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Agriculture Teachers' Integrated Belief Systems and its Influence on their Pedagogical Content Knowledge

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Abstract

This grounded theory study explored the pedagogical content knowledge (PCK) of experienced agriculture teachers in the plant sciences. The central phenomenon that emerged during data collection and analysis was the influence of beliefs on shaping participants' PCK. This finding guided subsequent collection and analysis that resulted in the following central research question: what shapes experienced agriculture teachers' PCK in plant sciences? The data presented here focused on the most emergent category shaping PCK, integrated belief systems, which included participants' beliefs about the purpose of agricultural education, beliefs about plant science education, and beliefs about teaching and learning in agricultural education. A substantive level theory was developed that illustrated the relationships between the three belief components on participants' PCK. These findings support further investigation into how beliefs are shaping agriculture teachers' PCK in plant sciences and other agriculture content areas.

Keywords: Agriculture teacher beliefs; teacher knowledge; teacher beliefs; pedagogical content knowledge; agriculture teacher PCK

Introduction

Effective agriculture teachers need to be able to determine students' learning needs, plan for and evaluate instruction, utilize a variety of teaching techniques, demonstrate knowledge of the teaching and learning process, and possess excellent knowledge of subject matter (Roberts & Dyer, 2004). Among other traits and skills, these teaching tasks require both content knowledge and pedagogical content knowledge (PCK) in agriculture topics. PCK is a professional knowledge base held by teachers that encompasses how they understand content and deliver that content to students (Shulman, 1986). Instructional tasks such as redirecting discussion and engaging in effective classroom discourse depend on teachers' PCK (Walshaw & Anthony, 2008). Teacher educators not only recommend agriculture teachers have PCK, but identify this knowledge base as essential to their success in the classroom (Roberts & Kitchel, 2010).

Despite its espoused importance in the literature, research in PCK specific to agricultural education have been limited to a handful of studies. Rice and Kitchel (2015a) explored preservice agriculture teachers' acquisition of agriculture content knowledge and how they planned to use that knowledge in their future teaching, within the contextual framework of PCK. They discovered that preservice agriculture teachers perceived their content knowledge preparation as inadequate and felt there was a lack of application of their content courses to teaching, which is imperative for PCK development (Rice & Kitchel, 2015a). A subsequent study examined beginning agriculture

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teachers' deconstruction of content knowledge for teaching and revealed that beginning teachers struggled to break down content knowledge for their students because of a self-identified content knowledge deficiency (Rice & Kitchel, 2016). This finding had direct implications to agriculture teachers' PCK development because content knowledge is the foundation for PCK (Ball, Thames, & Phelps, 2008). A model was developed that illustrated coping strategies for teachers when they are deficient in content and described the influencers that led them to choose specific strategies (Rice & Kitchel, 2016). Researchers recommended additional exploration into one specific influencer, the impact of teachers' personal philosophies and beliefs regarding agricultural education (Rice & Kitchel, 2016). Due to the content knowledge deficiency barrier, it was also recommended future research focus on experienced agriculture teachers' PCK (Rice & Kitchel, 2016), a recommendation which guided this study.

The lack of PCK conceptualization for agriculture teachers at any career stage, supports the focus on experienced teachers. While experience in the classroom does not guarantee an individual will possess PCK, it does play an active role in PCK development (Hashweh, 2005). Furthermore, teaching experience was perceived to be the most effective source of agriculture content knowledge for Missouri agriculture teachers and revealed a significant relationship with their PCK (Rice & Kitchel, 2015b). Research in PCK can inform strategies for how teachers are taught at the preservice level and increase the likelihood teachers will use that knowledge once they enter the classroom (Ball et al., 2008). For teaching to be better valued as a profession, PCK research is necessary to elucidate the complexity of teaching and further establish the importance of teachers' professional knowledge (Phelps & Schilling, 2004). Conceptualizing PCK for a specific topic in agriculture can provide a foundation for future research and inform agriculture teacher preparation programs nationwide.

Review of Literature

PCK can be further delineated into sub-components to provide a more detailed description of this elusive knowledge base. The Magnusson, Krajcik, and Borko (1999) framework for science PCK, one of the more prevalently utilized frameworks in the literature (Kind, 2009; Lannin et al., 2013; Padilla & Van Driel 2011), included four primary components that continuously appear in other studies and frameworks, though often under slightly different terms. The components included: knowledge of learners, knowledge of assessment, knowledge of instructional strategies, and knowledge of curriculum, all within a subject matter context. In their framework, orientations to teaching science was presented as influencing and being influenced by these four components of PCK (Magnusson et al., 1999). Orientations referred to a teachers' conceptualization, viewpoint, or overarching guide for teaching and learning a particular subject. Magnusson et al. (1999) described nine orientations specifically for teaching science including: process, academic rigor, didactic, conceptual change, activity-driven, discovery, project-based, inquiry, and guided inquiry. These orientations vary according to the characteristics of instruction (e.g. more teacher centered vs. student centered) and the goals for teaching science (e.g. scientific inquiry vs. transmission of information).

In more recent studies, orientations have become a central component of PCK frameworks and subsequently lines of inquiry. Padilla and Van Driel (2011) addressed orientations and their importance to teachers' overall PCK in their research in quantum chemistry, and Lee (2011) reinforced the view that orientations are a significant component to PCK in their research examining inquiry-based science teaching. In PCK literature, orientations are described differently depending upon the framework, and many researchers have expanded on Magnusson's et al. (1999) original description to include teacher beliefs about learning, approaches to teaching in general, specific approaches to subject matter, and teacher epistemologies. Grossman (1990) described orientations as the purposes and overall goals for teaching a particular subject. The lack of consistency with terms and definitions for what is influencing PCK has revealed many issues surrounding orientations in the literature (Friedrichsen & Berry, 2015). Concerns raised by Friedrichsen, Van Driel, and Abell (2010) included: various definitions and meanings behind the word orientations, weak or non-existent relationships between orientations and PCK, researchers simply assigning teacher orientations, and researchers simply not addressing orientations.

The role of teacher orientations, in addition to all of the previously described PCK components, are also reflected in the most current science PCK framework developed at the science PCK summit (Carlson, Stokes, Helms, Gess-Newsome, & Gardner, 2015). This consensus framework attempted to combine previous PCK frameworks from a variety of studies and included the knowledge of assessment, students, instruction, and curriculum, in addition to orientations, beliefs, and context. Their framework described influencers of PCK as amplifiers and filters for teachers' topic specific professional knowledge. These amplifiers and filters included orientations, beliefs, and context that directly influenced both the topic-specific professional knowledge of teachers (instructional strategies, content representations, student understandings, etc.) and classroom practice (Carlson et al., 2015). Due to the lack of common language (Friedrichsen et al., 2010), for the purposes of this study, influencers of PCK will be described more broadly as teacher beliefs, taking into account the concepts of orientations, beliefs, goals, and purposes for teaching. Hashweh (2005) claimed PCK is influenced heavily by teachers' beliefs, and there is evidence that these beliefs can even emerge and develop prior to entrance in a teacher preparation program (Kapyla, Heikkinen, & Asunta, 2009), further justifying their exploration in this study.

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 popular frameworks often include five components: knowledge of students, knowledge of instruction, knowledge of curriculum, knowledge of assessment, and orientations (Kind, 2009). The teachers' individual contexts, prior experiences, and content areas also impact their PCK (Gess-Newsome & Lederman, 1999). PCK develops continually over time (Lee, 2011) through experience (Baxter & Lederman, 1999; Hashweh 2005; Kind, 2009; Lee, Brown, Luft, & Roehrig, 2007; Van Driel, De Jong, & Verloop, 2002). 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 and highly specialized nature of PCK (Etkina, 2010; Carlson et al., 2015; Van Driel & Berry, 2012) warrants further examination of PCK, specifically in agricultural education.

Purpose of Study

The purpose of this grounded theory study was to both conceptualize PCK for a specific topic in agriculture and develop a model for the investigation and conceptualization of additional topics. The guiding question aligns with priorities four and five of the 2016-2020 National Research Agenda- meaningful and engaged learning in all environments and efficient and effective agricultural education programs (Roberts, Harder, & Brashears, 2016): What is experienced agriculture teachers' PCK related to the plant sciences? Exploration of experienced agriculture teachers' PCK will not only illuminate the current knowledge base for practicing teachers, but can also lead to more meaningful teacher preparation and curriculum development, ultimately strengthening agricultural education programs and increasing student learning.

Methods

The data analyzed were part of a larger study; therefore, many of the methods will be consistent or identical to the larger study. I chose grounded theory as the research design due to the exploratory nature of the guiding research question and the paucity of research in PCK within the agricultural education discipline. Additionally, PCK is the knowledge teachers use during the process of teaching (Kind, 2009) and investigating a process that shapes a phenomenon is a key component 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.

In qualitative inquiry, the researcher is the instrument through which data is interpreted (Creswell, 2013); therefore, it is also important to disclose my epistemological lens and positionality as it pertains to this study. Pragmatists view reality as an interaction between the actor and the environment because reality exists as experienced through people (Corbin & Strauss, 2008). Historically, significant assumptions of grounded theory such as the importance of action and interactions in developing meaning have origins in the work of early pragmatist philosophers (Corbin & Strauss, 2008), further substantiating the fit between my epistemological lens and the research design. I identify as a former high school agriculture teacher and current agriculture teacher educator at a large land-grant university. 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 and Data Collection

Eight high school agriculture teachers in Missouri with a minimum of eight years teaching experience as of the 2014-2015 school year were selected as participants in this study. Experienced teachers are more likely to possess PCK (Hashweh, 2005) and expertise begins after approximately five to eight years in the classroom (Darling-Hammond & Bransford, 2005). I utilized recommendations from teacher educators in the purposeful selection of teachers to insure possession and quality of PCK in the plant sciences. All selected teachers were teaching a plant science unit in the fall of 2014, had professional development experiences related to plant science, a reputation as an effective teacher by teacher educators, and were located within a 120-mile radius of the university for observations and field work. The topic specific nature of PCK (Carlson et al., 2015; Etkina, 2010; Magnusson et al., 1999; Van Driel & Berry, 2012) created a need to examine one particular area of agriculture for this study. Plant science was chosen because it was a commonly taught content area by experienced agriculture teachers across the state, and I had the appropriate content knowledge to recognize PCK in my participants.

I collected the following six sources of qualitative data: pre-observation interviews, field notes, classroom teaching observations, lesson artifacts, teacher journal reflections, and post-observation interviews. PCK is both the knowledge of, reasoning behind, and planning for teaching a specific topic, and the actual act of teaching a specific topic (Carlson et al., 2015). Reflection is also a critical component 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 (Carlson et al., 2015). 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, Verschafeel, & Kelchtermans, 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.

I collected data fall 2014 during a single plant science unit for each participant. To manage the data, the NVivo 10 qualitative software program was used. One-on-one semi-structured pre-observation interviews lasting between 45 minutes to an hour for each participant were first conducted to capture PCK emerging during the planning phase of teaching. Questions during the pre-observation interviews included having the participants 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. All pre-observation interviews were conducted prior to the beginning of the plant science unit.

Classroom teaching observations were conducted to capture PCK emerging during the in-the-moment teaching phase. For example, if students surface preconceptions or misconceptions related to the content during the lesson, the teacher may or may not demonstrate PCK in response to addressing those preconceptions and misconceptions by altering their lesson in real time. Two observation blocks were conducted each lasting two days in length to maximize the potential for PCK to be captured. Observations were video recorded because I wanted the opportunity to replay the video to search for instances of PCK and clips from the videos were used for stimulated recall during the post-observation interview. Field notes were taken to record PCK emerging during the in-the-moment teaching phase of teaching not evident on the video recording. Additionally, field notes were used to capture any instances of PCK that could be used for the stimulated recall portion of the post-interview.

Two data sources were collected over the course of the entire unit: lesson artifacts and teacher journal reflections. Lesson artifacts were collected to capture PCK emerging during both the planning phases and in-the-moment teaching phases of teaching (see Hume & Berry, 2011). Artifacts from the participants related to the lesson including: handouts, PowerPoints, and worksheets, captured PCK from the planning phase as the teachers designed their lessons. Artifacts related to the students including: student completed work without identifiers, captured PCK from the in-the-moment teaching phase. Additionally, the type of assignments utilized, the content of the PowerPoints, and the exams all provided evidence to create a complete picture of the participants' PCK. Teacher journal reflections were used to capture PCK emerging during the reflection phase of teaching. 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. An example of a reflection question was: what representations, illustrations, or analogies related to the content did you utilize during this lesson?

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 was: what do you feel were the strengths and weaknesses of this unit? These questions evolved throughout the process to meet the needs of the participants and 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). 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, Mulhall, & Berry, 2004). Video clips from the observations were played back for participants and they were asked to elaborate on the incident.

Data Analysis and Alterations to the Central Question

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 to search for similarities and differences (Corbin & Strauss, 2008). I followed the three step coding process of grounded theory: 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). To begin the open coding process, 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).

After the first few pre-observation interviews, it became evident 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. 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 an emergent 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. At times the central phenomenon that emerges from the data demands that the original research question be altered 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 the emergence of the central phenomenon, the new guiding research question became: "What shapes experienced agricultural teachers PCK in the plant sciences?" Using this question as my guide, I re-coded existing data and applied the new research question to all subsequent data collected and analyzed.

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

Trustworthiness

Throughout the study, I engaged in various validation strategies described by Tracy (2010) for qualitative research that met the following criteria: worthy topic, rich rigor, sincerity, credibility, resonance, significant contribution, ethics, and meaningful coherence. Exploration into agriculture teacher PCK is a research topic worthy of exploration because of its relevance to the field of agricultural education and the limited research to date specific to agriculture teachers' beliefs and PCK. Rigor was achieved through an intense data collection and analysis process that included various forms of data and rich, thick descriptions of experiences to assist the reader in understanding the themes. Sincerity was evident in the study through disclosure of my potential biases and transparency of the challenges inherit to the study, including changes to the central questing during analysis. Credibility was first addressed by triangulation of six separate data sources to corroborate evidence. Second, I engaged in member checking of findings and interpretations. Resonance was achieved through vivid description, including first hand observations, and weaving the various data sources into a story. The research provides a significant contribution to the body of literature through development of themes and ultimately a substantive theory. Procedural ethics for protecting human subjects were followed and participants were protected with pseudonyms. Meaningful coherence was achieved by memoing throughout the entire research process to develop connections, document my thoughts, to ask questions of the data, and to interconnect literature and interpretations.

Findings

These findings are part of a larger study where a substantive theory emerged from the data to explain what was shaping experienced agriculture teachers' PCK in the plant sciences (Rice & Kitchel, 2017). Experiences, context, and beliefs of the participants provided the framework for the substantive theory. Specifically, integrated belief systems was the most emergent of the three and had the greatest influence in shaping the PCK of experienced agriculture teachers in the plant sciences. The integrated beliefs systems theme was comprised of three main components that interacted with one another: beliefs about the purpose of agricultural education, beliefs about plant science education, and beliefs about teaching and learning in agricultural education. The findings below will focus on describing these individual components and unpacking the relationship between the participants' integrated beliefs systems and their PCK.

Beliefs about the Purpose of Agricultural Education

The participants believed the four main purposes of agricultural education were: career preparation, college preparation, agricultural literacy, and practical life skills. A fifth view labeled individualization, based on individual student need, was surfaced by the participant Clint as he attempted to combine all of the purposes to meet the needs of his diverse student population. The majority of participants held multiple views about the purpose of agricultural education for their students, but some expressed more of an emphasis on specific views than others, leading to primary and secondary view categories (see Figure 1). Specifically, the word views was utilized to avoid any confusion between terms and improve readability of the findings, but is reflective of participants' beliefs about 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 1. Participants' beliefs about the purpose of agricultural education

Participants who held a career preparation view about the purpose of agricultural education focused on the skills and knowledge their students needed to directly enter the agriculture industry or pursue training for a specific career. Participants with the college preparation view concentrated on the skills and knowledge their students needed to be successful in post-secondary education. Participants who held an agricultural literacy view were dedicated to developing general knowledge and awareness about agriculture in their students, often from a consumer and voter perspective. Participants with the practical life skills view focused on developing tangible life skills through an agricultural education context (e.g. create a budget) that went beyond agricultural literacy knowledge. Finally, student individualization encompassed all four of the previous views in an effort to meet the needs of each individual student.

The beliefs about the purpose of agricultural education directly influenced the other two components of the integrated belief systems (see Figure 2). For this reason, beliefs about the purpose of agricultural education and its impact on participants' PCK will be reported intertwined with beliefs about plant science education and beliefs about teaching and learning throughout the remainder of the findings.

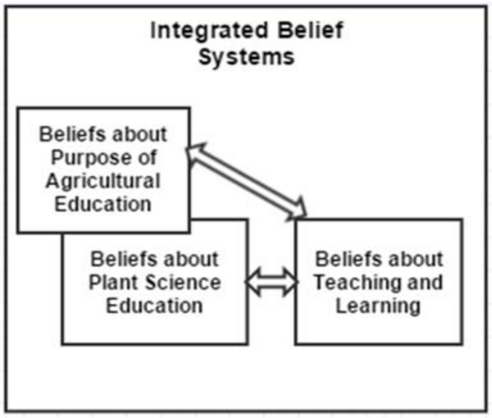

Figure 2. Integrated belief systems of experienced agriculture teachers in the plant sciences

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, and the influence of students' prior knowledge on the teaching of plant science. 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 (see Figure 2). For example, Cora held a primary career preparation view and consequently believed the greenhouse should be utilized to develop career and business skills and the level of science integration should focus on applied science.

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 for plant science content. However, the primary difference between participants was some of them viewed the purpose of greenhouse as a laboratory, others saw it as business, and some had dual purposes for greenhouse. James, with a primary agricultural literacy view, approached the school greenhouse as a laboratory. He stated, "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." Some of the participants viewed the school greenhouse primarily as a business because they had a career preparatory focus or because the school put additional pressure on the viability of the greenhouse. Cora, with a primary career view, described her school greenhouse as a "true production facility." Dawn, with combined agricultural literacy and career preparation views, stated, "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 second plant science belief that emerged from the data was the belief that science integration was a component, at least to some degree, of teaching plant science. Many of the participants 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 also expressed a view of agriculture as an applied science, "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." Kelly, who had a primary agricultural literacy and life skills view, stated, "So I think a good mix of the sciences and the practice is a good combination."

The belief that 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 but instead complimenting biology and other core science curriculum. However, a couple 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. 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." Many participants organized their content to include science based curriculum in the fall and more manual skills content in the greenhouse in the spring.

The final 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. In reference to his plant processes unit James said, "This first lesson is just a review of information that students have learned since 2nd 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 in dialogue with students during my classroom observations.

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." 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 in plant science because they assumed students already had the knowledge. This was 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 prior knowledge, they spent more time in the review stage like I observed in Ashley's unit where she recapped crucial plant science concepts in more detail.

Beliefs about Plant Science Education and its Connection with Teachers' PCK

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." With plant science knowledge not directly tied to skill development, participants were more likely to feel confident having less knowledge than when it was tied to skill development. 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, not because she felt this was an important skill for her students to master for their future careers.

Believing the purpose of the school greenhouse was primarily business also influenced the structure and sequence of the content for some participants. Many participants 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, which was reflected in 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)." While this sequence of fall content and spring application may be the best strategy for student knowledge development, it was the circumstances revolving around the use of the greenhouse, not how the students' best processed the concepts, that drove the curriculum.

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 evidenced through observations, reflections, and lesson artifacts. 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. 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. This was in direct contrast with participants like Jane, with agricultural literacy as her primary view, who developed less PCK and even foundational content knowledge in complex science concepts. Instead she vocalized that knowing the "basics" was enough to achieve her goal of agricultural literacy.

Finally, participants' beliefs about the quantity and quality of prior knowledge possessed by their students in plant science content directly impacted their PCK, specifically their knowledge of content and students. Dawn described that she didn't teach students how to use dichotomous keys in her identification unit because they had experience in biology with the tool. 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 just how influential assumed student prior knowledge was on both the content James decided to teach and the level at which he decided to teach it. Prior knowledge of students, an important concept in PCK, was mentioned by all participants. Some participants seemed to have a more accurate grasp on students' actual prior knowledge evidenced from students' observed responses to content taught and ability to make connections with that content. Other participants' possessed arguably inaccurate assumptions of student prior knowledge, which compromised many of their teaching decisions.

Beliefs about Teaching and Learning

The final component of the integrated belief systems was the participants' beliefs about teaching and learning in agricultural education. These beliefs were distinctly separate from plant science specific education beliefs and delved into general pedagogical beliefs that could apply across content areas in agriculture. Specific beliefs related to teaching and learning that shaped participants' PCK were: a teacher is a lifelong learner and reflector, students have a role in determining content taught, and students learn best through hands-on experience and application.

The most influential belief about teaching learning in agricultural education on the participants' PCK was that it is the teachers' responsibility to be a lifelong learner and reflector. This belief was held by all participants, but was especially evident in conversations with Clint, who also held a student individualization purpose of agricultural education. Clint expressed a need to continually develop new knowledge to meet the needs of each of his individual students. Many participants communicated that 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."

Participants believed agriculture teachers had an obligation to not only engage in lifelong learning but also to reflect on their knowledge and experiences in the classroom. Utilizing stimulated recall, the majority of participants described a variety of instructional strategies for the same piece of content and all the participants expressed that they would like to alter numerous aspects of their lessons for improvement. 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 agreed it was the responsibility of the agriculture teacher to find time for reflection. 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 difficult to reflect on their experiences due to time constraints.

The second belief participants' held about teaching and learning in agricultural education was the belief that students held a substantial role in determining the agriculture content they were taught in the classroom. 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." 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. Because agricultural education was not a mandatory course for students in the majority of these schools, enrollment was critical for teacher employment. 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."

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. 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'. Without those activities, they're not doing it, so, consequently, how much are they learning it?" 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 greenhouse setting. 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. Kelly also utilized hands-on and real life application by incorporating a wedding project in her floral industry unit.

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. In fact, many of the participants utilized lecture in their classrooms 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 contemplation he responded with, "yes, nothing is better than the real thing."

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."

Beliefs about Teaching and Learning and its Connection with Teachers' PCK

Many of the beliefs about teaching and learning described above are most likely common beliefs of teachers in a variety of disciplines. However, they are significant to this study because of their profound influence on the participants' PCK. The belief that teachers should be lifelong learners and reflectors heavily influenced the type of professional development experiences (both formal and non-formal) participants sought out 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 time to engage in this activity. The participants who expressed difficulty in finding time to reflect consequently struggled more than other participants come up with multiple ways to teach content when prompted during the stimulated recall.

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 a topic 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 solely on student inquiry. This often required her to seek out additional knowledge. 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. Some of the participants based entire units around what their students were interested in, whether or not they deemed themselves proficient in content knowledge of that particular topic or experienced in how to teach that topic. Beliefs about the importance of student engagement on student learning also influenced participants' PCK. Ashley 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 content was because students were engaged, and learned more as a result.

The strong belief in hands-on learning led to many participants attending professional development initiatives to develop manual greenhouse skills such as thermostat control, pest management, and maintenance. Participants who utilized the greenhouse more frequently, and who held career preparatory views about the purpose of agricultural education, also attended more of these types of professional development opportunities. If these opportunities were limited 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 curriculum, which relied on a knowledge and comprehension level approach to agriculture content.

Discussion, Implications, and Recommendations

The utilization of grounded theory methodology for this study allowed what was shaping the participants' PCK to surface from the data. The integrated 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. 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 (Magnusson et al., 1999) without exploring them further, I made the decision to refer to them simply as integrated belief systems and not regulate participants into pre-determined categories. Beyond identifying the beliefs of the participants, I also 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. 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 teacher would have a key role in shaping their PCK. These various beliefs led to different PCK development in participants and approaches in the classroom

Grossman's (1990) description of orientations as purposes for teaching more closely fits the integrated belief systems theme that emerged from this study. One particular plant sciences 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 financially and for some it was an important fundraiser for their agriculture program. This additional pressure on the success of plant production in the greenhouse influenced the educational approach used by participants in their plant science units. If the participant's school and community expected a successful plant sale than they were more likely to operate 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 often gave less responsibility to their students. This change in responsibility affected the type and depth of content students learned and the subsequent knowledge teachers' sought.

To varying degrees, all of the participants believed a purpose of plant science was science integration. With the increased emphasis on science, technology, engineering, and math (STEM) education at the national level, agricultural education has been exploring their role in further integrating STEM in the secondary classroom (Stubbs & Myers, 2016). While teaching content based on community needs or student interest was described by various participants, there was also a need to address overarching science concepts that spanned agriculture and science disciplines. Curriculum for Agricultural Science Education (CASE) is one curriculum system that explores rigorous science concepts through student inquiry and experiential methods and provides teacher professional development on use of the curriculum (National Council for Agricultural Education, 2013). If agriculture teachers desire to prepare students for future careers, as evidenced by many of the participants' views about the purpose of agricultural education, then perhaps the focus on science careers within the secondary classroom should increase. To facilitate this shift, agriculture teacher educators need to better prepare preservice teachers to seek out additional science knowledge and to collaborate with other science teachers both during and after student teaching. Tools such as the content representations (CoRe) rubric developed by Loughran, Berry, & Mulhall, (2012) could be utilized to assist agriculture teachers in breaking down science concepts they already address in their classrooms to facilitate their PCK development (Hume & Berry, 2011). It is recommended conversations continue among agricultural teachers and teacher educators about the role of agriculture in STEM education.

Another belief about plant science education that surfaced from the data was the assumption that students possessed more prior knowledge of plant science content than other agriculture content areas. Understanding student prior knowledge of content and utilizing this knowledge in teaching is reflected in various PCK models that address knowledge of content combined with knowledge of students (Gess-Newsome, 2015; Hill, Ball, & Shilling, 2008;

Magnusson et al., 1999; Park & Chen, 2012). However, some of the participants in the study, such as Jane, did not test their assumptions of student prior knowledge and instead just expected the knowledge was acquired in previous science courses. If students possess minimal or inaccurate content knowledge than the connections to new content may be weak or non-existent.

In order for student prior knowledge to facilitate absorption of new content it has to be activated, sufficient, appropriate, and accurate (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010). James, for example, was explicit in making connections between student prior knowledge and new content, evidenced from classroom observations and his dialogue with students. The extent to which students are able to connect the prior knowledge of a subject to new knowledge is dependent upon the nature of their prior knowledge, but also in the instructor's ability to effectively harness that knowledge (Ambrose et al., 2010). Strategies recommended by Ambrose et al. (2010) for assessing student prior knowledge included talking to colleagues, administering assessments, having students assess their own knowledge, brainstorming to reveal knowledge, concept mapping, and examining student work for patterns of error. It is recommended agriculture teachers are both exposed to and encouraged to use these strategies in their own classrooms. Even if all of these strategies are employed and students possess accurate prior knowledge, it still does not guarantee they will be able to apply that knowledge to new material to sufficiently support further learning (Ambrose et al., 2010). Relying on student prior knowledge from elementary and middle school, as evidenced by many participants, may create gaps between what the students know and the new content being introduced.

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 crucial for PCK development (Hashweh, 2005; Schneider & Plasman, 2011). The shared belief that learning and reflecting are critical to engage in throughout their teaching careers is most likely a factor in the development of these participants' strong plant science PCK. 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 agriculture teacher.

A couple participants surfaced that they thought current beginning agriculture teachers were not taking initiative to learn and reflect on content inservice. This lack of reflection could hinder their PCK development (Hashweh, 2005; Schneider & Plasman, 2011). Rice and Kitchel (2016) discovered beginning agriculture teachers often utilized coping strategies that involved ignoring content they were unfamiliar with or simply focusing on content in which they did have expertise. This study indicates a potential issue with the amount of learning that agriculture teachers are engaging in inservice. It is possible that beginning agriculture teachers do not truly understand what it means to be a lifelong learner and reflector. Or they may see the value in lifelong learning and reflection, but do not have the time and/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 to engage in reflection. Traditionally during student teaching, reflection is limited to journal entries that often serve as a sounding board for the emotional challenges of student teaching. While this is a worthy area for support and growth, teacher educators must evaluate whether students are truly engaging in meaningful reflection about practice and approaching reflection as a vehicle for growing as a teaching professional.

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; Friedrichsen & Berry, 2015). Examination of what shapes PCK specifically in agriculture teachers can serve as a starting point for future PCK development studies specifically in agricultural education. Finally, this study focused just on plant science. Future studies should investigate other agricultural content areas such as animal sciences or agricultural mechanics to see what beliefs there are specific to those areas, how many beliefs (if any) overlap with plant science, and what is unique (if anything) to those content areas. The hands-on skill component of agricultural education that was regarded as a hallmark of the discipline by all of the participants could serve as an important vehicle to explore PCK further and could potentially contribute to the larger body of PCK research.

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