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The Development of Preservice Agriculture Teachers' Pedagogical Content Knowledge through a Greenhouse for Teachers Course

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Abstract

The purpose of this qualitative research study was to explain the development of preservice agriculture teachers' PCK for the concept of plant fertilizers within a content-focused methods course. The emergent central phenomenon was an overall lack of PCK development for plant fertilizers, highlighted by five main themes that impeded the development. Preservice teachers felt less self- efficacious in horticulture content knowledge and possessed a greater desire for horticulture content knowledge over pedagogical knowledge. Additionally, the preservice teachers exhibited development of horticulture content knowledge and mathematics content knowledge through the unit. Finally, the lack of a content knowledge foundation inhibited the development of PCK in preservice teachers, despite the purpose of the course and vision of the instructor. Recommendations include more purposeful integration of PCK at the preservice level, utilization of tools like the CoRe rubric (Loughran, Mulhall, & Berry, 2004) during lesson planning, increased field experience imbedded in the teacher preparation program, and a more careful examination of the preservice teachers' pre-existing content knowledge base prior to enrollment in the content-focused methods course.

Keywords: Preservice Agriculture Teachers; Pedagogical Content Knowledge; Preservice Agriculture Teacher PCK; PCK Development

Introduction

Teachers perform a significant role in the process of student knowledge acquisition and construction (Gablinske, 2014). Effective teaching of any content area requires teachers to develop a variety of professional knowledge bases that undergird instruction (National Research Council, 2010). Historically, there have been shifts in which knowledge bases are considered most important for effective teachers to possess, with content knowledge and pedagogical knowledge both having periods of focus in early research, certification, and professional development efforts (Ong, 1958). Shulman (1986) recognized the importance of content knowledge during a time when pedagogical knowledge was at the forefront of education reform. He postulated that teachers possessed more

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than just content knowledge and pedagogical knowledge alone, and coined the term pedagogical content knowledge (PCK) to describe knowledge specific for teaching content (Shulman, 1986).

PCK research has blossomed over the past three decades, with various models and definitions utilized across education disciplines to describe the elusive knowledge base (Kind, 2009). More recently, Morrison and Luttenegger (2015) defined PCK as a teacher's intersection of content knowledge, pedagogy, and the context of the learning situation. The foundation of PCK lies in a teacher's ability to convey knowledge to students effectively and aid them in developing a deeper understanding of content (Morrison & Luttenegger, 2015). PCK is not solely based on what a teacher knows about a content area, but rather how they are able to use that knowledge purposefully while teaching their students (Beyer & Davis, 2011).

Despite the importance of PCK in the literature, empirical research illuminates a struggle for teachers in numerous education disciplines to develop this complex knowledge base (Ball, Thames, & Phelps, 2008). Specifically, in agricultural education, Rice and Kitchel (2015a) found preservice teachers were displeased with the quality and quantity of content knowledge gained in their teacher education programs and their perceived ability to transfer that knowledge to their future classrooms for teaching. While time and experience are necessary ingredients in the cultivation of PCK, development can begin to occur at the preservice level with the aid of teacher preparation programs (Hume & Berry, 2011; Magnusson, Krajcik, & Borko, 1999; and Schneider & Plasman, 2011). One such course with potential to develop PCK in preservice agriculture teachers is the Greenhouse for Teachers course at the Southern Land Grant University (SLGU). This qualitative study will focus on elucidating the PCK trajectory of preservice agriculture teachers within the context of a plant fertilizers unit within the Greenhouse for Teachers course.

Literature Review

PCK has become accepted across education disciplines as a dynamic form of teacher knowledge that is constantly being expanded and transformed from other teacher knowledge bases (Nilsson, 2008). At times, it can seem meaningless because of it extensity, or it can seem reiterative because of its narrowness (Nilsson & Loughran, 2011). Various models and definitions have attempted to further describe PCK, often including knowledge of students, knowledge of instructional strategies, knowledge of curriculum, and knowledge of assessment, all within a content area context, as essential components (Kind, 2009). More recently, PCK has been defined as not only specific to a particular concept or topic, but also specific to the individual teacher, their personal beliefs, and the situation (Van Driel & Berry, 2012). PCK research studies have explored disciplines ranging from science education, to elementary education, to agricultural education; have focused on both practicing and preservice teachers; and have targeted topics as broad as plant science and as specific as using particle models in chemistry (De Jong, Van Driel, & Verloop, 2005; Magnusson et al., 1999; Nilsson & Loughran, 2011; and Rice & Kitchel, 2017).

Regardless of the context or domain, PCK is a critical knowledge base not only for practicing teachers to possess, but also for preservice teachers to begin to develop (Kilic, 2009). Preservice agriculture teachers typically spend four years in a teacher preparation program with the expectation that upon completion they will gain the knowledge needed and the skills necessary to effectively teach their future students (Rice & Kitchel, 2015a). University teacher educators have similar goals when preparing preservice teachers. If teachers are not well-versed in the content they are teaching, they are in danger of passing on misconceptions and inaccurate information to their students (Darling-Hammond & Bransford, 2005). The desire to adequately prepare preservice teachers for the numerous challenges they will face in their future classrooms is a priority for teacher educators nationwide (Stuart & Thurlow, 2000).

However, preservice teachers do not enter teacher preparation programs as blank slates. Contrarily, they bring with them preformed beliefs about education based on their prior knowledge and experiences (Stuart & Thurlow, 2000). These beliefs are usually formed early, and they rarely fade away, even after years of purposeful instruction (Darling-Hammond & Bransford, 2005; Kagan, 1992). The challenge for teacher educators resides in the fact that many of those beliefs are inaccurate and faulty, which can lead to issues in the development of preservice teacher knowledge, including PCK (Stuart & Thurlow, 2000). Nilsson and Loughran (2011) contributed to the research of PCK development in preservice teachers with a study involving preservice elementary science teachers. Their study showed if preservice teachers are engaged in purposefully identifying, self-assessing, and clearly developing their knowledge of teaching in a specific content area, their understanding of PCK can increase (Nilsson & Loughran, 2011).

There have been a myriad of studies exploring the PCK of preservice teachers. In their science-based study, Nilsson and Loughran (2011) utilized the content representations (CoRe) rubric designed by Loughran, Mulhall, and Berry (2004) to research the development of PCK in preservice elementary science teachers enrolled in a science methods course. They discovered PCK exploration can offer an alternative way of thinking about preservice teacher preparation that goes beyond traditional teaching methods (Nilsson & Loughran, 2011). Finally, Rice and Kitchel (2015a) uncovered a lack of agricultural content knowledge confidence in preservice teachers at a large mid-western university. The participants in the study revealed hesitance for teaching agriculture subjects for which they did not feel efficacious in the content (Rice & Kitchel, 2015a).

There have been few studies conducted that relate to the PCK development of preservice teachers specifically in agricultural education (Rice & Kitchel, 2015b). Schneider and Plasman (2011) recommended more research concentrate on preservice teacher PCK development within specific topic contexts. For this study, not only was agricultural education the overarching discipline of focus, but the specific topic of plant fertilizers was highlighted. According to the Southern State (SS) Department of Education (2013), plant science and horticulture are among the most commonly taught content areas in the SS. This study heeds the previous scholar recommendations through its investigation of preservice agriculture teachers' PCK development in one of the more commonly taught areas of agriculture.

Purpose and Research Question

The purpose of this qualitative research study was to utilize grounded theory methods to explain the development of preservice agricultural teachers' PCK for the concept of plant fertilizers during a fertilizers and supplements unit. This unit was a part of the Greenhouse for Teachers course curriculum at a Southern Land Grant University (SLGU). The central question guiding the study was: How does preservice agriculture teachers' PCK for the concept of plant fertilizers develop during a Greenhouse for Teachers content-focused methods course? This study aligns with priority four of the 2016-2020 National Research Agenda- meaningful and engaged learning in all environments (Roberts, Harder, & Brashears, 2016).

Methodology

This research study employed a grounded theory design. Grounded theory was selected based on the exploratory nature of the central research question. PCK is a complex knowledge base that develops over time with experience (Hashweh, 2005; Kind, 2009). Because this study was focused on a developmental process, grounded theory methodology was an appropriate methodological fit (Birks & Mills, 2015). Additionally, conceptualization of preservice teachers'

PCK development for a specific concept (plant fertilizers) can serve as a foundation for future studies. Specifically, this study was guided by the work of Birks and Mills (2015).

The purpose of a grounded theory approach is to generate new theory from collected data (Birks & Mills, 2015). Because grounded theory is consistent with the philosophy of pragmatism, this grounded theory study was approached using a pragmatic lens (Birks & Mills, 2015). According to Birks and Mills (2015), the ontological, epistemological, and methodological roots of the pragmatic paradigm are in line with grounded theory methodology.

It is important that I not only share the epistemological lens that guided my study, but also disclose my positionality because of its impact on my research (Creswell, 2013). As an undergraduate student, I was enrolled in numerous methods and curriculum development courses that were designed to develop pedagogical knowledge. I have also taken courses that covered a range of content knowledge areas including: agricultural technologies, soils, and aquaculture, to name a few. When I began my student teaching experience, I realized there was something missing from my teacher training. I possessed some content knowledge and some pedagogical knowledge, but I failed to learn how to link the two together. I am currently a practicing agriculture teacher, and I continue to find myself attempting to link content knowledge and pedagogical knowledge in my instruction. The goal of my research is to conceptualize the PCK of preservice teachers, so the findings can be used to assist teacher preparation programs.

Participants

Participants in this study included six preservice agricultural education teachers enrolled in a Greenhouse for Teachers course. Preservice teachers were chosen as the population to determine how their PCK for the concept of plant fertilizers were formed. All participants were in their third year of the agricultural education program. Educational backgrounds of the participants prior to enrollment in the program varied. Commonalities included all preservice teachers had all taken introductory-level education courses before the Greenhouse for Teachers course. Three out of the six preservice teachers had taken a Soils and Hydrology content course and an Agriscience for Teachers content focused methods course at the SLGU. All six preservice teachers will be completing their student teaching experiences one year following their participation in this study.

Data Sources and Collection

PCK can be explored using a wide array of methods, and more than one data source is recommended for thorough investigation (Morrison & Luttenegger, 2015). To effectively elucidate the development of PCK, even for a concept as specific as plant fertilizers, it was important to investigate different sources of data that could reveal PCK. Four sources of qualitative data were collected including: pre-observation interviews, classroom observations, field memos, and post-observation interviews. Triangulation was achieved by utilizing the four data sources to corroborate evidence (Creswell, 2013). The use of various sources of data added rigor to the collection process and increased the probability that PCK would be captured given this study focused on only one concept within the course (Creswell, 2013).

Because PCK is content and topic specific, the plant fertilizers unit within the Greenhouse for Teachers course was utilized for data collection and focused on the following SS Department of Education (2013), General Horticulture and Plant Science standard: AFNR-GHPS-9 Explore the use of plant fertilizers and proper fertilizing methods.

The unit was taught over a course of two class meetings. The first day was used primarily for lecture. In this lecture, the professor began and ended with discussions about pedagogical strategies that could be used to teach the content. He also included instruction in the content knowledge involved in a plant fertilizers unit. The second day was used for application of that content knowledge. The preservice teachers were divided into three groups in a greenhouse laboratory setting to perform three separate lab activities related to the concept of plant fertilizers. The laboratory activities included the following: irrigation controls, temperature controls, and water-soluble fertilizers. The groups rotated in thirty-minute increments with the purpose of developing knowledge in the content of plant fertilizers as well as how to teach that content to future middle and high school students.

Data from this study were collected spring of 2016 during the plant fertilizers unit in a Greenhouse for Teachers course. Pre-observation interviews took place at least one week prior to the classroom observations of the unit. These one-on-one semi-structured interviews were audio recorded for transcription. The following are examples of questions that the preservice teachers were asked during the pre-observation interviews: 1) Tell me about your background in plant science specifically related to this plant science unit, 2) why did you enroll in Greenhouse for Teachers, 3) what specific teaching strategies could be used if you were teaching this unit, 4) what specific assessment strategies could be used to teach this unit, and 5) what are your beliefs about teaching greenhouse and plant science? Each day of the unit was observed, and the researcher recorded field notes during each classroom observation. The purpose of the observations was to provide further context to the unit and to enable the researcher to witness first- hand student and instructor interactions, questions that arose from instruction, and were utilized as prompts for questions in the post-observation interviews.

Post-observation interviews were conducted after the unit was complete. It was important to conduct the interviews as soon as possible after the completion of the unit, so the events from class were easier to recall for the preservice teachers. These interviews reflected on the unit and were designed to encourage preservice teachers to think more deeply about their PCK development for plant fertilizers. The following are examples of questions that the preservice teachers were asked during the post-observation interviews: 1) What aspects of this unit (if any) contributed to your ability to teach this unit in the future, 2) what aspects of this unit (if any) contributed to your ability to design curriculum for this unit in the future, 3) what aspects of this unit (if any) contributed to your ability to create assessments for this unit in the future, 4) What aspects of this unit (if any) contributed to your understanding of student learning for teaching this unit in the future, and 5) what specific teaching strategies could be used if you were teaching this unit?

Data Analysis

Following the guidelines of Birks and Mills (2015), this grounded theory study required collection and analysis of data to be completed simultaneously. Each interview and observation video was transcribed verbatim. All data sources were used during data analysis. Constant comparative analysis was performed to compare data against data (Birks & Mills, 2015). Data were sorted during collection, initial codes were developed, and questions were altered to explore emergent phenomena present in the data (Birks & Mills, 2015).

NVivo 10 qualitative software was the data management platform used for analysis. All verbatim transcriptions, field memos, and observation videos were loaded into the program for analysis. NVivo 10 was utilized to organize and code data, establish connections between codes, create memos, and organize literature related to the study. Open, axial and selective coding

procedures were followed to develop codes, connect codes into categories, and to develop themes, respectively (Birks & Mills, 2015).

Validation Strategies

Four validation strategies for qualitative work as described by Creswell (2013) were utilized in this study. The strategies included: triangulation, clarifying researcher bias, member checking and rich, thick description. The four data sources collected throughout the study were utilized to provide evidence of the phenomena. Triangulation was attained by gathering the data from both pre and post observation interviews, classroom observations, and field memos. Corroborating evidence from all four data sources were used to shed light on the emergent themes (Creswell, 2013). Researcher bias was clarified by addressing past experiences, prior bias or prejudices, and orientations that could have possibly shaped the interpretation of the study (Creswell, 2013). Rich, thick description was used to provide a clear explanation of the development and findings of the study, including participant quotes and researcher observations (Creswell, 2013). Finally, the researcher engaged in member checking of the findings to ensure accuracy of the participants' responses (Creswell, 2013). This is the most crucial technique for establishing credibility in qualitative research (Lincoln & Guba, 1985). Member checking in this particular study involved restating and summarizing information during interviews, checking transcripts, and sharing emergent findings with participants for feedback.

Findings

The emergent central phenomenon was an overall lack of PCK development for plant fertilizers. Instead, the data centered around the preservice teachers' development of horticulture content knowledge, rather than their development of PCK for plant fertilizers. Five main themes surfaced that impeded the PCK development of preservice teachers during a Greenhouse for Teachers course.

Preservice Teachers Felt Less Self- Efficacious in Horticulture Content Knowledge

The six preservice teachers in this study all had minimal backgrounds in horticulture content, specifically in the topic of plant fertilizers. Although they did recall content-related courses taken in high school and college, there was an overall low perceived self-efficacy among the preservice teachers in relation to horticulture content knowledge. During her pre-observation interview prior to the beginning of the unit, Callie reflected on her past college courses and experiences, "I really don't have any background in any kind of plant structures, fertilization, anything like that." After the unit concluded, Callie's self-efficacy had not changed much. When asked what areas of content she felt confident in, she replied,

> Honestly, only animal science. That's the only one that I would feel like I could go into the classroom [and teach] and really that's kind of a stretch. Horticulture is getting there just because its bringing a lot of stuff back from high school that I did learn, but as far as being able to walk into a classroom and being able to teach a lesson, I think animal science would be the only one.

Ashley and Lindsey also expressed concerns with content knowledge levels related to horticulture and their ability to teach that content to future students. Ashley stated, "The fertilization part I don't know a lot about at all". Lindsey shared, "I feel like I'm not extremely confident in any area of agriculture". The preservice teachers enrolled in the class did not express confidence in their

ability levels related to plant fertilizers content before or after the unit, making it difficult for PCK to develop.

Preservice Teachers Possessed a Greater Desire for Horticulture Content Knowledge over Pedagogical Knowledge

Another element that impeded the development of PCK in the Greenhouse for Teachers course was the preservice teachers' personal desire for content knowledge procurement, rather than pedagogical knowledge or PCK. They expressed aspirations related to content knowledge acquisition during both the pre and post-interviews and classroom observations. I observed the preservice teachers asking questions related solely to developing content related knowledge. During an interview, when asked why she enrolled in the course, Marsha responded,

> Well since I am going to be an ag teacher, I'm most likely going to have a greenhouse. I figured it would be good to learn about greenhouses and have more knowledge about them, because really all I knew before was, yes, we have one, it controls the temperature, and you grow plants in it.

Even after being asked her overall goal for the unit, Marsha's response was strictly content-related. "I'm hoping that I will have a better understanding for greenhouses and plants in general."

Ashley described an earlier instance in the course when Dr. James presented ways future students of the preservice teachers could utilize what they were learning in a horticulture class within their Supervised Agricultural Experience Programs. She did not think class time should be spent on that topic. "I feel like we could have spent less time on that [Supervised Agricultural Experience Programs] and going ahead and gone to the greenhouse and got things, seed in and stuff like that". The preservice teachers' expressed desire for learning content knowledge over pedagogical knowledge, or even a combination of the two, could have negatively affected the development of PCK throughout the unit.

Preservice Teachers Exhibited Development of Horticulture Content Knowledge and Mathematics Content Knowledge

Although there was no substantial evidence that PCK was developed among the preservice teachers, it was clear that they developed some content knowledge related to the unit topic, plant fertilizers. During field observations, it was easy to observe the preservice teachers gaining content knowledge. Most of the class discussions for the two days of observation related to fertilizers and how to operate the fertigation system. They continuously asked questions of the instructor, Dr. James, that were specifically related to the content, rather than how to teach that content. When asked what information he gained from the unit, John focused mainly on content-related items.

> I learned how to find the rate of water soluble fertilizer, doing that math. I learned how to set the irrigation system where you can add fertilizer through it, the overhead irrigation. I really liked learning how to calculate the math part because I didn't know how to do that before and it's really useful to know how to do that.

There weren't any preservice teachers who shared a pedagogical-based learning outcome from the unit, even when prompted by "What aspects of this unit, if any, contributed to your ability to teach this unit in the future?" and other similar questions. The second day of field observations also highlighted content knowledge development in horticulture. The class of preservice teachers was divided into groups, and each group was given a different greenhouse system. While rotating

through the stations, I observed the preservice teachers discussing how to work the systems, but there was no evidence or discussion of what strategies they could use to teach those systems or struggles in their future careers as agriculture teachers.

The first day of observations was used for whole-group discussion in the classroom. While observing on the first day, I noticed development of a different type of content knowledge. Along with horticulture-based content knowledge, the preservice teachers also developed mathematics content knowledge, specifically within the area of conversions. During the discussion, Dr. James mentioned a mathematics concept to the teachers called the "rule of 75". Dr. James assumed the preservice teachers had heard of the concept before, however, there was not a single preservice teacher in the room who knew or understood the concept. Due to this lack of understanding, Dr. James focused his instruction on the "rule of 75". This lack of background knowledge led to more time being spent on content knowledge development in both horticulture and mathematics.

Following my observations, I altered the post-observation interview questions to include discussion of the "rule of 75". All participants admitted they had no prior knowledge of the math concept. When asked about the topic, Lindsey replied, "I'd never heard of it, so yeah, I was pretty lost too". John had a similar response. "I had no idea what he was talking about, at all." After the unit, however, the preservice teachers felt as if they understood the math-related content knowledge taught during the unit. Callie made this evident in her post-observation interview. "He taught us how to mix fertilizers, how to calculate certain requirements for different plants, so how each plant, what they need, and how to calculate that, and then how to actually mix it." Content knowledge in horticulture and mathematics related to plant fertilizers were developed, but there was no real evidence of pedagogical development or PCK for the preservice teachers.

The Lack of Content Knowledge Foundation Inhibited the Development of PCK in Preservice Teachers

The preservice teachers' lack of horticulture content knowledge before the unit, or even the course, and its inhibition of the development of PCK, was a fourth theme that emerged during the study. Analysis of the pre-observation interviews revealed a lack of content knowledge possessed by most of the preservice teachers before the start of the unit. Callie stated her lack of content background, "I don't have an understanding [of plant fertilizers], so I really need everything I can get out of the class". This suggested basic content knowledge of fertilizers would need to be taught. As a result, the majority of the time for the fertilizers unit was spent on developing basic content knowledge among the preservice teachers.

During the first day of field observations, I noticed the preservice teachers constantly asked content-related questions. The professor, Dr. James, spent most of his time during the unit answering content-related questions, and explaining material he expected the preservice teachers to already know. When Dr. James first mentioned the "rule of 75", he realized the preservice teachers didn't know as much as he thought. He asked John, "Where else do you see that [rule of 75]? John responded, "I haven't". The entire class had confused looks on their faces. Dr. James replied, "Alright that's okay. Anybody ever seen that before?" When none of the preservice teachers reacted, he proceeded to explain the "rule of 75" to the preservice teachers.

The first day of the unit was spent in the classroom. Dr. James began the day by having the students review a model for experiential learning. This learning model was learned by the preservice teachers within the course, but it was not taught during the plant fertilizers unit. After a quick review, he introduced the topic of water-soluble fertilizers. From there, the discussion continued with numerous questions from the preservice teachers about how to calculate fertilizer

concentration and how to operate the dosimeter (a device that injects a small quantity of concentrated fertilizer solution into the irrigation line in a greenhouse). The questions initiated by the preservice teachers revealed a lack of content knowledge in horticulture and math, related to plant fertilizers, to build upon before the unit even began.

The second day of the unit, the class worked in groups to operate one of three different systems in the greenhouse. The time spent during class that day was again focused almost entirely on content knowledge development, because the instructor saw a need to for the preservice teachers to start learning the content at an introductory level. Following announcements, Dr. James began the discussion by recalling a question asked by Ashley at a previous class meeting. This question began the content-based discussion that would last the remainder of the observation time. The preservice teachers' lack of content knowledge in plant fertilizers resulted in a lack of time for pedagogical skill development during the unit; therefore, the preservice teachers could not connect the content and pedagogical knowledge bases of fertilizers to develop PCK.

A Lack of PCK Developed, Despite the Purpose of the Course and Vision of the Instructor

The purpose of this study was to describe the preservice teachers' development of PCK for the concept of plant fertilizers. Instead, there were factors throughout the unit that inhibited the development of PCK. Before observation of the fertilizers unit, there was an anticipation that preservice teachers would potentially feel confident and prepared about teaching agricultural content related to fertilizers when beginning their career as an agricultural education teacher. Preservice agricultural education teachers did not develop PCK for the concept of fertilizers.

Callie made it evident she learned the content material, but she did not make the connection to pedagogy needed to develop PCK. "I think that it [fertilizers] was taught to where we could understand it, but I'm not sure that I have a great foundation of how to teach that to other students." Amy also thought she grasped the content of fertilizers, but she failed to connect the reason why the topic should be taught to her future students. "I don't understand, like, I understand why we had to learn it, but it' s not really anything that we can teach. Because they can't really mess with the fertilizer, because you can't really trust a high school student to do it." After the unit, Marsha was able to share numerous examples of content knowledge she gained from the two days of instruction; however, when asked if there was anything that occurred during the course of the unit that influenced her ability to teach this in the future, she replied, "I don't really think there was any". Overall, the development of PCK among preservice teachers during the plant fertilizers unit was virtually non-existent. The preservice teachers failed to see the connection of taking the content they already knew or learned during this unit and applying it to teaching future students.

Discussion

In this research, the original goal was to use grounded theory methods to explain the development of preservice agriculture teachers' PCK for the concept of plant fertilizers. The emergent central phenomenon was an overall lack of PCK development during the unit, highlighted by five themes that impeded the development. This study has echoed the findings of related studies by reiterating the complex nature of PCK development (De Jong et al., 2005).

If a teacher does not possess PCK, he or she is more likely to have a low self-efficacy related to teaching that content area (Kola & Sunday, 2015). Interviews with preservice agriculture teachers in this study revealed their low self-efficacy levels in horticulture-related content. This lack of self-efficacy impeded PCK development. The preservice teachers felt as if they could not teach if they did not understand the content they were teaching. Pendergast, Garvis, and Keogh

(2011) found that as a greater understanding of the teaching profession is gained, the self-efficacy level of preservice teachers declines. The first theme that impeded the development of PCK in this study supports this finding. The participants in this study had all taken at least two introductory-level education courses. It is possible their low self-efficacy stemmed from their budding understanding of the reality that comes with being a teacher. In addition, the preservice teachers had very little, if any, background in the content area of plant fertilizers. The experience that was mentioned by the participants included high school classes that, for most, took place three to four years prior to the Greenhouse for Teachers course. The lack of content related courses in the past could have contributed to their low self-efficacy, because they did not feel proficient in the content.

Similar to this study, Rice and Kitchel (2015a) discovered a lack of confidence in preservice teachers' agricultural content knowledge at the University of Missouri. It is possible the lack of confidence and self-efficacy in plant fertilizers resulted in the preservice teachers' desire for content knowledge, rather than pedagogical knowledge or PCK. A large amount of class time during the unit was used for the professor to stop and explain content-related terms and concepts. The focus on content knowledge development guided by their desire to gain fundamental fertilizer knowledge, could have led to the preservice teachers missing the pedagogical aspect of the unit or course entirely. Content knowledge is the foundation for PCK development, however, the learning does not stop there (Ozden, 2008). The preservice agriculture teachers entered the unit with a desire for content knowledge acquisition, and they attained that goal. However, just because they are now more confident in plant fertilizers content, does not mean they can effectively teach that material to future students. It is critical for preservice teachers to know and understand the subject matter being taught, but it is also important they know how to teach it to a diverse group of learners and are able to assess their learning (Gardner, 2006).

During the pre-observation interview stage, all the preservice teachers expressed a lack of content knowledge foundation for plant fertilizers. When compared to the post-observation interviews, this revealed that the lack of a content knowledge foundation impeded the development of PCK. More and more preservice teachers are entering agriculture education programs with a limited amount of content knowledge in various areas of agriculture (Rice & Kitchel, 2015a). Over half of the preservice teachers in the study felt as if they would not feel confident teaching a horticulture course to middle and high school students. They felt more confident in the agriculture areas in which they had a strong content background, such as animal science. According to the SS Department of Education (2013), agriculture teachers should be prepared to teach a wide variety of agriculture content areas. In this case, the professor of the Greenhouse for Teachers course had to take time to fill in the content knowledge gap of plant fertilizers, at the expense of the purpose of the unit, PCK development.

The development of PCK in preservice teachers is an extremely complex process (De Jong et al., 2005). This research was an attempt to exhibit that process of development, but instead highlighted several impediments to the process. The purpose of the unit was to develop preservice agriculture teachers PCK in plant fertilizers. There were inhibitors during the unit that stunted PCK development. Preservice teachers need to enter content-focused methods courses with a stronger background and understanding of the content knowledge associated with the subject matter at hand, so more time can be spent on combining the existing pedagogical and content knowledge to more purposefully form PCK.

Recommendations for Practice and Research

If preservice teachers are encouraged to understand PCK as a knowledge base, they will be more aware of the process they are undertaking (Kind, 2009). Therefore, it is recommended the

syllabus of the Greenhouse for Teachers course be structured to include exposure of PCK as a knowledge base. Instructing the preservice teachers on the basics of PCK could increase the likelihood that they understand what they are supposed to be gaining from the course. This could possibly decrease time spent exploring content knowledge and increase the time spent on PCK.

In addition to including PCK as a part of the syllabus, it is recommended the instructor of the course clearly exhibit the purpose of the Greenhouse for Teachers course at the beginning of the semester. Goal setting is an integral part of motivation and learning for all ages (Schunk, 2012). In the future, setting learning goals for the preservice agriculture teachers could increase the likelihood of PCK development. If the preservice teachers are told what is expected of them, and they make a commitment to meet those expectations, they are likely to alter their performance to work toward achieving those goals (Schunk, 2012). If goals for pedagogy, content, and PCK development are set in place, it could increase the likelihood of PCK development in preservice agriculture teachers in future Greenhouse for Teachers courses.

In addition to setting goals, the professor could incorporate the CoRe rubric designed by Loughran et al. (2004). The CoRe rubric is a valuable tool that can increase preservice chemistry teachers' awareness of components that will eventually lead to their PCK development (Hume & Berry, 2011). If incorporated in the Greenhouse for Teachers course, the CoRe rubric could positively impact the PCK development of preservice teachers. The findings from Hume and Berry's (2011) study demonstrate CoRe rubrics could be an ideal beginning for the growth of PCK, regardless of the educational backgrounds of the preservice teachers. It is recommended the instructor incorporate the use of CoRe rubrics to aid students in developing their PCK.

Field experience is a central component to effective teacher preparation (Darling-Hammond, 2006). It could be beneficial for preservice agriculture teachers in the Greenhouse for Teachers course to visit middle and high school classrooms where horticulture is being taught. As a part of the current course curriculum, the preservice teachers visit different schools to see the structures of greenhouses, but it is likely a visit to see teaching in those classrooms and greenhouses could be more effective for their PCK development. An increased exposure to teaching through early field experience could facilitate a connection between the pedagogical knowledge and content knowledge of the preservice teachers.

In addition to recommendations for components within the course, it is also recommended the course be placed in a later sequence of the preservice teachers' preparation program. Most preservice agriculture teachers in the study expressed very little background in both pedagogical knowledge and horticulture content knowledge. Since the structure of the Greenhouse for Teachers course does not currently warrant any pre-requisite courses, it could be beneficial to place it later in the preservice teachers' course sequence, after additional methods and curriculum development courses. Finally, a content related course, like Soils and Hydrology, could serve as a pre-requisite for preservice teachers enrolled in Greenhouse for Teachers.

It is also recommended more research be conducted to explore how PCK develops among preservice agriculture teachers. This study only focused on one unit within a single course at the SLGU. Since only one unit was represented, the same findings may not hold true for other units within the course. This study could be replicated with similar units and courses at the SLGU and other universities that engage in agriculture teacher preparation. It is also possible that studying PCK development in preservice teaching is too ambitious; maybe their development for PCK does not occur until later in the teacher education program. It is recommended more studies be conducted to determine the PCK development in practicing student teachers. Studies of this nature could better

inform the profession about when PCK development begins to be revealed, leading to more purposeful PCK development of preservice teachers.

References

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

Beyer, C. J., & Davis, E. A. (2011). Learning to critique and adapt science curriculum materials: Examining the development of preservice elementary teachers' pedagogical content knowledge. *Wiley Periodicals, Inc.* 130-157. doi: 10.1002/sce.20466

Birks, M., & Mills, J. (2015). *Grounded theory: A practical guide*. Los Angeles, CA: Sage Publications.

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

Darling-Hammond, L. (2006). Constructing 21st century teacher education. Journal of Teacher Education, 57(3), 300-314. doi:10.1177/0022487105285962

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

De Jong, O., Van Driel, J., & Verloop, N. (2005). Preservice teachers' pedagogical content knowledge of using particle models in teaching chemistry. *Journal of Research in Science Teaching*, 42, 947-964.

Gablinske, P. B. (2014). A case study of student and teacher relationships and the effect on student learning. *Open Access Dissertations*. Paper 266.

Gardner, H, (2006). *Multiple intelligences: New horizons.* New York, NY: Basic Books.

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

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

Kagan, D. M. (1992). Implications of research on teacher belief. *Educational Psychologist*, *27*, 65-90

Kilic, H. (2009). The nature of preservice teachers' pedagogical content knowledge. [online] http://www.cerme7.univ.rzeszow.pl/WG/17a/CERME7_WG17A_Kilic.pdf

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

Kola, A. J., & Sunday, O. S. (2015). A review of teacher self-efficacy, pedagogical content knowledge and out-of-field teaching: Focusing on Nigerian teachers. *International Journal of Elementary Education*. *4*(3), 80-85.

Lincoln, Y. S. & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage Publications.

Loughran, J., Mullhall, P., & Berry, A. (2004). In search of pedagogical content knowledge in science: Developing ways of articulating and documenting professional practice. *Journal of Research in Science Teaching*, *41*(4), 370– 391.

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

Morrison, A. D., & Luttenegger, K. C. (2015). Measuring pedagogical content knowledge using multiple points of data. *The Qualitative Report*, *20*(6), 798-809.

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

Nilsson, P. (2008). *Learning to teach and teaching to learn: Primary science student teachers' complex journey from learners to teachers*. Dissertation. Linkoping Studies in Science and Technology Education No 19.

Nilsson, P., & Loughran, J. (2011). Exploring the development of pre-service science elementary teachers' pedagogical content knowledge. *Journal of Science Teacher Education*, *23*, 699-721. doi: 10.1007/s10972-011-9239-y

Ong, W.J. (1958). *Ramus, method and the decay of dialogue.* Cambridge, MA: Harvard University Press.

Ozden, M. (2008). The effect of content knowledge on pedagogical content knowledge: The case of teaching phases matters. *Educational Sciences: Theory and Practice*. *8*(2), 633-645.

Pendergast, D, Garvis, S. & Keogh, J. (2011). Pre-service student-teacher self-efficacy beliefs: An insight into the making of teachers. *Australian Journal of Teacher Education, 36*(12), 46-58.

Rice, A. H., & Kitchel, T. (2015a). Preservice agricultural education teachers' experiences in and anticipation of content knowledge preparation. *Journal of Agricultural Education, 56*(3), 90-104.

Rice, A. H., & Kitchel, T. (2015b). The relationship between agriculture knowledge bases for teaching and sources of knowledge. *Journal of Agricultural Education, 56*(4), 154-169. doi:10.5032/jae.2015.04153

Rice, A. H., & Kitchel, T. (2017). Shaping pedagogical content knowledge for experienced agriculture teachers in the plant sciences: A grounded theory. *Journal of Agricultural Education,58*(4), 50-64. doi:10.5032/jae.2017.04050

Roberts, T. G., Harder, A., & Brashears, M. T. (Eds). (2016). American Association for Agricultural Education national research agenda: 2016-2020. Gainesville, FL: Department of Agricultural Education and Communication.

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

Schunk, D. H. (2012). *Learning theories: An educational perspective* (6th ed.). Boston, MA: Pearson Education Inc.

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

Southern State Department of Education (2013). Career, technical, and agricultural education career clusters/pathways. Retrieved from: https://www.georgiastandards.org/standards/Pages/CTAE-Career-Clusters-Pathways.aspx

Stuart, C., & Thurlow, D. (2000). Making it their own: Preservice teachers' experiences, beliefs and classroom practices. *Journal of Teacher Education*, (*51)*2, 113-121.

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