged it could not be the only curriculum resource, "Do I think that a teacher can be successful teaching just IML in today's ag room? No I don't. Is IML bad? No, I don't believe that either." Jane, the participant who utilized IML curriculum the most, relied on IML for sequence, presentation, and inclusion of content. When I asked Jane if there were any concepts she wasn't going to elaborate on for her unit, she told me she was going to include all of the concepts in the IML curriculum plant processes unit. It is possible relying more on IML, or any curriculum package, could limit a teachers' PCK, particularly in the area of knowledge of content combined with knowledge of curriculum.

Overall, IML curriculum shaped participants' PCK regarding knowledge of content and curriculum, specifically depth, sequence, delivery, and choice of content. Clint commented on the sequencing of content in the IML curriculum and how he appreciated the ordering of the concepts. Cora utilized IML curriculum as an indicator of what content was important to teach because she trusted the IML curriculum. During the post-observation interview, I asked Clint what he would have used as a curriculum resource if IML curriculum had not existed. He replied, "That's a good question. I don't know. Since I have been in this business and even since I was a student here it has been IML."

Career Development Events Context

The final contextual influencer specifically related to agriculture is the structure of career development events through FFA as an intra-curricular part of agricultural education. The participants varied in the amount of influence career development events had on their PCK. James acknowledged the influence of career development events on his knowledge. He said, "I would say CDE's [career development events] play a significant role as the objectives for many CDE's are the same as major parts of my classes." Many of the participants also chose the students to compete in career development events from their classes and utilized teaching the contest as a way to get students engaged in learning the content. Clint claimed, "One of the best recruiting tools to get students on that grasslands team is learning about it in class. It peaks their interest then they want to be on the contest team." Dawn also described how she chose her official contest teams from her greenhouse classes. It is not uncommon for teachers in Missouri to teach IML curriculum content combined with a career development event competition related to that content or even hold a mock career development event competition to apply knowledge learned in the classroom.

In many ways, career development events were a part of the curriculum for Missouri teachers. However, some participants chose to focus on a career development event in its entirety like Jane with floriculture and some participants chose to break up the competitive event across multiple units like Allison with the same floriculture competition. Allison described the role of career development events in her classroom:

> I use the floriculture tool and plant ID list to determine what our state considers the most important for the industry and those are what the students have to id. Otherwise, I do not let it influence what I chose to cover in class and if it is something they might see on a CDE test/TSA I will mention that in passing.

Career development events for Missouri agriculture teachers involved more than just FFA involvement and application of curriculum. In Missouri, career development events results of students determined funding for agriculture programs. This assessment method and emphasis on career development events contributed to the type of knowledge participants developed because many felt the need to teach the test. Dawn stated, "I make sure to teach the main components of the floriculture CDE [career development event] since students will have to test for MOASK and IRCS." Some participants, like James, also expressed a pressure to prepare students for end of course exams. This could also potentially limit the PCK development of agriculture teachers if they felt pressure to teach using certain methods to better prepare students for the various tests.

Type of School and Department Context

Being in a multi-teacher or single teacher department was another contextual component influencing PCK. Dawn said, "If you're a single teacher, you need to be broad-ranged. For me, I knew I wanted to teach in a multi-teacher and I knew that's where my interest areas were so it made it a lot easier to specialize." It is interesting to note that all of the participants in the study who were purposefully selected because they demonstrated strong PCK in plant sciences were all located in multi-teacher programs and had the opportunity for the majority of their careers to specialize in plant sciences. Related to the type of department was the type of school. Participants who emphasized content or skills based professional development were all based at area career centers. This setting also influenced the participants' views about agriculture education.

Resource Availability Context

Facilities and monetary resources influenced participants' abilities to seek out professional development opportunities and invest in supplies for their classroom. CASE, another agriculture curriculum mentioned previously, had a cost attached to preparation and implementation. Dawn expressed cost and limited resources were barriers to her pursuing this type of curriculum, which focuses on science applications of agriculture. “Even if I got a grant to go, my school district doesn’t have money for enhancements and stuff. We don’t have a lot of matching funds and it you look around my classroom it’s not suited well-enough for labs.” Cora described a recent activity she conducted in her class, “It was a quick hands-on activity. They learned it, they were able to do it, and it didn’t take a lot of time. But sometimes you don’t have that. Sometimes it takes a lot of money and supplies.”

If participants were operating under a constricted budget this influenced the type of activities they did in their classroom, which also limited their PCK for various teaching methods in plant science.

Technology was another contextual influencer in the school directly tied to resources and funds. I saw technology utilized in multiple classrooms during multiple classroom observations. Ashley used class computers for testing before a final exam for her plant science unit, Allison used class computers to do an internet scavenger hunt for her plant reproduction unit, and Clint was piloting a Google classroom. Despite piloting a Google classroom, Clint cautioned that teachers can rely too much on technology. He described this dilemma when we discussed other strategies he could have utilized in his teaching during the post observation interview:

> Let’s be honest 30-40 years ago you didn’t have pictures, you didn’t have the internet, and Google images. If I was going to show you a baler we would go look at it. Please don’t get me wrong I’m not downing

technology, it’s wonderful, but I still think we miss some of that real life hands-on stuff with it.

Overall Summary: Contextual Influencers and their Connection to the Substantive Theory

Overall, contextual influencers in agriculture and general education had an important role in shaping the PCK of the participants directly because teachers are always operating within a given context. Some of the agriculture specific influencers are common in agricultural education but have not yet been explored in relation to PCK. Even more impactful was the influence of context on PCK through integrated belief systems and experiences, specifically experiences during inservice. The theme of context was an important component to the overall substantive theory behind what shapes experienced agriculture teachers’ PCK in the plant sciences.

Substantive Theory

Based on the three main themes (beliefs, experiences, and context) a theory was developed to describe what shapes experienced agriculture teachers’ PCK in the plant sciences. See Figure 4.4 for a depiction of the connections between those three themes and their influence on participants’ PCK.

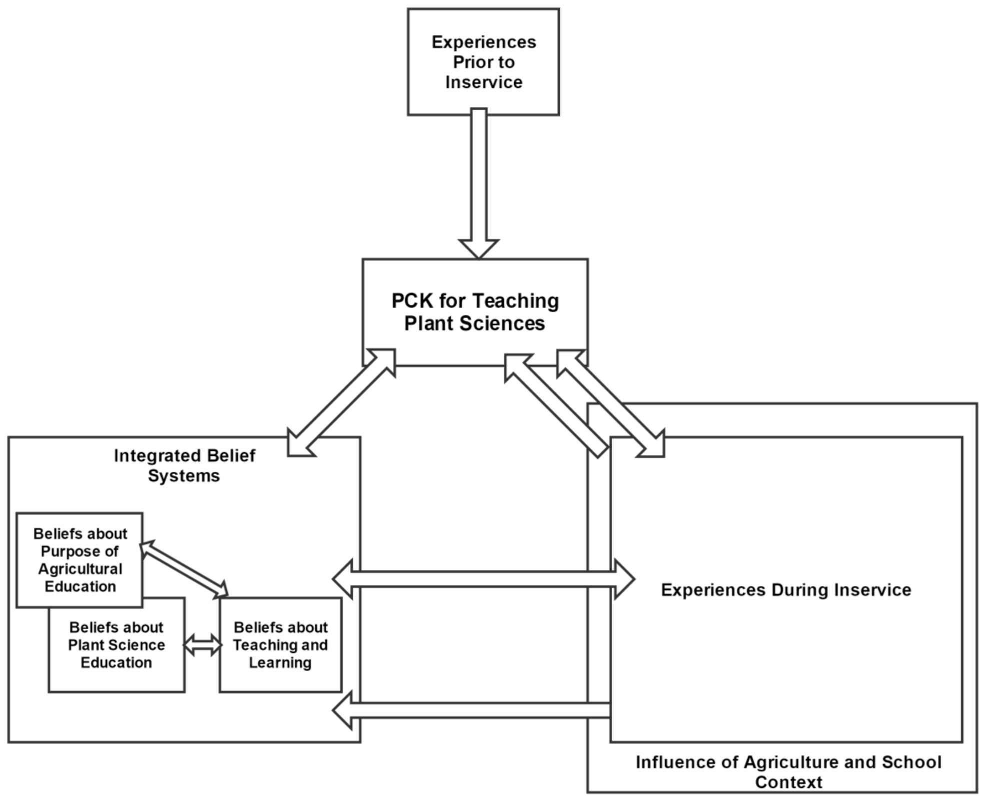

Figure 4.4 Substantive Theory behind what is Shaping Experienced Agriculture Teachers' PCK in the Plant Sciences

Within this substantive theory, all three themes influenced PCK directly in a variety of ways. Additionally, experiences can alter beliefs, beliefs can determine experiences, and teachers are always developing new knowledge for teaching within a context. Development of PCK occurs during a teachers' entire life. The first experiences participants surfaced as having a profound influence on shaping their PCK began with their high school agriculture classes, with the exception of participants who grew up on a production farming operation. These experiences prior to inservice directly influenced PCK. Experiences during inservice were more heavily influenced by context and had linkages with the integrated belief system. Contextual influencers unique to agricultural education such as IML curriculum and the community context were a critical part of this overall model because they influenced the other components. Finally, the integrated belief system was the most emergent phenomenon in the overall theory with the beliefs about plant science education and beliefs about teaching and learning in agricultural education mirroring beliefs about the purpose of agricultural education. This theory behind what is shaping experienced agriculture teachers' PCK in the plant sciences could be useful information for teacher preparation programs and professional development initiatives.

CHAPTER 5: DISCUSSION

The substantive theory developed from this study depicted PCK as a continuously evolving fluid knowledge base throughout a teachers' career. This echoes findings from previous studies in other education disciplines that describe PCK as an ongoing cyclical process (Hashweh, 2005; Lee, 2011). The three main themes involved in the PCK shaping process that emerged from this study (integrated belief systems, experiences, and context) have been included in various PCK studies and models; however, there has been a lack of depth when examining these shapers of PCK (Friedrichsen et al., 2010).

In previous research, particularly in the field of science education, the concept of orientations is primarily utilized to describe what is shaping teachers' PCK. Magnusson et al. (1999) discussed nine orientations for science teachers and included these orientations to teaching as shaping all of the other components of PCK in their model such as knowledge of instructional strategies, knowledge of science curricula, knowledge of assessment of scientific literacy, and knowledge of students' understanding of science. Since the Magnusson et al. (1999) model became popularly utilized in science PCK research, many researchers have adopted their definition of orientations and often use the same nine orientations Magnusson et al. (1999) originally proposed (Aydin et al. 2014; Friedrichsen & Dana, 2005; Kapyla et al., 2009; Lee, 2011; Padilla & Van Driel, 2011; among others). However, there are many issues surrounding the concept of orientations in PCK literature surfaced by Friedrichsen et al. (2010) including: various definitions and meanings behind the word orientations, weak or non-existent relationships between orientations and the rest of the PCK model, researchers simply assigning teacher orientations, and researchers simply not addressing this proposed component of PCK.

The utilization of grounded theory methodology for this study allowed what was shaping the participants' PCK to emerge from the data. The belief systems theme was the most emergent component, and fits many of the characteristics of orientations described by Friedrichsen et al. (2010) including: beliefs about the purpose and goals of science teaching, nature of science, and science teaching and learning. It also aligns with the goals and purposes language utilized in the Magnusson et al. (1999) model. Because, of the controversy surrounding the nature of orientations, its specific use in science education, and the tendency for researchers go back to the nine original orientation descriptions for science teachers without exploring them further, I decided to simply call them integrated belief systems. By exploring how integrated belief systems shaped PCK and not pigeonholing participants into one of nine categories, I was able to explore the concept in more depth.

Prior to Magnusson et al. (1999), other researchers such as Grossman (1990) described orientations as concepts of purposes for teaching subjects that included knowledge and beliefs. The concept of beliefs first postulated by Grossman (1990) more closely fits the belief systems theme that emerged from this study. The integrated belief systems that included beliefs about the purpose of agricultural education, beliefs about plant science education, and beliefs about teaching and learning in agricultural education, were similar to the characteristics of orientations explored by Friedrichsen et al. (2010), but were not limited to nine orientations. Other researchers have explored shapers of PCK that were not limited to the term orientations, including beliefs and epistemologies or included beliefs in their model of PCK (Gess-Newsome & Carlson, 2014; Hashweh, 2005; Luft & Roehrig, 2007).

Beyond simply identifying the beliefs of the participants, I explored the influence of these beliefs on the participants' PCK. Friedrichsen et al. (2010) discussed that there were often weak or nonexistent connections between orientations and PCK in the literature. While the themes beliefs, experiences, and context influencing PCK are not new concepts in PCK literature, the specific beliefs within the integrated belief systems and how they influenced PCK was in need of further research. By focusing on what shaped PCK, I was able to tease out specific beliefs and look at the impact of context and experiences on those beliefs. Often, the concept of beliefs or orientations is described in a vacuum without describing in what ways it influenced participants' PCK.

If PCK is truly person specific (Van Driel & Berry, 2012), then it makes sense that the individual belief systems of a person would have a key role in shaping their PCK. In fact, Veal (2004) postulated that to develop PCK sometimes our beliefs about education have to change. These various beliefs led to different types of PCK development in participants and different approaches in the classroom. One of the most emergent beliefs in this study was the purpose of agricultural education. The debate over the purpose of agricultural education is not new (Roberts & Ball, 2009), and many of the participants described changing their purposes over time. However, instead of simply labeling participants as agricultural literacy focused or career preparatory skills focused, I explored the purposes of agricultural education more in-depth. The participants in this study held multiple views for the purpose of agricultural education (career preparation, college preparation, agricultural literacy, practical life skills, and individualization) that often complimented one another. These primary and secondary purposes of agricultural education are similar to central and peripheral goals of science education surfaced by Friedrichsen and Dana (2005).

Beliefs about the purpose of agricultural education influenced the following in the participants: how much they knew, how much they felt they needed to know, what they decided to teach, and how they decided to teach it. Beliefs emerged as one of the most influential components shaping the participants' PCK. However, it is uncertain if holding multiple views about the purpose of agricultural education creates well-rounded teachers who can reach a variety of students, or if it limits the PCK development of a teacher because their purposes are split across multiple views. Future agricultural education research should further explore the impact of multiple views about the purpose of agriculture education on PCK development, specifically examining beginning teachers who are still in the early stages of PCK development (Schneider & Plasman, 2011).

Participants' views about the purpose of agricultural were focused on what their students would do with the knowledge gained. This focus on students pervaded data from every participant as they relied on their knowledge of content combined with their knowledge of students to make the majority of teaching decisions (Hill et al., 2008). Agriculture teachers are in the rare position of getting to know the majority of their students over the course of multiple years because of the nature of agriculture programs. Additionally, FFA activities outside of the classroom and visits to the home or workplace for SAE's can contribute to agriculture teachers' knowledge of their students' interests and goals upon graduation.

All of the participants believed that agricultural literacy was a purpose of agricultural education, either as primary or secondary view. This finding is similar to a previous study of preservice agriculture teachers where all of the participants expressed that their primary goal of agricultural education when they entered the classroom was agricultural literacy (Rice & Kitchel, 2013). This suggests that this view begins at least at the preservice level, if not earlier, which is consistent with a study from Kapyla et al. (2009) that found student teachers orientations to teaching were connected to their backgrounds in education. The belief that agricultural literacy is an important purpose of agricultural education could be a reflection of the current state of the agriculture industry with various groups opposing agriculture practices and the prevalence of social media in expressing opinions about current issues. For example, recently in the state of Missouri, the Keep Missouri Farming Amendment was proposed and passed (Missouri Farm Bureau, 2015). This type of legislation was voted on by all Missouri citizens and was surrounded by multiple viewpoints, demonstrating a potential need for general agricultural literacy in schools.

Agricultural literacy, for many participants, was described as a responsibility. However, when agricultural literacy education was first explored as a purpose by the teacher education in agriculture, the vision was focused on education separate from the regular agriculture classroom, specifically targeting elementary age audiences through FFA programs like Food for America (Talbert et al., 2005). Some of the participants discussed that they taught with an agricultural literacy purpose more often in their introductory level classes. This could be because teachers see literacy as a foundation for agricultural education. With more and more students entering agricultural education classes without agriculture backgrounds (National FFA, 2015); the need to begin at a basic level with agricultural education may be increasing in importance. If agriculture teachers have to begin at the literacy level to meet their students where they are currently at, in terms of agriculture knowledge, we may not be able to expect students to gain knowledge beyond agricultural literacy within the typical four years of an agriculture program. Many of the teachers expressed they taught agricultural literacy because it fit their student audience and their needs after high school. Jane said it was rare for her students to get a degree in agriculture, so she focused on literacy. However, are her students not pursing agriculture degrees *because* she is teaching literacy over skills or is it simply *why* she is teaching literacy over skills?

Another concern about an agricultural literacy focus is that the content may be too shallow. When asked for their definitions of agricultural literacy, participants used words such as basic knowledge of agriculture, informed consumers, and voters. Similarly, the National Council for Agricultural Education (2009) described agricultural literacy as a vision for agricultural education that included all people valuing and understanding agriculture. This raises the question, how much do teachers actually need to know (both content knowledge and PCK) to teach with an agricultural literacy focus? There are more opportunities to pursue science-related careers in agriculture than ever before with 74% of agriculture jobs expected in the science and business sectors by the end 2015 (United States Bureau of Labor Statistics, 2011). If part of the need for literacy is to appeal to current student needs, it may be beneficial for agriculture programs to focus more on science integration or science related careers.

Some of the participants expressed that they thought agricultural education was an applied science and that dictated their limited science integration. However, it is possible that agricultural literacy is more appealing to students, and the reality is the vitality of agriculture programs is reliant on student enrollment because of the elective nature of the majority of agricultural education classes (Talbert et al., 2005). Agricultural literacy was also the only one of the five views that explicitly extended beyond what the student needed and delved into taking information directly back into the community. Further examination on agricultural literacy as a primary purpose of agricultural education is needed, in particular an examination of the content rigor and the use of agricultural literacy content beyond the high school classroom.

The college preparation view was a secondary view about the purpose of agricultural education held by many of the participants. The experiences of the participants with their students influenced the college preparation view. As of fall 2014, there were approximately 21 million students attending American colleges and universities, which is an increase of almost 6 million students since fall 2000 (National Center for Educational Statistics, 2015). This increase in students pursuing a college education has led to an increased pressure for teachers to prepare these students for college during their high school years, including agriculture teachers.

Participants that believed the purpose of agricultural education was career preparation or practical life skills, and subsequently felt the need to teach students specific skills, developed PCK that included knowing how to actually perform those skills themselves and how to break those skills down for student understanding. This required very different preparation and knowledge development than participants who held other views about the purpose of agricultural education. When the participants described their teacher preparation program's role in developing manual skills, such as transplanting plants, most referred to upper level college courses. Because of the limited minimum requirements in plant science at the undergraduate level for teacher certification at some universities, some of the participants did not receive as much skills knowledge at the preservice level.

Dawn commented that most teachers do not have the greenhouse operation skills upon graduation and have to seek out additional knowledge. Cora, for example, had to gain most of her manual plant science skills knowledge through experiences in the classroom after graduation. Cora discussed when teaching students manual skills it is more difficult to "fake it". This phenomenon could be similar to other career and technical education areas or other disciplines such as music education. Music education teachers would presumably need more than a rudimentary knowledge of instruments in order to instruct students on how to play instruments. PCK research in music education has established the need for skill development in preservice teachers (Ballantyne & Packer, 2004; Haston & Leon-Guerro, 2008). Specifically, Haston and Leon-Guerrero (2008) found that in music education, the instrumental training history prior to admittance into the teacher preparation program was a factor in the PCK of teachers. Examining the PCK of teachers in various disciplines who engage in teaching students manual or psychomotor skills may uncover valuable information about the nature of PCK.

While skill development and hands-on education was described by many as a hallmark of agricultural education and was substantiated by the literature (Talbert et al., 2005), there may be issues with teachers focusing solely on skill development in the classroom. Some agriculture content areas, like agricultural economics, would be difficult to teach through a psychomotor skill based view of agricultural education. Because of the wide array of content that can be taught in agricultural education, it may be possible that a single primary view about the purpose of agricultural education is not appropriate for all agriculture content areas.

The individualization view, surfaced by Clint, attempted to combine all of the purposes of agricultural education. This view may have benefits for students, but this purpose may not be practical for teachers. It is extremely difficult for any teacher to meet the needs of all of their students all of the time. Split focuses on college preparation, career preparation, practical life skills, agricultural literacy, and the all-encompassing individualization belief has the potential to alter instruction in teacher preparation programs. It is unknown if agricultural education teacher preparation programs are preparing future teachers for these vastly different approaches. And because these beliefs shape much of teachers' PCK development, it is recommended teacher preparation programs guide teachers in considering these beliefs in both their preservice and inservice careers. PCK development takes time and continues to be developed with experience in the field inservice (Baxter & Lederman, 1999; Clermont et al., 2006; Hashweh, 2005; Kind, 2009; Lee et al., 2011; and Van Driel et al., 2002). It is also possible that explicitly addressing PCK and what shapes this knowledge base at the preservice level in some ways is beyond the developmental readiness of the students (Kapyla et al., 2009), and instead should be implicitly embedded throughout the curriculum.

In addition to their views about the purpose of agricultural education, beliefs about plant science education and beliefs about teaching and learning in agricultural education also influenced participants' PCK. One belief that divided participants was the end use for the school greenhouse. For the majority of the participants, the greenhouse needed to be at the very least self-sustaining and for many it was an actual fundraiser for their program. This additional pressure on the success of plant production in the greenhouse influenced the educational approach the participants took in their plant science instructional units. If the participants' school and community expected a successful plant sale than many of the participants ran the greenhouse like a business instead of a laboratory environment. The overlap between fundraising and learning with the school greenhouse may be unique to agricultural education. Participants that needed to make a profit from their school greenhouse and thus had "higher stakes" on the vitality of the greenhouse crop often gave less responsibility to their students. This change in responsibility affected the type of content students learned and the depth of that content. Additionally, if participants needed the greenhouse to be a financial success, they often spent more time developing PCK related to the business and management aspects of plant science and greenhouse education.

Another strongly held belief by all the participants was it was the responsibility of the agriculture teacher to be a lifelong learner and reflector. This belief is particularly important because reflection is critical for PCK development (Hashweh, 2005; Schneider & Plasman, 2011). This shared belief that learning and reflecting throughout their careers is most likely why these participants developed strong PCK that led to their recommendation to participate in this research study. The National Association of

Agricultural Educators (2015) agriculture teachers creed, which hung in the classroom of multiple participants in the study, included a call for agriculture teachers to increase their knowledge of agriculture through studying, traveling, and exploration. The participants in this study strongly believed that accumulating new knowledge and reflecting on that knowledge was the responsibility of the individual teacher. A couple of the participants surfaced they thought current beginning agriculture teachers were not taking it upon themselves to continue to learn and reflect on content inservice. This lack of reflection could hinder their PCK development.

Rice and Kitchel (2013) discovered preservice agriculture teachers were dissatisfied with the quality, quantity, and transferability of their college agriculture content classes for teaching. The preservice teachers expressed a need to be more prepared after leaving their teacher preparation programs (Rice & Kitchel, 2013). Similarly, beginning agriculture teachers often utilized coping strategies that involved ignoring content they weren't familiar with or simply focusing on content in which they did have expertise (Rice & Kitchel, 2014a). These studies indicate a potential issue with the amount of learning that agriculture teachers are engaging in post their initial teacher certification. It is possible that beginning agriculture teachers do not truly understand what it means to be a lifelong learner and reflector. It is also possible that beginning agriculture teachers do see the value in lifelong learning and reflection, but do not have the time or resources to commit to these tasks. It is recommended that teacher preparation programs encourage lifelong learning and reflection and provide preservice teachers with tools and resources to engage in lifelong learning and reflection.

Overall, the influence of the integrated belief systems on participants' PCK warrants further attention to teacher beliefs in future preservice teacher education and inservice professional development. These individual beliefs could be seen throughout various data sources and greatly impacted the various strategies the participants utilized in the classroom. Because of the personal nature of beliefs, it is possible many agriculture teachers have not discussed how these beliefs impact their teaching in a professional setting. It will be important future work of teacher preparation programs to bridge the gap between beliefs and teaching and to make teachers aware of how their beliefs are influencing both the knowledge they gain and the knowledge they disseminate to their students.

Experiences also had an influence on the participants' PCK. Grossman (1990) identified sources of PCK development including: classroom observations, university coursework, experiences in the classroom inservice, and professional development. All of these were mentioned by participants in this study in some capacity as influential to their PCK development. One source that may be unique to agricultural education is the influence of participants' high school experiences in agricultural education on their PCK. Multiple participants expressed their first sources of plant science knowledge were their high school experiences and they often taught in similar ways to their high school agriculture teacher, even James who had been teaching inservice for 28 years. This is consistent with teaching and learning literature that stated the majority of teachers will teach in ways similar to how they were taught as students (Darling-Hammond, 2005) and with the previously mentioned study that found high school experiences were an important source of content knowledge and PCK for inservice agriculture teachers (Rice

& Kitchel, 2014b). However, utilizing high school experiences as sources of knowledge could be problematic as agriculture content information and pedagogical information changes over time.

Modeling, which has roots in Bandura's (1977) social cognitive theory of learning, was a frequent strategy enacted by participants. Allison mentioned a modeling strategy when she described her previous experiences with student teachers. Specifically when teaching manual greenhouse skills in the classroom, she had her student teachers watch her teach the lesson first and then replicate it in the following period on their own. This learning by observation approach could have many implications on PCK of agriculture teachers, including their reliance on memories of their own high school agriculture teachers approaches to teaching content. If teachers are unable to learn many of these manual skills in college because of the common lecture method in college courses, then they must develop these skills during student teaching or inservice when they are concurrently attempting to teach that content to students.

Many of the participants in this study earned a double major or minored in plant science content. This additional content preparation experience at the preservice level shaped the participants' PCK. For example, Allison indicated that her minor in plant science assisted her in interpreting agriculture text books. Content knowledge is the foundation for PCK (Ball & McDiarmid, 1990; Kennedy, 1998), so it logically follows that increased content knowledge would help facilitate the participants' PCK development. Cora, Jane, and James, who did not have majors or minors in plant science content, expressed more of an initial struggle teaching plant science content and focused on content knowledge development early in their inservice careers. Cora even began her pre-observation interview unprompted with a discussion about not feeling prepared in plant science content after finishing her teacher preparation program.

While teacher preparation programs are an important source of knowledge for agriculture teachers (Rice & Kitchel, 2014b), data from this study indicated they may not have as much of an influence on PCK development as could be anticipated. The most influential teacher preparation experience from all participants was student teaching, which is consistent with agricultural education literature (Edwards & Briers, 2001). Student teaching was when many of the participants began heavily engaging in the learning and reflecting process and when they were able to apply their newly forming PCK to teaching real-life students.

The discussion surrounding majors and minors in specific agriculture content areas prompted some debate over agriculture teacher specialization. All of the participants in this study were in multi-teacher programs. This was not planned as these teachers were simply recommended as having PCK in the plant sciences, were located within close proximity to the university so field work could be conducted, and had at least eight years of classroom experience. It is possible that being located in a multi-teacher program positively affected their PCK development because the participants had more of an opportunity to specialize in fewer areas of agricultural education. Since PCK is topic specific (Etkina, 2010; Gess-Newsome & Carlson, 2014; Van Driel & Berry, 2012), developing PCK in a variety of agriculture content areas could be challenging, particularly in a single teacher department. However, the reality remains that many agriculture programs across the nation are still single teacher programs and those teachers are responsible for teaching a variety of agriculture content.

Clint discussed that his high school agriculture teacher and mentor influenced the types of courses he enrolled in during college. He mentioned that he engaged in agriculture experiences outside of his strength areas and made an effort to develop new content knowledge and PCK. Other participants in this study such as Kelly and Dawn also supplemented their knowledge with work experience during college. These teachers did not express that they were engaging in these types of opportunities because of messages from their teacher preparation programs.

If current preservice teachers are not inherently engaging in this type of behavior, as predicted by Cora and Clint, it is partially the responsibility of teacher preparation programs to provide assistance. Perhaps an exam when students enter teacher preparation programs to identify weaker areas of content or advising sessions that address the need for additional knowledge in agriculture content during college could assist future teachers. Teacher preparation plans of study often include elective courses in agriculture content that could also be utilized to enhance content knowledge and PCK if purposefully selected. The influence of previous agriculture industry experiences was surfaced by participants in this study and is also corroborated by the literature (Newcomb et al., 2004). For students who do not come from agriculture backgrounds, internships and work experiences during college could be a way to supplement their agriculture knowledge and should be encouraged by teacher preparation programs.

While experiences prior to inservice did have an influence on participants' PCK, experiences in the classroom during inservice were the most influential experiences, which is consistent with previous literature (Gess-Newsome, 1999; Hashweh, 2005; Van Driel et al., 1998). These experiences were especially impactful when they were combined with in-depth reflection (Hashweh, 2005). In particular, the trial and error method surfaced by multiple participants was not as effective when participants did not reflect back on what was effective and not effective during the lesson. It is again recommended that teacher preparation programs provide preservice teachers with the tools to reflect on practice and establish the need for reflecting on practice during inservice. It should not be assumed by agriculture teacher educators that preservice teachers will develop positive reflection habits on their own.

Overall, teacher educators and their students must realize that PCK development is not complete when students graduate and receive their initial teacher certification. In fact, the PCK development trajectory continues to occur long after teacher preparation (Abell et al., 2009). Therefore, it is recommended the quantity and quality of professional development for inservice teachers should increase. There is evidence from the literature that professional development can impact the PCK of beginning teachers (Clermont et al., 1993). The participants in this study also indicated that professional development for mid-career teachers was not always applicable to their situations. They expressed a desire for professional development that delved deeper into the content, professional development separate from beginning teachers when appropriate, and lower cost associated with professional development. Popular professional development programs, such as CASE, were not explored by the participants in this study primarily due to cost. Teacher preparation programs, agriculture content professors, state agriculture staff, and community stakeholders should collaborate to develop professional development that is useful for teachers at all stages of their careers.

Finally, context greatly influenced the PCK of experienced agriculture teachers. Since the beginning of agriculture programs, agriculture teachers have been encouraged to utilize their local autonomy to design their agriculture programs around their local communities (Talbert et al., 2005). Talbert et al. (2005) also stated that even in states with mandated curriculum the local agriculture teachers should practice autonomy and address local community needs. This common desire to teach to the needs of the local community had interesting implications on participants' PCK. If the surrounding community had careers available in agriculture, the participants were more likely to include a career or college preparatory focus as their purpose of agricultural education. Particularly in the plant sciences, the community influenced what the participants grew in the greenhouse, contributed to the participants' decision to utilize the greenhouse as a business or as a laboratory, and often provided important supplemental knowledge to the participants in the plant sciences. Talbert et al. (2005) acknowledged agriculture teachers cannot know everything about their subject matter and emphasized the importance of local community partnerships to supplement knowledge. Future research should include exploration to see if agricultural education is unique in its flexibility and variability of content.

Depending on the influence of the local community, participants in the study sought out different types of knowledge and engaged in different professional development experiences. Clint for example, who was located in a community that was heavy in forage production, described professional development he attended specifically in grasslands to better meet the individual needs of is community. Additionally, participants expressed a desire to teach to the interests and needs of their students, which related to the local community influence. If high school agriculture teachers desire to maintain a community focus, then tools for knowledge development related to individual communities must be provided to preservice teachers by teacher preparation programs. Additionally, encouragement to develop advisory councils, a groups of stakeholders in the community that advise agriculture programs (Talbert et al., 2005), could also assist beginning teachers in meeting the needs of their communities.

IML curriculum also emerged as an important contextual influencer for participants. Every participant utilized IML curriculum to some degree and Clint revealed during an interview that if IML curriculum did not exist he wasn't sure what curriculum he would use to guide his teaching. At the same time, multiple participants also surfaced that IML curriculum was outdated and lacked meaningful application activities they could utilize in their classrooms. It is possible that participants are relying on IML curriculum because they do not have strong PCK related to knowledge of content and knowledge of curriculum (Hill et al., 2008). Additionally, agricultural education does not currently have national curriculum guidelines for teachers to follow, which could lead to both a reliance on IML curriculum and a deficit in knowledge of content and curriculum. It is recommended that further investigation into agriculture teachers' knowledge of content and curriculum be conducted to explore if this is a weak PCK area for agriculture teachers.

This exploratory study scratched the surface on what shapes experienced agriculture teachers' PCK. For this specific group of participants, five different beliefs about the purpose of agricultural education were surfaced. It is possible there are additional beliefs that teachers may have about the purpose of agricultural education.

Considering the significant impact that the belief systems theme had on the participants' PCK, it would be important future research to explore other agriculture teachers in Missouri and other states to see if they have similar beliefs about the purpose of agricultural education or if other beliefs emerge. A longitudinal study examining teachers over time to see how their beliefs change could also be important future research, especially considering the indication from participants James and Kelly that their purposes of agricultural education had changed over the course of their teaching careers.

One participant stood out in both his unique beliefs about the purpose of agricultural education and his extensive contribution to the study. A case study just focused on Clint could yield additional information about PCK. Examining how Clint teaches other agricultural units or having him complete CoRe or PaPeRs (Loughran et al., 2004) could provide interesting data on agriculture teacher PCK. Specifically, because of Clint's individualization focus it would be interesting to see how this purpose emerges and is managed within other agriculture subjects and how Clint's emphasis on lifelong learning and reflection impacted his teaching.

Part of the struggle with PCK research is capturing this illusive knowledge base (Kind, 2009). The exploratory nature of this study also led to thoughts on future data sources for PCK. Conducting lesson creation and analysis similar to Friedrichsen and Dana (2005) or completing CoRe or PaPeRs (Loughran et al., 2004) might be helpful in examining PCK more specifically for an agriculture topic. This data source could also supplement classroom observations. Journal reflections were a surprisingly insightful data source for participants in this study. If journal reflection contain directed questions and teachers are given adequate time to complete the reflection, this could be a valuable data source for future agricultural education PCK research. It might also be interesting to examine beginning teachers' reflections and compare them to experienced agriculture teachers' reflections. Finally, the use of stimulated recall did not seem necessary for experienced teachers in this study. Many participants surfaced discussion points I had planned to address during the interview before we viewed the video clip. Experienced teachers, at least in this study, were very aware of what they were doing during their classroom observations. If a future study is conducted with early-career teachers, stimulated recall maybe a better avenue for data collection.

This study focused just on plant science. Future studies should investigate other agricultural content areas such as animal sciences to see what beliefs there are specific to animal science, how many beliefs (if any) overlap with plant science, and what is unique (if anything) to animal science. For instance, do agriculture teachers perceive that students think animal science is dry and boring like plant science or that it is always taught best utilizing hands-on methods? Additionally, agricultural mechanics, because of its inherent reliance on manual skill related knowledge and development could provide interesting findings to contribute to future agricultural education PCK research and general PCK research.

PCK is one of the most effective knowledge bases for classroom teaching (Loughran et al., 2012); therefore, it is important to continue to unpack what is shaping teachers' PCK development. This data can be utilized in teacher preparation programs to surface or even positively alter teachers' integrated belief systems and to connect the influence of experiences and context on those beliefs. Delving into the nuanced relationships between the three will be important as this area is understudied

(Friedrichsen et al., 2010). Examination of what shapes PCK specifically in agriculture teachers can serve as a starting point for future PCK development studies specifically in agricultural education. Data from this study points to inservice experiences as the most impactful type of experience, but teacher preparation programs and student teaching did serve a role in shaping participants' PCK. This substantive level theory can be utilized as a guide for both future research and as knowledge for teacher preparation programs.

The data from this study also raises philosophical questions about the true purpose of agricultural education and how these beliefs influence teacher PCK and subsequently classroom teaching. There is a need to explore teacher beliefs about the purpose of agricultural education more in-depth because of the influence it had on the other components of the integrated belief system and the other themes shaping PCK. It is uncertain when these beliefs begin to develop and what has the most impact on these beliefs.

Finally, there is a need for further PCK research in agricultural education. Conceptualization of experienced agriculture teachers' PCK for a variety of agriculture topic areas, including plant science, is still needed in the agricultural education discipline. Additionally, exploration into the development of PCK in preservice and beginning teachers will also be critical future research. Data from this study surfaced influencers of PCK that may be unique to the agricultural education. Examining the influence of high school experiences on PCK, community influence and teacher autonomy on PCK, and the tradition of manual skill development and career preparation on PCK could provide important knowledge not only for the agricultural education discipline, but also the body of PCK research as a whole.

APPENDIX A: CONSENT LETTER

Conceptualizing Pedagogical Content Knowledge for Experienced Agriculture Teachers in the Plant Sciences

Consent to participate in research study

You are being invited to take part in a research study exploring how pedagogical content knowledge is being used by agriculture teachers in the process of planning and teaching. If you volunteer to take part in this study, you will be one of about 15 people to do so.

The person in charge of the study is Amber Rice of the University of Missouri Department of Agricultural Education and Leadership, under the advisement of Dr. Tracy Kitchel. We hope to examine thought processes of agriculture education teachers across the state of Missouri towards the deconstruction of content knowledge for student understanding in the plant sciences.

The research will be conducted using various forms of the data and will take place over the course of a single plant science unit. The first portion of data collection is two forty-five minute to seventy-five minute semi-structured private interviews. The interview will be audio tape recorded for transcription purposes only and you will not be identified in this study. The second portion of data collection will be conducted through four on site field observations lasting the length of a regular class period, forty -five minutes to ninety minutes. This observation will also be video recorded for transcription purposes only and again you will not be identified in this study. The camera will be placed in the back of the classroom and will be focused only on the teacher not the students. The third portion of data collection will involve responses to five reflection questions for each lesson taught in the plant science unit. These responses will be e-mailed to the researcher. The final portion of data collection is artifact collection. Any worksheets, PowerPoints or other materials related to a lesson will be collected throughout the course of the unit. These documents can be given to the researcher during site visits or may be e-mailed.

Information gathered from this study may be reported in academic articles or papers. To the best of our knowledge, the things you will be doing have no more risk of harm than you would experience in everyday life. Your willingness to take part may help society better understand this research topic. Additionally, for completing the reflection questions you will receive a $20 gift card for your time.

We will make every effort to keep private all research records that identify you to the extent allowed by law. Your information will be combined with information from other participants in this study. When we write about the study to share with other researchers, you will not be personally identified in anyway. We may publish the results of the study; however, we will keep your name and any identifying information private.

Only Dr. Kitchel and Amber Houck Rice will have access to any data collected, any audio tapes or video tapes, any transcribed interviews, any lesson artifacts, any reflection questions, and any field notes. All transcriptions and data will be kept in a locked office or password protected computer.

Refusal to participate in this study will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled.

Before you decide whether to accept this invitation to take part in this study, please ask any questions that may come to mind immediately. Later, if you have questions, suggestions, concerns, or complaints about the study, you can contact the principal investigator, Amber Rice or advisor, Dr. Tracy Kitchel at 573-882-7451. If you have questions about your rights as a volunteer in this research, contact the staff in the Office of Research Campus Institutional Review Board at the University of Missouri at 573-882-9585. If you wish to contact someone not involved with this study, please contact Dr. Anna Ball at 573-882-7451.

______________________________ ________________ _____________

Signature of person agreeing to take part in study Date

____

Printed name of person agreeing to take part in the study

Amber Rice, Primary Investigator

____ ______________

Name of [authorized] person obtaining informed consent Date

____

Signature of Investigator

APPENDIX B: PRE-OBSERVATION INTERVIEW QUESTIONS

1. Tell me about your background as a plant science teacher.
    a. How many years have you taught plant science content?
    b. What professional development have you engaged in for plant science content?
2. Describe the context of the unit.
3. What are the most important concepts in this unit?
    a. Why do you believe those concepts are important?
    b. What else do you know about these concepts that you do not intend for your students to know yet? (Due to readiness, complexity, time, etc.).
4. What resources will you use to teach this unit?
    a. How do you decide what to teach first in this unit?
    b. How does this unit fit in with other units in this course? In this program?
5. What strategies will you use to facilitate student learning of those concepts?
    a. What are the advantages and disadvantages of these instructional strategies?
    b. How do you know these are the best strategies to use for these concepts?
6. What preconceptions do students typically have with concepts in this unit?
    a. How do these preconceptions influence your teaching strategies (if at all)?
    b. Where are students developmentally in regards to the concepts in this unit?
7. What difficulties or limitations do you predict students to have with concepts in this unit?
    a. How will you address those difficulties or limitations?

b. What are the most common questions students have about concepts in this unit?

8. How will you know that the students learned the content in this unit?

   a. What specific strategies do you use?

   b. What is your overall learning goal for this unit?

APPENDIX C: REFLECTION QUESTIONS

1. What student misconceptions or difficulties surfaced (if any) during this lesson and how did you address those misconceptions or difficulties? You may describe multiple instances if applicable.
2. What representations, illustrations, or analogies related to content did you utilize during this lesson and why did you choose those particular strategies? You may describe multiple representations, illustrations, or analogies if applicable.
3. How do you know the students learned the concepts for this specific lesson? What assessment strategies (formative or summative) did you utilize and why?
4. How did this lesson connect to or build from your other lessons in this unit?
5. What could you have done differently to improve the content of this lesson?

APPENDIX D: POST-OBSERVATION INTERVIEW QUESTIONS

General Questions

1. What was your overall impression of the instruction of this unit?
   a. What do you feel were the strengths and weakness of this unit?
   b. What changes (if any) would you make to this unit if you were to reteach it again?
   c. Why would you make those particular changes?
2. What was your role in this unit?
   a. What was your students' role?
3. How would you define agricultural education?
   a. What is the purpose of agricultural education?
   c. What was the purpose of this plant science unit?

Stimulated Recall Questions

4. I see that you used X teaching strategy in this clip. What other strategies could you have utilized? How did this strategy help you achieve your goals for this lesson and unit?
5. I see you dealt with X student misconception. What other student misconceptions have you observed?
6. I see you used X as a means of assessment. What other assessment strategies could you have utilized?
7. I see you modified your lesson based on X. What other modifications could you have used?

8. I see you answered X student question in this clip. What other questions have you observed related to these concepts?
9. I see you used questioning as a teaching method. Walk me through your questioning strategy with this particular concept.
10. I see that you decided to use X activity in this lesson. Did you consider using other activities? Why or why not?
11. I did not see X strategy or X reaction. Did you consider a different approach? Why or why not?

APPENDIX E: CHART CONNECTING QUESTIONS TO LITERATURE

The following connected the previous interview and reflection questions with the component of PCK they were intended to capture.

Component of PCK	Interview and Reflection Questions
Knowledge of Instructional Strategies for Teaching Plant Science	Appendix B Question 5 Appendix C Question 2
Knowledge of Curriculum for Teaching Plant Sciences	Appendix B Question 4 Appendix C Question 4
Knowledge of Students for Teaching Plant Sciences	Appendix B Question 6 Appendix B Question 7 Appendix C Question 1
Knowledge of Assessments for Teaching Plant Science	Appendix B Question 8 Appendix C Question 3
Orientations and Beliefs for Teaching Plant Science	Appendix D Question 2 Appendix D Question 3

APPENDIX F: FOLLOW-UP QUESTIONS

1. What is the purpose of a school greenhouse?
2. What is the role of students in the school greenhouse?
3. What are the most important skills a student can acquire from your greenhouse/ plant science unit/course?
4. Do you teach sales in conjunction with your greenhouse/plant science unit/course? Do you teach greenhouse maintenance? Do you teach greenhouse management? If so, why?
5. What is your definition of agricultural literacy? Describe what this might look like in the classroom.
6. What influence (if any) does the community have on the content you teach? The resources you acquire? The methods you use to deliver material?
7. What role does science have (if any) in your teaching of plant science content?
8. What role (if any) do current agricultural issues have on your teaching of plant science content?
9. What role (if any) do CDE's and FFA have on your teaching of plant science content?

REFERENCES

Abell, S. K. (2008). Twenty years later: Does pedagogical content knowledge remain a useful idea?. *International Journal of Science Education, 30*(10), 1405-1416.

Abell, S. K., Rogers, M. A. P., Hanuscin, D. L., Lee, M. H., & Gagnon, M. J. (2009). Preparing the next generation of science teacher educators: A model for developing PCK for teaching science teachers. *Journal of Science Teacher Education, 20*(1), 77-93.

Aydin, S., Friedrichsen, P. M., Boz, Y., & Hanuscin, D. L. (2014). Examination of the topic-specific nature of pedagogical content knowledge in teaching electrochemical cells and nuclear reactions. *Chemistry Education Research and Practice, 15*(4), 658-674. doi:10.1039/c4rp00105b

Ball, D. L., & McDiarmid, G. W. (1990). The subject matter preparation of teachers. In W. R. Houston (Ed.), *Handbook of research on teacher education* (pp. 437–449). New York: Macmillan.

Ball, D. L., Hill, H. C., & Bass, H. (2005). Knowing mathematics for teaching: Who knows mathematics well enough to teach third grade and how can we decide?. *American Educator, 29*, 14-22.

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education, 59*(5), 389-407. doi:10.1177/0022487108324554

Ballantyne, J., & Packer, J. (2004). Effectiveness of preservice music teacher education programs: Perceptions of early-career music teachers. *Music Education Research, 6* (3), 299-312. doi:10.1080/1561380042000281749

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Barrick, R. K., & Garton, B. L. (2010). Frameworks for agriculture teacher preparation. In R. M. Torres, T. Kitchel, & A. L. Ball (Eds.), *Preparing and advancing teachers in agricultural education* (pp. 31-41). The Ohio State University Columbus, OH: Curriculum Materials Service.

Baumert, J., Kunter, M., Blum, W., Brunner, M., Voss, T., Jordan, A., ... & Tsai, Y. M. (2010). Teachers' mathematical knowledge, cognitive activation in the classroom, and student progress. *American Educational Research Journal*, *47*(1), 133-180. doi:10.3102/0002831209345157

Baxter, J. A., & Lederman, N. G. (1999). Assessment and measurement of pedagogical content knowledge. In J. Gess-Newsome, & N. G. Lederman (Eds.), *Examining pedagogical content knowledge and science education*. Netherlands: Kluwer Academic Publishers.

Beijaard, D., Verloop, N., & Vermunt, J. D. (2000). Teachers' perceptions of professional identity: An exploratory study from a personal knowledge perspective. *Teaching and Teacher Education, 16*(7), 749-764.

Borko, H., Eisenhart, M., Brown, C. A., Underhill, R. G., Jones, D., & Agard, P. C. (1992). Learning to teach hard mathematics: Do novice teachers and their instructors give up too easily? *Journal for Research in Mathematics Education, 23*(3), 194-222. doi:10.2307/749118

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

Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis.* Thousand Oaks, CA: Sage Publications.

Chick, H. L., Baker, M., Pham, T., & Cheng, H. (2006). Aspects of teachers' pedagogical content knowledge for decimals. *In Proceedings of the 30th annual conference of the International Group for the Psychology of Mathematics Education.*

Clermont, C. P., Borko, H., & Krajcik, J. S. (1994). Comparative study of the pedagogical content knowledge of experienced and novice chemical demonstrators. *Journal of Research in Science Teaching*, *31*(4), 419-441. doi:10/1002/tea.3660310409

Clermont, C. P., Krajcik, J. S., & Borko, H. (1993). The influence of intensive in-service workshop on pedagogical content knowledge growth among novice chemical demonstrators. *Journal of Research in Science Teaching, 30*(1), 21-43.

Corbin, J., & Strauss, A. (2008). *Basics of qualitative research: Techniques and procedures for developing grounded theory.* Thousand Oaks, CA: Sage Publications.

Creswell, J. W. (2013). *Qualitative inquiry & research design: Choosing among five approaches*. Thousand Oaks, CA: Sage Publications.

Darling-Hammond, L. (2006). Constructing 21st-century teacher education. *Journal of Teacher Education, 57*(3), 300-314.

Darling-Hammond, L., & Bransford, J. (Eds.). (2005). *Preparing teachers for a changing world: What teachers should learn and be able to do.* San Francisco, Calfornia: Jossey-Bass.

Depaepe, F., Verschafeel, L., & Kelchtermans, G. (2013). Pedagogical content knowledge: A systematic review of the way in which the concept has pervaded mathematics educational research. *Teaching and Teacher Education, 34*, 12-25. doi:10.1016/j.tate.2013.03.001

Diakidoy, I. N., & Iordanou, K. (2003). Preservice teachers' and teachers' conceptions of energy and their ability to predict pupils' level of understanding. *European Journal of Psychology of Education, XVIII*(4), 357-368.

Driver, R., Squires, A., Rushworth, P., & Wood-Robinson, V. (1994). *Making sense of secondary science: Research into children's ideas.* London: Routledge.

Dunne, C. (2011). The place of the literature review in grounded theory research. *International Journal of Social Research Methodology,14*(2), 111-124.

Educational Testing Service. (2011). *2011 praxis client conference*. Retrieved from http://www.ets.org/s/praxis/newsletter/2011/16804/index.html.

Edwards, M. C., & Briers, G. E. (2001). Cooperating teachers' perceptions of important elements of the student teaching experience: A focus group approach with quantitative follow-up. *Journal of Agricultural Education, 42*(3), 30-41.

Enfield, M. (2012). Content and pedagogy: Intersection in the NSTA standards for science teacher education.

Etkina, E. (2010). Pedagogical content knowledge and preparation of high school physics teachers. *Physical Review Special Topics- Physics Education Research, 6*(2). doi:10.1103/PhysRevSTPER.6.020110

Fassinger, R. E. (2005). Paradigms, praxis, problems, and promise: grounded theory in counseling psychology research. *Journal of Counseling Psychology, 52*, 156- 166.

Floden, R., & Meniketti, M. (2005). Research on the effects of coursework in the arts and sciences and in the foundation of education. In M. Cochran-Smith & K. M. Zeichner (Eds.), *Studying teacher education* (pp. 261-308). Mahwah, NJ: Erlbaum.

Friedrichsen, P., Van Driel, J. H., & Abell, S. K. (2010). Taking a closer look at science teaching orientations. *Science Education, 95*(2), 358-376. doi:10.1002/sce.20428

Friedrichsen, P. M., & Dana, T. M. (2005). Substantive-level theory of highly regarded secondary biology teachers' science teaching orientations. *Journal of Research in Science Teaching, 42*(2), 218-244. doi:10.1002/tea.20046

Garton, B. L., & Chung, N. (1996). The inservice needs of beginning teachers of agriculture as perceived by beginning teachers, teacher educators, and state supervisors. *Journal of Agricultural Education*, *37*, (3), 52-58. doi:10.5032/jae.1996.03052

Gess-Newsome, J., & Carlson, J. (2014, April). Pedagogical content knowledge summit: A new way to visit an old construct. In M. Giamellaro (Chair), *Pedagogical content knowledge: Considering models, methods, and recommendations from the PCK summit*. Symposium conducted at the meeting of the American Education Research Association, Philadelphia, PA.

Gess-Newsome, J., & Lederman, N. G. (Eds.). (1999). *Examining pedagogical content knowledge*. Netherlands: Kluwer Academic Publishers.

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research.* Hawthorne, NY: Aldine De Gruyter.

Grossman, P. L. (1990). *The making of a teacher: Teacher knowledge and teacher education*. New York: Teachers College Press.

Gudmundsdottir, S., & Shulman, L. (1987). Pedagogical content knowledge in social studies. *Scandinavian Journal of Educational Research*, *31*(2), 59-70.

Halim, L., & Meerah, S. M. (2002). Science trainee teachers' pedagogical content knowledge and its influence on physics teaching. *Research in Science and Technological Education, 20*(2), 215-225. doi:10.1080/0263514022000030462

Hashweh, M. Z. (2005). Teacher pedagogical constructions: A reconfiguration of pedagogical content knowledge. *Teachers and Teaching: Theory and Practice, 11*(3), 273-292. doi:10.1080/13450600500105502

Haston, W., & Leon-Guerrero, A. (2008). Sources of pedagogical content knowledge: Reports by preservice instrumental music teacher. *Journal of Music Teacher Education, 17*(2), 48-59. doi:10.1177/1057083708317644

Hattie, J. A. C. (2009). *Visible learning: A synthesis of 800+ meta-analyses on achievement.* London: Routledge.

Hess, A. J., & Trexler, C. J. (2011). A qualitative study of agricultural literacy in urban youth: Understanding for democratic participation in renewing the agri-food system. Journal of Agricultural Education, 52(2), 151-162. doi:10.5032/jae.2011.02151

Herren, R. V. (2007). *The science of agriculture: A biological approach.* (3rd ed.) Clifton Park, NY: Delmar Cengage Learning.

Hill, H. C., Ball, D. L., & Schilling, S. G. (2008). Unpacking pedagogical content knowledge: Conceptualizing and measuring teachers' topic specific knowledge of students. *Journal for Research in Mathematics Education, 39*(4), 372-400.

Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal, 42*(2), 371-406. doi:10.3102/00028312042002371

Hill, H.C., Schilling, S.G., & Ball, D.L. (2004) Developing measures of teachers' mathematics knowledge for teaching. *Elementary School Journal 105*, 11-30.

Houck, A., & Kitchel, T. (2010). Assessing preservice agriculture teachers' content preparation and content knowledge. *Journal of Assessment and Accountability in Educator Preparation, 1*(1), 29-36.

Hume, A., & Berry, A. (2011). Constructing CoRes- a strategy for building PCK in pre-service science teacher education. *Research in Science Education, 41*(3), 341-355. doi: 10.1007/s11165-010-9168-3

Kaplan, L. S., & Owings, W. A. (2002). *Teacher quality, teaching quality, and school improvement*. Bloomington, IN: Phi Delta Kappa International Press.

Kapyla, M., Heikkinen, J. P., & Asunta, T. (2009). Influence of content knowledge on pedaogcical content knowledge: The case of teaching photosynthesis and plant growth. *International Journal of Science Education, 31*(10), 1395-1415.

Kennedy, M. M. (1998). Education reform and subject matter knowledge. *Journal of Research in Science Teaching, 35*(3), 249-263. doi:10.1002/(SICI)10982736(199803)35:3<249::AID-TEA2>3.0.C0;2-R

Kennedy, M. M. (2010). Attribution error and the quest for teacher quality. *Educational Research, 39*(8), 591-598.

Kind, V. (2009). Pedagogical content knowledge in science education: Potential and perspectives for progress. *Studies in Science Education, 45*(2), 169-204.

Knobloch, N. A. (2002). What is a qualified, competent, and caring teacher? *The Agriculture Education Magazine, 75*(2), 22-23.

Lannin, J. K., Webb, M., Chval, K., Arbaugh, F., Hicks, S., Taylor, C., & Burton, R. (2013). The development of beginning mathematics teachers pedagogical content knowledge. *Journal of Mathematics Teacher Education, 16*(6), 403-426. doi:10.1007/s10857-013-9244-5

Layfield, K. D., & Dobbins, T. R. (2002). Inservice needs and perceived competencies of South Carolina agricultural educators. *Journal of Agricultural Education*, *43*(4), 46-55.

Lee, Y. (2011). Enhancing pedagogical content knowledge in a collaborative school-based professional development program for inquiry-based science teaching. *Asia-Pacific Forum on Science Learning and Teaching*, *12*(2), 1-29.

Lee, E., Brown, M. N., Luft, J. A., and Roehrig, G. H. (2007). Assessing beginning secondary science teachers' PCK: Pilot year results. *School Science and Mathematics, 107*(2), 52-60. doi:10.1111/j.1949-8594.2007.tb17768.x

Loughran, J., Berry, A., & Mulhall, P. (2012). *Understanding and developing science teachers' pedagogical content knowledge.* Netherlands: Sense Publishers.

Loughran, J., Mulhall, P., & Berry, A. (2004). In search of pedagogical content knowledge in science: Developing ways of articulating and documenting professional practice. *Journal of Research in Science Teaching, 41*, 370-391.

Luft, J. A., & Roehrig, G. H. (2007). Capturing science teacher' epistemological beliefs: The development of the teacher beliefs interview. *Electronic Journal of Science Education, 11*(2). Retrieved from http://ejse.southwestern.edu

Mackey, A., & Gass, S. M. (2005). *Second language research: Methodology and design*. Mahwah, New Jersey: Lawrence Erlbaum Publishers.

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources, and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome & N. G. Lederman (Eds.), *Examining pedagogical content knowledge* (pp. 95-132). Netherlands: Kluwer Academic Publishers.

Meade, P., McMeniman, M., Wilson, J., Kanes, C., & Davey, I. (1991). Towards making explicit the implicit knowledge of effective math and science teachers- a triangulated methodology. *In Annual Meeting of Australian Association of Research in Education.*

Mishra, P., & Koehler, M. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *The Teachers College Record, 108*(6), 1017-1054.

Missouri Department of Elementary and Secondary Education. (2011). *Curriculum profiles for agricultural education.* Retrieved from: http://dese.mo.gov

Missouri Farm Bureau. (2015). *Keep Missouri Farming.* Retrieved from: http://www.mofb.org/KeepMissouriFarming

Monk, D. H. (1994). Subject area preparation of secondary mathematics and science teachers and student achievement. *Economics of Education Review, 13*, 125-145.

Mulhall, P., Berry, A., & Loughran, J. (2003). Frameworks for representing science teachers' pedagogical content knowledge. *Asia-Pacific Forum on Science Learning and Teaching, 4*(2), 1-25.

Mundt, J. P., & Connors, J. J. (1999). Problems and challenges associated with the first years of teaching agriculture: A framework for preservice and inservice education. *Journal of Agricultural Education, 40*(1), 38-48. doi:10/5032/jae.1999.01038

Myers, B. E., Dyer, J. E., & Washburn, S. G. (2005). Problems facing beginning agriculture teachers. *Journal of Agricultural Education*, *46*(3), 47-55. http://dx.doi.org/10.5032/jae.2005.03047

National Association of Agriculture Educators (2015). *Ag teacher's creed.* Retrieved from: http://www.naae.org/whoweare/creed.cfm

National Center for Educational Statistics (2015). *Fast facts.* Retrieved from: https://nces.ed.gov

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

National FFA (2015). *About the FFA.* Retrieved from http://www.ffa.org/about/what-is-ffa

National Research Council. (2010). *Preparing teachers: Building evidence for sound policy*. Committee on the Study of Teacher Preparation Programs in the United States, Center for Education. Division of Behaviors and Social Sciences Education. Washington, DC: The National Academies Press.

Newcomb, L. H., McCracken, J. D., Warmbrod, J. R., Whittington, M. S. (2004). *Methods of Teaching Agriculture*, 3rd edition. Upper Saddle River, New Jersey: Pearson Prentice Hall.

Nilsson, P. (2008). Teaching for understanding: The complex nature of pedagogical content knowledge in pre-service education. *International Journal of Science Education, 30*(10), 1281-1299. doi: 10.1080/09500690802186993

Okpala, C. O., & Ellis, R. (2005). The perceptions of college students on teacher quality: A focus on teacher qualification. *Journal of Education, 126*(2), 374-383.

Padilla, K., & Van Driel, J. (2011). The relationship between PCK components: the case of quantum chemistry professors. *Chemistry Education Research and Practice, 12*(3), 367-378.

Phelps, G., & Schilling, S. (2004). Developing measure of content knowledge for teaching reading. *The Elementary School Journal, 105*(1), 31-48.

Rice, A., & Kitchel, T. (2013). Preservice agriculture teachers' facilitation of mastery learning of content. Proceedings of the North Central Region AAAE Research Conference, Platteville, WI.

Rice, A. & Kitchel, T. (2014a). Deconstructing content knowledge: Coping strategies and their underlying sources of motivation for beginning agriculture teachers. *Proceedings of the National AAAE Research Conference*, Snowbird, UT.

Rice, A. & Kitchel, T. (2014b). The relationship between agriculture knowledge bases for teaching and sources of knowledge. *Proceedings of the National AAAE Research Conference*, Snowbird, UT.

Roberts, T. G., & Ball, A. L. (2009). Secondary agricultural science as a content and context for teaching. *Journal of Agricultural Education, 50*(1), 81-91. doi:10.5032/jae.2009.01081

Roberts, T. G., & Dyer, J. E. (2004). Characteristics of effective agriculture teachers. *Journal of Agricultural Education, 45*, 82-85.

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. 31-41). The Ohio State University Columbus, OH: Curriculum Materials Service.

Rowan, B., Schilling, S. G., Ball, D. L., & Miller, R. (2001). Measuring teachers' pedagogical content knowledge in surveys: An exploratory study. *Ann Arbor, MI: Consortium for Policy Research in Education, Study of Instructional Improvement, University of Michigan.*

Schneider, R. M., & Plasman, K. (2011). Science teacher learning progressions: A review of science teachers' PCK development. *Review of Educational Research, 81*(4), 530-565. doi:10/3102/0034654311423382

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14. doi:10.3102/0013189X015002004

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22.

Solis, A. (2009). Pedagogical content knowledge: What matters most in the professional learning of content teachers in classrooms with diverse student populations. *Intercultural Development Research Association.*

Steele, M. D., Hillen, A. F., & Smith, M. S. (2013). Developing mathematical knowledge for teaching in a methods course: The case of the function. *Journal of Mathematics Teacher Education, 16*(6), 451-482.

Stronge, J. H. (2007). *Qualities of effective teachers*. Alexandria, VA: Association for Supervision and Curriculum Development.

Strubing, J. (2007). Research as pragmatic problem-solving: The pragmatist roots of empirically-gounded theorizing. In A. Bryant & K. Charmaz (Eds.), *The Sage handbook of grounded theory* (pp. 580-601). Thousand Oaks, CA: Sage Publications.

Talbert, B. A., Vaughn, R., & Croom, D. B. (2005). *Foundations of agricultural education*. Catlin, IL: Professional Educators Publications.

Turner-Bisset, R. (1999). The knowledge bases of the expert teacher. *British Educational Research Journal, 25*(1), 39-55. doi:10.1080/0141192990250104

United States Bureau of Labor Statistics. (2012). *Education and training outlook for occupations*, 2013-22. Retrieved from http://www.bls.gov/emp

United States Department of Education, Office of Postsecondary Education. (2013). *Preparing and credentialing the nation's teachers: The secretary's ninth report on teacher quality*. Washington, D.C. Retrieved from http://www.title2.ed.gov

Usak, M. (2009). Preservice science and technology teachers' pedagogical content knowledge on cell topics. *Educational Sciences: Theory and Practice, 9*(4), 2033-2046.

Van Dijk, E. M., & Kattmann, U. (2007). A research model for the study of science teachers' PCK and improving teacher education. *Teaching and Teacher Education, 23*, 885-897.

Van Driel, J. (2010). Model-based development of science teachers' pedagogical content knowledge. *In International Seminar, Professional Reflections, National Science Learning Centre, York.*

Van Driel, J. H., & Berry, A. (2012). Teacher professional development focusing on pedagogical content knowledge. *Educational Researcher, 41*(1), 26-28. doi:10.3102/0013189X11431010

Van Driel, J. H., De Jong, O., & Verloop, N. (2002). The development of preservice chemistry teachers' pedagogical content knowledge. *Science Education*, *86*, 572-590. doi:10.1002/sce.10010

Van Driel, J. H., Verloop, N., & De Vos, W. (1998). Developing science teachers' pedagogical content knowledge. *Journal of Research in Science Teaching, 35*(6), 673-695. doi:10.1002/(SICI)1098-2736(199808)35:6,673::AID-TEA5.3.3.C0;2-9

Veal, W. R. (2004). Beliefs and knowledge in chemistry teacher development. *International Journal of Science Education, 26*(3), 329-351.

Walshaw, M., & Anthony, G. (2008). The teacher's role in classroom discourse: A review of recent research into mathematics classrooms. *Review of Educational Research, 78*(3), 516-551.

Washburn, S. G., King, B. O., Garton, B. L., & Harbstreit, S. R. (2001). A comparison of the professional development needs of Kansas and Missouri teachers of agriculture. *Proceedings of the 28th Annual National Agricultural Education Research Conference* (pp. 396-409).

VITA

Amber Rice grew up in Bardstown, KY and became interested in agricultural education after enrolling in a high school greenhouse course. Her high school agriculture teacher encouraged her to pursue a career in agricultural education upon entering the University of Kentucky. She taught as a high school agriculture teacher for four years in her hometown and loved every moment of that experience. Propelled by a desire to continue to make an impact in agriculture and the lives of students, she pursued a PhD at the University of Missouri in agricultural education. Her research interests focus on pedagogical content knowledge and content knowledge of agriculture teachers. Her goal is to utilize her teaching and research to find the best ways to prepare future agriculture teachers so they can be knowledgeable and successful in the classroom. In the fall of 2015, she will continue her academic journey as a faculty member at the University of Georgia in agricultural education.