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

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Abstract

This grounded theory study explored the pedagogical content knowledge (PCK) of experienced agriculture teachers in the plant sciences. The most emergent phenomenon to surface from the data was the influence of beliefs on participants' PCK. This central phenomenon became the cornerstone for the model of what was shaping experienced agriculture teachers' PCK in the plant sciences. The three major components that shaped the participants' PCK were: integrated belief systems, experiences prior to and during inservice, and the influence of the school and community context. A substantive level theory was developed that illustrated relationships between these three main components and their impact on participants' PCK. Recommendations from this study include conceptualization of experienced agriculture teachers' PCK for a variety of agriculture topic areas and exploration into the development of PCK in preservice and beginning teachers.

Keywords: Pedagogical Content Knowledge; Agriculture Teacher Pedagogical Content Knowledge; Teacher Knowledge

Introduction and Review of Literature

The most significant impact on student learning is the teacher and how they use their knowledge to teach (Darling-Hammond & Bransford, 2005). 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). PCK is a teachers' knowledge of content merged with knowledge of how to teach that content (Shulman, 1986). 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 valuing the content knowledge of teachers and challenged educators to reassess the importance of content knowledge in relation to pedagogy.

Since its introduction by Shulman (1986), various research studies have been conducted to further elaborate on the PCK construct. 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 (Loughran, Berry, & Mulhall, 2012).

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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).

PCK is not just important; it is arguably the most important knowledge base a teacher can possess. Specifically, in agricultural education, PCK is considered critical for effective teaching (Knobloch, 2002; Roberts & Kitchel, 2010). Agriculture teachers' PCK influences their choice of teaching strategies, approach to curriculum, assessment methods, and knowledge of their student base, all within an agriculture context. 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 demonstrate how they influence plant growth. Dispelling this misconception could pave the way for deeper conversations about photosynthesis. Knowledge of student misconceptions for a particular topic 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 cannot describe what PCK agriculture teachers have or need to have for any topic within agriculture. Investigating experienced agriculture teachers currently in the field is an important first step in unpacking agriculture teachers' PCK. In science education research, experienced teachers were consulted to develop documents representing detailed PCK for specific science topics such as genetics and 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). 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 (Rice & Kitchel, 2016). This further substantiates the need to investigate experienced agriculture teachers. Additionally, because this study is focused on providing a foundation for future agricultural education PCK research, it is also important to study teachers with not only teaching experience, but with expertise in a specific agriculture topic.

Purpose of Study

The purpose of this grounded theory study was to conceptualize PCK for a specific topic in agriculture and develop a model for investigation and conceptualization of additional agriculture topics. The guiding question supports priority four of the 2016-2020 National Research Agenda-meaningful and engaged learning in all environments (Roberts, Harder, & Brashears, 2016): What is experienced agriculture teachers' PCK related to the plant sciences?

Methods

The methods used in this study may be similar or identical to methods used in an extension of this study. I chose grounded theory as the research design because of the exploratory nature of my guiding question. PCK research in agricultural education has been limited to a handful of studies (Rice & Kitchel, 2016). Unlike other discipline areas, such as science education, there has not yet been a conceptualization of PCK for specific agriculture topic areas, including the plant sciences. Creating a substantive theory of PCK within the plant sciences has potential to pave the way for future agriculture topic areas to be explored. Additionally, PCK is rooted in the teaching and learning process, and investigating a concept associated with a process is a defining tenant of grounded theory methodology (Corbin & Strauss, 2008). Specially, 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.

I approached this study from a pragmatic lens (Strubing, 2007). Grounded theory has a strong foundation in pragmatism and interactionalism (Strubing, 2007), further supporting this decision. In addition to my epistemological lens, it is also important to disclose my positionality because of its influence on my research (Creswell, 2013). I identify as a former high school agriculture teacher from a multi-teacher agriculture program with a strong background in plant science content. At present, I am employed as a teacher educator at a land-grant university. The goal of my research is to conceptualize the PCK of expert agriculture teachers so this information can be used to enhance preparation of preservice teachers and assist development of practicing teachers. My desire is for more agriculture teachers to feel they have the skills necessary to adequately understand and effectively teach agriculture content.

The sample was composed of eight high school agriculture teachers in Missouri with a minimum of eight years teaching experience. This specific experience range was appropriate for this study because expertise is understood to begin for teachers between five to eight years of teaching experience in the field (Darling-Hammond & Bransford, 2005). Also, the likelihood that teachers possess PCK increases with teaching experience (Hashweh, 2005). The teachers included in the study were purposefully selected using recommendations from teacher educators regarding teachers' quality and possession of plant science PCK. Lastly, the location of the schools in which each of the study participants were located was limited to a 120-mile radius of the university. This geographical boundary increased the feasibility of the field work.

Data Sources and Collection

PCK is demonstrated across the planning, in-the-moment, and reflection phases of teaching (Carlson, Stokes, Helms, Gess-Newsome, & Gardner, 2015; Hashweh, 2005). Reflection is also a key input to PCK development (Schneider & Plasman, 2011; Van Driel & Berry, 2012). More specifically, knowledge, reasoning, and planning prompts explicit reflection *on* action and the act of teaching leads to explicit or tactic reflection *in* action (Carlson et al., 2015).

To adequately study agriculture teachers' PCK in the plant sciences, the inclusion of data sources reflective of all three phases became important. Specifically, I drew on six sources of qualitative data: 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 aforementioned phases and thus contributed to the formulation of a comprehensive view of agriculture teachers' PCK. Data were collected during fall 2014, which accounted for a single plant science unit for each participant. Plant science was identified as an appropriate disciplinary focus primarily because it is a common content area in Missouri taught by numerous experienced agriculture teachers. Secondarily, I had the appropriate content knowledge to recognize and study plant science PCK. Each participant was visited on six separate occasions (i.e., 48 total visits). Considering PCK is in part an internal construct (Baxter & Lederman, 1999), interviews became an essential data source (Padilla & Van Driel, 2011). Accordingly, I conducted semi-structured interviews with each individual participant. The interviews lasted between 45 minutes to an hour. I conducted pre-observation interviews before teachers initiated classroom instruction with the intent of capturing PCK emerging during the planning phase of teaching. An example of a pre-observation interview question was: What strategies will you use to facilitate student learning of concepts in this unit?

I captured PCK emerging during the in-the-moment teaching phase through classroom teaching observations. 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. PCK is not always revealed during a single lesson observation (Loughran, Mulhall, & Berry, 2004). To increase the likelihood of viewing teacher PCK "in action," I conducted two, two day observations of each participant. I video recorded the sessions I observed to enable iterative analysis of instances of PCK and stimulate recall during post-observation interviews. Additionally, I relied on field notes to document instances of PCK that emerged during the in-the-moment teaching phase not captured on video.

PCK is partially an internal construct, which makes its expression difficult to recognize (Kind, 2009). To capture such internal processing, I gathered two additional sources of data that spanned the entire plant science unit. First, I collected lesson artifacts to capture PCK during the planning and in-the-moment teaching phases of teaching (see Hume and Berry, 2011). Second, I relied on teacher journal reflections to illuminate instances of PCK throughout the reflection phase of teaching. The complexity of PCK required me to document the participants' thoughts as the unit progressed. The participants responded to five reflection questions corresponding to each lesson in the unit immediately after its completion. An example of a reflection question was: How did this lesson connect to or build from your other lessons in this unit?

Lastly, I conducted post-observation interviews with stimulated recall to reveal instances of PCK during the reflection phase of teaching. I completed one-on-one semi-structured interviews lasting between 45 minutes to 90 minutes in length upon completion of the unit. For example, I asked the participants the following post-observation interview question: what do you feel were the strengths and weakness of this unit? Additionally, I showed each participant a minimum of three video clips from the two teaching observation blocks to engage their stimulated recall. Stimulated recall is an introspective technique that allows participants to articulate their thought processes and decision making after hearing and/or viewing a recollection prompt (Mackey & Gass, 2005; Meade, McMeniman, Wilson, Kanes, &Davey, 1991).

Data Analysis and Changes to Central Question

I engaged in data collection and analysis simultaneously consistent with the principles of grounded theory methodology (Corbin & Strauss, 2008). I analyzed data originating from all six data sources using a constant comparative process. This analytical technique involves data being compared against other data, beginning with the first piece of datum collected, with the intent of revealing similarities and differences (Corbin & Strauss, 2008). I used the three-step coding process (i.e., open, axial, selective) throughout my analysis (Corbin & Strauss, 2008). Open coding develops categories, axial coding connects categories, and selective coding creates a story ending in a developed theory (Corbin & Strauss, 2008). I used open coding to examine all data sources as they became available to develop initial codes. I then adapted my data collection and analysis to the point of reaching saturation specific to each idea that was revealed to be relevant to the research question (Creswell, 2013). Following the development of a preliminary set of categories, I articulated a pervasive phenomenon that served as the central piece of my theory (Creswell, 2013).

The first three interviews revealed to me that the plant sciences was not specific enough of a topic to be able to adequately describe the participants' PCK and allow for comparisons between participants and the development of a theory. More specifically, the unit topics taught by the participants varied. Concurrently, a different phenomenon was exposed. The participants discussed during the pre-observation interviews their beliefs regarding agricultural education, which was surprising given that questions regarding orientations were purposefully left for the post-observation interviews. During open coding, I also noticed this emerging theme of beliefs that appeared to influence teacher knowledge. A benefit of grounded theory, is the capacity to use a relatively broad research question to illuminate authentic and genuine trends within data (Creswell, 2013). Related, the researcher must remain flexible and willing to alter the original research question to reflect important phenomenon that unexpectedly emerges from the data. The original research question that I raised was: "What is experienced agriculture teachers' PCK related to the plant sciences?" Following uncovering of the central phenomenon, I revised the guiding research question to become: "What shapes experienced agricultural teachers PCK in the plant sciences?" I then re-coded existing data and applied the new research question to all subsequent data collection and analysis activities.

I performed axial coding using my central phenomenon as a guide. Axial coding involves converging data in new, more meaningful ways that is reflective of context, conditions, and consequences (Corbin & Strauss, 2008). This process fosters a better understanding of the central phenomenon and how relevant categories are interrelated. I recorded memos throughout the entire research process and consistently reflected upon them throughout data collection and analysis. These memos were a crucial part of the data analysis process in that they aided me in recognizing how beliefs shaped participant PCK (Corbin & Strauss, 2008).

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 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 and to achieve saturation (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 were developed as the study progressed, and follow-up questions were asked to refine lingering questions about connections in the data.

Validation Strategies

Creswell (2013) described 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, I developed a research question associated with a process. 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, I engaged in open, axial, and selective coding (Corbin & Strauss, 2008). I utilized rich, thick description of the data itself to demonstrate how the theory emerged from the data. I presented the theory as a diagram and a story line was used to connect the concepts of the theory. I used memoing throughout the research process and it was an instrumental tool in surfacing the central phenomenon, establishing connections between categories, and refining the overall substantive theory. I elected to not utilize theoretical sampling in the traditional sense of sampling additional participants to contribute to the developing theory, but instead used it as a means of sampling the existing data and focusing on events, incidents, and scenes that contributed to the developing theory (Fassinger, 2005). I addressed reflexivity and positionality by continuously reflecting on my own previous experiences with content knowledge and PCK to prevent my own biases from overshadowing the emerging data collection and analysis process.

Findings

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 1). Throughout the description of the findings, I elaborated on each of the three main themes in more detail including: connections between themes, the influence of those themes on the participants' PCK, and finally how the three main themes coalesce to explain the overall substantive theory.

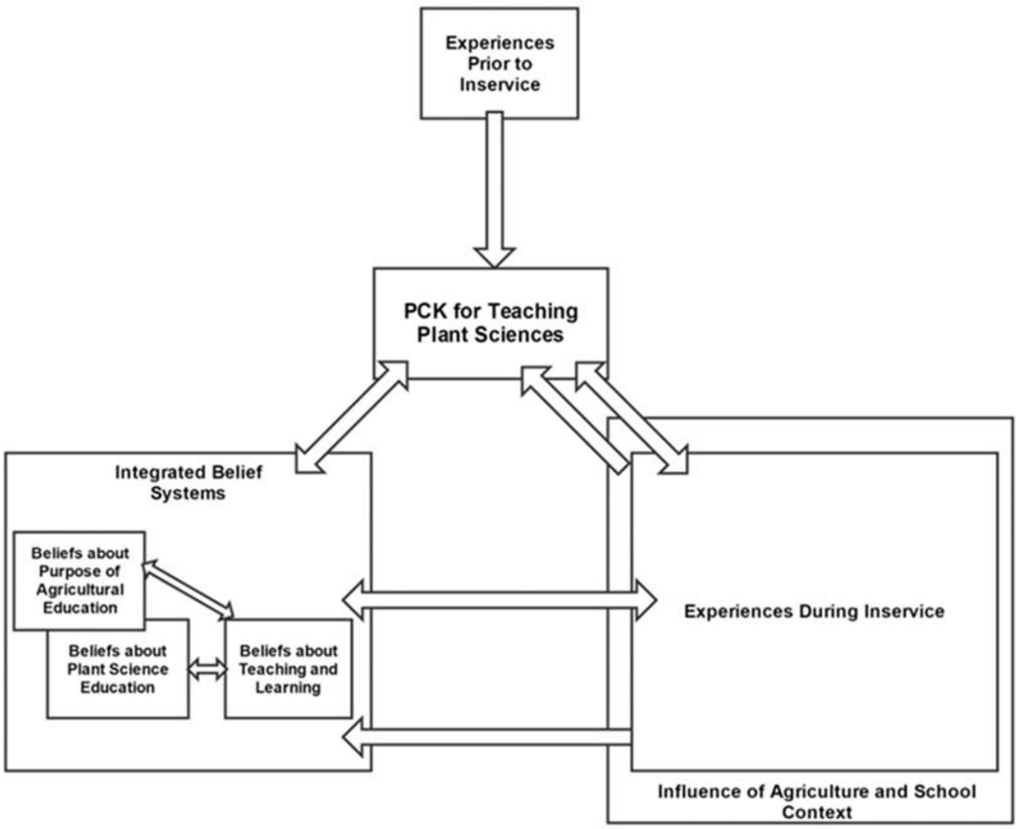

Figure 1. Substantive Theory behind what is Shaping Experienced Agriculture Teachers' PCK in the Plant Sciences

The integrated belief systems theme was presented first because it was the most emergent theme in the study. This theme has previously been described, as it was the richest of the three themes and warranted a thorough unpacking in its own manuscript (Rice & Kitchel, in press). To achieve clarity in the connections between the three main themes and their contribution to the overall theory, I described the integrated beliefs system theme again in this manuscript.

Integrated Belief Systems and their Connection with Teachers' PCK

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. 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 beliefs about the purpose of agricultural education.

Beliefs about the purpose of agriculture included five different views: career preparation, college preparation, agricultural literacy, practical life skills, and student individualization. Clint demonstrated how important beliefs were to his teaching and the structure of his agriculture program. "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." Beliefs about plant science education that emerged from the data included beliefs about the purpose of the school greenhouse (teaching lab vs. production facility), belief that science integration was an important component to plant science, and the belief that students possess more plant science prior knowledge than other agriculture subjects. When describing her balance of student work in the greenhouse, 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."

Finally, beliefs about teaching and learning included: belief that it is the teachers' responsibility to be a lifelong learner and reflector, belief that students played a substantial role in determining the agriculture content taught, and belief that students learn best through hands-on experience. Utilizing stimulated recall, the majority of participants described a variety of instructional strategies for teaching the same piece of content and all expressed aspects of their lessons they planned to alter for improvement. For example, James discussed in a post-observation interview that his students were not effectively grasping plant diseases and contemplated utilizing a disease triangle handout to increase student comprehension. To sum up the importance of reflection Clint stated, "I truly believe sincerely practicing daily reflection of the educational process leads to pedagogical growth as a professional."

Experiences Prior to and During Inservice and their Connection with Teachers' PCK

Many of the participants' experiences prior to inservice directly influenced the participants' PCK in the plant sciences. One participant in particular, Clint, often discussed the role of his own high school experiences on his PCK. 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. 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 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." This quote acknowledged that while experiences prior to inservice could influence participants' PCK, they may not always have the influence teacher educators expect.

Experiences in the classroom also directly influenced participants' PCK. Specifically, classroom experiences developed knowledge about student misconceptions with content and ways to present content 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 plants." 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." Another 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 "through experience in the classroom."

Professional development experiences also directly influenced participants' PCK. Cora illustrated just how important a greenhouse course 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." Cora went on to describe how she utilized experts to help her gain the necessary PCK to teach students how to raise poinsettias. However, professional development for mid-career teachers was a concern for 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."

Contextual Influencers and their Connection with Teachers' PCK

The most emergent contextual influencer in agricultural education was the role of the community, specifically the type of agriculture in the community (e.g. forages production or local greenhouses). 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." Allison and Dawn mentioned their advisory councils, which are bodies of community stakeholders that meet periodically and advise the local agriculture teacher(s) and programs (Talbert, Vaughn, & Croom, 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.

Another contextual influencer specifically related to agriculture is the structure of career development events (CDEs) through FFA as an intra-curricular part of agricultural education. The participants varied in the amount of influence CDEs had on their PCK. James said, "I would say CDE's 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. CDEs for Missouri agriculture teachers involved more than just FFA involvement and application of curriculum. In Missouri, CDE results of students influenced funding for agriculture programs. This assessment method contributed to the type of knowledge participants developed because many felt the need to teach to the test.

In addition to agriculture specific contextual influencers, there was also the influence of the participants' school structure and available resources. Being in a multi-teacher or single teacher program influenced 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 [agriculture program] 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. Facilities and monetary resources influenced participants' abilities to seek out professional development opportunities and invest in supplies for their classroom. CASE, an agriculture instructional curriculum, 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. 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.

Summary: Connection of Themes to the Substantive Theory

Within this substantive theory, all three themes (beliefs, experiences, and context) influenced PCK directly in a variety of ways. Additionally, experiences can alter beliefs, beliefs can determine experiences pursued, and teachers are always developing new knowledge for teaching within a particular context. Development of PCK occurs over the course of a teachers' entire career. 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 FFA, CDEs, and the community context were a critical part of this overall model because they heavily influenced the other components. Finally, the integrated belief system was the most emergent phenomenon in the overall theory with beliefs about plant science education and beliefs about teaching and learning in agricultural education mirroring beliefs about the purpose of agricultural education.

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 educational 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 (beliefs, 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 in the literature (Friedrichsen, Van Driel, & Abell, 2010). 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.

Experiences also had a significant 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 sources were mentioned by participants in some capacity as influential sources of PCK. 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 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 & Bransford, 2005) and high school experiences were an important source of content knowledge and PCK for inservice agriculture teachers (Rice & Kitchel, 2015). However, utilizing high school experiences as sources of knowledge could be problematic as both agriculture content information and pedagogical information changes over time.

While teacher preparation programs are an important source of knowledge for agriculture teachers (Rice & Kitchel, 2015), 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.

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 (Carlson et al., 2015; Etkina, 2010; Van Driel & Berry, 2012), developing PCK in a variety of agriculture topics within various content areas could be challenging, particularly in a single teacher program. 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.

Finally, context greatly influenced the PCK of experienced agriculture teachers. Since the beginning of agriculture programs, agriculture teachers have been encouraged to utilize their teaching autonomy to design their agriculture programs around their local communities (Talbert et al., 2005). Talbert et al. (2005) also claimed 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 for production vs. 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.

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 with substantial forage production, described professional development he attended specifically in grasslands to better meet the individual needs of his community. Additionally, participants expressed a desire to teach to the interests and needs of their students, which related to the local community influence. If the agricultural education discipline as a whole desires 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.

Recommendations for Practice

Clint discussed that he engaged in agriculture experiences outside of his strength areas and made an effort to develop new content knowledge and PCK. Kelly and Dawn also supplemented their knowledge with work experience during college and held the belief that teachers should be lifelong learners and reflectors. 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. 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 educators.

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 & Lederman, 1999; Hashweh, 2005). These experiences were especially impactful when they were combined with in-depth reflection (Hashweh, 2005). 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.

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, Rogers, Hanuscin, & Gagnon, 2009). Therefore, it is recommended the quantity and quality of professional development for inservice teachers should also increase. There is evidence from the literature that professional development can impact the PCK of beginning teachers (Clermont et al., 1994). 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.

Recommendations for Research

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 reflections 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.

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.

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