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The Relationship between Agriculture Knowledge Bases for Teaching and Sources of Knowledge

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Abstract

The purpose of this study was to describe the agriculture knowledge bases for teaching of agriculture teachers and to see if a relationship existed between years of teaching experience, sources of knowledge, and development of pedagogical content knowledge (PCK), using quantitative methods. A model of PCK from mathematics was utilized as a framework to guide the study. On the job teaching experience, teacher preparation program, high school agriculture experience, previous agriculturally related jobs and internships, internet and other media, and professional development were all reported as effective sources of content knowledge. All six of the PCK knowledge constructs were perceived by teachers as possessing them to a fair extent. The content knowledge constructs were rated higher on average than the PCK constructs. Stepwise multiple linear regressions were utilized to determine if linear relationships existed between perceived PCK bases and sources of content knowledge. Four of the PCK knowledge constructs yielded statistically significant predictive models. Six of the seven sources of content knowledge were significant predictors for at least one of the constructs. Future research should include going beyond teachers' perceptions and measuring PCK and examination into the process from the sources of content knowledge to the development of PCK.

Keywords: Pedagogical Content Knowledge; Content Knowledge; Agriculture Teachers; Knowledge Bases for Teaching

With a rise in novice teachers, it is imperative to assess knowledge bases of teachers and their ability to transfer their knowledge to the classroom. In 2011, the number of teachers with five or fewer years of teaching experience in the United States increased to 26% (Feistritzer, 2011). Beginning teachers may have deficiencies in various aspects of their knowledge including students' reasoning, teaching strategies, and curriculum (Angell, Ryder, & Scott, 2005). Houck and Kitchel (2010) caution the variability in content preparation at the preservice level could lead to unprepared teachers in some subjects within agricultural education. According to the Council for Accreditation of Educator Preparation (CAEP, 2013), licensed teachers must possess the following knowledge bases for teaching: *content knowledge*, *pedagogical knowledge*, *professional knowledge*, and *pedagogical content knowledge* (PCK). Out of these knowledge bases, PCK is regarded as one of the most influential pieces of teacher knowledge translating to effective classroom teaching (Baumert et al., 2010; Gess-Newsome & Lederman, 1999; Loughran, Berry, & Mulhall, 2012). First described by Shulman (1986, 1987), PCK has been researched heavily in the last decade and is the combination of content knowledge and pedagogical knowledge to create knowledge specifically for teaching. PCK is critical to a teacher's development and their ability to impart

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knowledge upon their students (Diakidoy & Iordanou, 2003). For teacher education this means identifying, developing, and evaluating this knowledge base in preservice and inservice teachers.

Despite the importance of PCK, teacher preparation programs may not adequately address content knowledge and its application to the classroom. In music education for example, there was a need to address PCK more explicitly in methods courses (Ballantyne & Packer, 2004). Various studies in the fields of science and mathematics indicate a deficiency in the PCK of teachers. In mathematics, novice teachers were unable to give detailed explanations and placed more emphasis on developing classroom activities than on providing meaningful lessons to students (Borko et al., 1992). In physics, teachers were unable to transform the material due to an inadequate content knowledge base and often made incorrect judgments about pupil misconceptions (Halim & Meerah, 2002). Additionally, preservice teachers often had gaps in their content knowledge in the field of chemistry (Van Driel, De Jong, & Verloop, 2002). Knowledge of specific subject matter concepts such as what constitutes a good definition or knowing how a formula works are essential skills for teaching (Ball, Thames, & Phelps, 2008). Because teaching is difficult and contains abstract concepts and ideas, teachers may attempt to simplify the subject matter to focus on rote learning instead of developing true understanding (Floden & Meniketti, 2005; Loughran, et al., 2012).

Need for the Study

Since Shulman (1986) first introduced the term PCK, a wide variety of subject areas have conducted research on the phenomenon including: science, math, social studies, English, physical education, communication, religion, chemistry, engineering, music, special education, English language learning, higher education, and others (Ball et al., 2008); with mathematics and sciences being at the forefront of research. Despite the frequency and variety of other education fields interested in pursuing the subject, agricultural education has no research directly addressing PCK. Studies have been limited to needs studies of agriculture teachers and effective characteristics of agriculture teachers (Birkenholz & Harbsreit, 1987; Claycomb & Petty, 1983; Garton & Chung, 1996; Layfield & Dobbins, 2002; Mundt & Connors, 1999; Myers, Dyer, & Washburn, 2005; and Washburn, King, Garton, & Harbstreit, 2001) among others. The demand for content knowledge may be higher in agricultural education due to the depth and breadth of content covered (Edwards & Thompson, 2010). This presents an additional challenge when studying PCK, which is highly topic specific (Etkina, 2010; Hashweh, 2005; Van Driel & Berry, 2012). An important first step needs to be taken to assess the current state of agriculture teachers in terms of agriculture knowledge for teaching so teacher preparation programs and professional development initiatives can better meet the needs of teachers at their current level. If there are problems related to a lack of PCK in science and math teachers, there may be similar problems present in agriculture teachers, because agriculture, by definition, is an applied science. An examination of the PCK of agriculture teachers is crucial for the future generations of students if we truly want them to grasp agriculture content. Do Missouri agriculture teachers with various years of teaching experience have PCK in agriculture and if so to what extent?

Theoretical and Conceptual Framework

Due to a lack of research on PCK specifically for agricultural education, there is a need to rely on close fields such as mathematics and sciences for a framework. Various models involving PCK have been utilized since the late 1980's. A recent model (see Figure 1) developed by Hill, Ball, and Schilling (2008) which seems to have some transferability to science related areas, divides knowledge for teaching into six domains separated into two groups. The first group, subject matter knowledge, includes: common content knowledge (CCK), horizon content knowledge (HCK), and specialized content knowledge (SCK). The second group, specifically PCK, includes: knowledge of content and students (KCS), knowledge of content and teaching (KCT), and knowledge of content and curriculum (KCC).

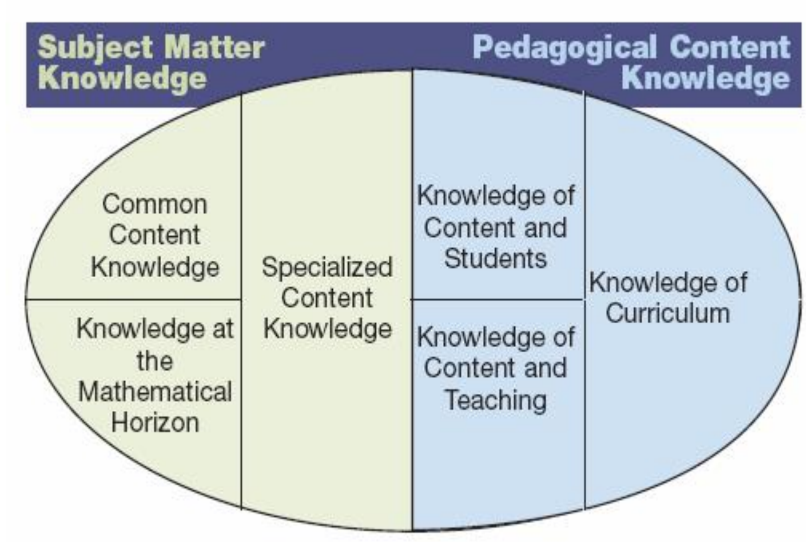

Figure 1. Model of MKT (Hill, Ball, & Schilling, 2008)

The model of Mathematical Knowledge for Teaching (MKT) was developed specifically for the mathematics discipline. Common content knowledge, specialized content knowledge, and horizon content knowledge all represent mathematical topics and concepts related to subject matter knowledge, which is the foundation for PCK (Ball & McDiarmid, 1990). The other side of the model, knowledge of content and teaching, knowledge of content and students, and knowledge of content and curriculum correspond directly to PCK, which threads subject matter knowledge with the knowledge of how students learn. Knowledge of content and teaching is the knowledge base combining knowledge of teaching and knowledge about mathematics. Knowledge of content and students is the knowledge base combining knowledge of students and knowledge about mathematics. Knowledge of content and curriculum is the knowledge base combining knowledge of curriculum with knowledge about mathematics (Hill et al., 2008). Ball et al. (2008) describes numerous reasons why utilizing the MKT model can yield richer data on PCK, including exploration into how different aspects of the knowledge bases can effect student achievement and to aid in studying how different approaches to development impact various aspects of PCK. More specific areas outlined in the model can also assist teacher education programs and professional development initiatives. While Hill et al. (2008) does recognize the lines between the domains can blur, the ability to narrow down a teacher's knowledge base more specifically is important as PCK continues to be explored given the wide range of knowledge and abilities PCK can encompass.

Utilizing these six domains is a logical starting place for examining the current knowledge bases of agriculture teachers. Regarding subject matter knowledge, it can be argued agriculture has its own distinct common content knowledge, specialized content knowledge, and horizon content knowledge. Chick, Baker, Pham, and Cheng (2006) provide insight on specific characteristics teachers' exhibit when using their PCK. An example of common content knowledge would be the ability to identify when a student gives an incorrect answer. An example of specialized content knowledge would be taking that scenario a step further and explaining why the student's answer was incorrect. Horizon content knowledge for agriculture would be the ability to link the subject matter to other units within and beyond agriculture. Regarding PCK constructs, Knowledge of content and teaching, knowledge of content and students, and knowledge of content and curriculum are all knowledge bases used by teachers in agricultural education. According to Chick et al. (2006), an example of knowledge of content and students would be predicting what concepts would be most challenging for students and knowing where they are developmentally. An example of knowledge of content and teaching would be utilizing questioning techniques to help students understand concepts. Knowledge of content and curriculum would involve curriculum design and sequencing lessons (Chick et al., 2006).

Based on MKT and a comprehensive review of literature, a conceptual framework, grounded in substantive theory, was developed to guide this study of agricultural education PCK. Studying specific knowledge bases for teaching is important, but exploring factors assisting in the development of knowledge could also impact teacher development (Figure 2). There are many variables that may contribute to the process, but one of the most extensively studied is the impact of teaching experience. One's own teaching experiences were ranked the most valuable in developing competence to teach (Feistritzer, 2011). Learning from the practice of teaching through reflection and analysis can lead to more effective teaching (Hiebert, Morris, Berk, & Jansen, 2007). According to Darling-Hammond (2000), it takes five to eight years in the field for expertise to begin to be developed. There is disagreement among researchers regarding the role expertise has in PCK development. Many studies related to PCK and teaching experience have concluded expertise is necessary for PCK development. Beginning teachers have been found to demonstrate fewer of the knowledge bases associated with PCK than expert teachers (Clermont, Borko, & Krajcik, 1994; Gudmundsdottir & Shulman 1987; Turner-Bissett, 1999). Characteristics of PCK are consistent with literature on expert knowledge that states experts not only have a deep understanding of subject matter but are able to apply and retrieve it with ease (Bransford, Brown, & Cocking, 2000). Newer models for PCK development indicate it is a cyclical process interacting with all of the knowledge bases and includes reflecting on teaching and implementing new strategies as a result of this reflection (Lee, 2011). Hashweh (2005) proposed PCK is a set of pedagogical constructions developing over time as a teacher re-teaches a specific topic, making experience and practice essential components. Thus, we included experience as a variable in this study.

Ball and McDiarmid (1990) indicate while it is widely believed teachers will develop deeper subject matter knowledge as a result of teaching content, there is little empirical evidence to back up this claim. In a recent study by Schneider and Plasman (2011), it was found PCK for continuing teachers was actually quite similar to the PCK for early career teachers. Magnusson, Krajcik, and Borko (1999) state PCK may begin to develop during the teacher preparation stage. PCK is typically envisioned as unattainable knowledge for beginning teachers, but maybe that is not the case. Additionally, years of experience in the field does not necessarily yield true expertise. Exposure to knowledge is not enough; the teacher has to be able to evaluate knowledge for the purpose of use in the classroom (Turner-Bissett, 1999). Bereiter and Scardemalia (1993) discuss the issue of novices developing into experienced non-experts by serving many years in the field but not necessarily gaining additional expertise in content. If many teachers are simply becoming experienced non-experts, then years spent teaching may not have the desired effect on the development of their PCK. An examination of agriculture teachers at all stages of their careers is needed to create a clear picture of the knowledge bases.

Other factors, in addition to teaching experience, may serve a significant role in the development of PCK. Background in the content, including secondary education experiences, may be the beginning of PCK development for teachers. The majority of teachers will teach in ways similar to how they were taught as students (Darling-Hammond & Bransford, 2005). Haston and Leon-Guerrero (2008) found in music education, the instrumental training history prior to admittance into the teacher preparation program was a factor in the PCK base of teachers. Having a previous job in the agriculture field to gain content knowledge is encouraged in agriculture education. "Actual work experience in agriculture is essential if teachers are to achieve the level of technical competence required for teaching agriculture successfully" (Newcomb, McCracken, Warmbrod, & Whittington, 2004, p. 23). Additional knowledge gained before entering the program, or lack thereof, could have an impact on the PCK of practicing agriculture teachers and should be explored further.

Teacher preparation programs have also been found to have an impact on the PCK development of teachers. In a study on the sources of PCK for preservice music teachers, apprenticeship, methods courses, and mentor teachers were all recognized as influential sources of PCK (Haston & Leon-Guerrero, 2008). These sources are all directly associated with the components of a university teacher preparation program. In mathematics, teacher preparation had an influence on teacher effectiveness and specifically math content preparation was found to increase student achievement (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2008). Baumert et al. (2010) discovered a correlation between the design of the teacher preparation program and the teachers' PCK, emphasizing there must be a balance between content knowledge and PCK instruction. Some teachers in agriculture may have an additional major or minor other than education that could contribute to their content knowledge base. It is imperative for teacher educators to be aware of the impact of teacher preparation programs in order to modify the curriculum to best suit the needs of future teachers.

Factors outside of the classroom complimenting a teachers' knowledge base cannot be dismissed when exploring how sources of content knowledge affect a teachers overall PCK. Teacher preparation programs are not the only source of content knowledge for practicing teachers, and to ignore the experiences outside of school would be to ignore a major source of content knowledge (Ball & McDiarmid, 1990). Professional development for inservice teachers is essentially a continuation of their learning during practice. "Because teachers are the subject matter experts, decisions about core content will be more correct and instruction will be more relevant when teachers consistently strive to be knowledgeable about their content" (Newcomb et al., 2004, p. 52). Finally, one of the most widely used content resources is the internet. Utilization of the internet and other media has made an impact on teacher knowledge. Technology has such an important role in PCK development, a new framework has been developed called technological PCK (TPACK) that attempts to describe how educational technology competence intersects with Shulman's (1986) original concept of PCK (Koehler & Mishra, 2009). For the millennial generation entering the profession, internet and other educational technologies are a critical source of their current and future content knowledge and must be taken into consideration as a knowledge source. In summary, teaching experience, years spent teaching, high school agriculture experience as a student, agriculture jobs and internships, university teacher preparation programs, professional development, and internet and other media are all potential sources of content knowledge that could impact a teacher's PCK.

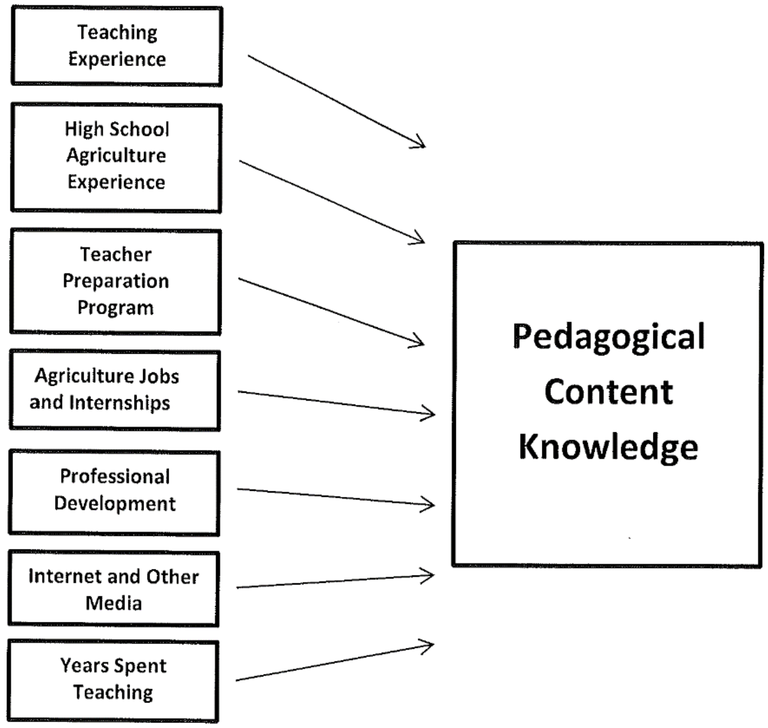

Figure 2. The Relationship between Sources of Content Knowledge and PCK

Purpose of the Study

The purpose of this study was to describe the agriculture knowledge bases for teaching of Missouri agriculture teachers and to see if a relationship exists between years of teaching experience, sources of knowledge, and development of PCK. The Hill et al. (2008) model was used to operationalize agriculture knowledge for teaching and a review of literature guided the seven sources of content knowledge.

The following objectives guided the study:

1. Describe the perceived effectiveness of sources of content knowledge for agriculture teachers.
2. Describe the perceived PCK of agriculture teachers according to the six areas of the Hill et al. (2008) model.
3. Determine if a relationship exists between perceived PCK bases and sources of content knowledge including: teaching experience, high school agriculture experience, university teacher preparation programs, previous agriculture related jobs or internships, professional development workshops, internet and other media, and years spent teaching.

These objectives align with the 2011-2015 National Research Agenda for agricultural education. Priority four, meaningful and engaged learning in all environments, states the primary outcome is, "learners in all agricultural education learning environments will be actively and emotionally engaged in learning; leading to high levels of achievement, life and career readiness, and professional success" (Doerfert, 2011, p. 21). This study addresses ways to provide these environments specifically for teacher preparation. Examining the knowledge bases of current agriculture teachers in conjunction with sources of knowledge and years of experience may shed light on how teacher preparation programs can develop teachers to be adaptive experts in the classroom.

Methods

This descriptive relational study utilized the Hill et al. (2008) model for MKT. The following characteristics were investigated: common content knowledge, specialized content knowledge, horizon content knowledge, knowledge of content and teaching, knowledge of content and students, and knowledge of content and curriculum. Seven sources of content knowledge were also examined based on a review of literature. The target population of this study was agriculture teachers in Missouri. A frame for all of the agriculture teachers in the state was acquired consisting of 497 practicing teachers for the 2012-2013 school year. Frame error was avoiding by consulting the state's department of education to obtain an accurate and up to date frame. A random sample of 217 teachers was taken from the population frame according to the recommendations by Krejcie and Morgan (1970). A simple random sample was used to generalize to the population (Creswell, 2009).

A questionnaire was designed to measure the perceived PCK of current agriculture teachers with three to five questions representing each of the six areas of the Hill et al. (2008) model. The CoRe research tool (Loughran et al., 2012), and the framework for analyzing PCK (Chick et al., 2006) were both consulted in designing the questionnaire. The questionnaire examined all six areas of the model from the perspective of a specific lesson in a unit a teacher felt like they knew the content well. PCK is very topic-specific in nature (Etkina, 2010; Hashweh, 2005; Van Driel & Berry, 2012); therefore, it was necessary to have the participants self-identify the lesson they felt like they had adequate expertise in to accurately anchor their perceptions. Topics were not analyzed as they were a means to the end of asking teachers to focus on specific content they knew well. The items utilized a Likert-type scale (1 = no extent to 5 = great extent) for perceived ability in performing each teaching task corresponding to a specific knowledge base. An example question from the survey was: I can easily identify the advantages and disadvantages of various instructional strategies. The second section utilized a Likert-type scale to determine how effective teachers felt sources of knowledge were on their teaching ability (1 = very ineffective to 6 = very effective). To establish face and content validity of the questionnaire, a panel of experts was used.

Reliability was established by conducting a pilot test on teachers from Kentucky. The questionnaire was distributed online via Qualtrics to 21 teachers. Cronbach's alpha was calculated utilizing SPSS on the six major constructs to estimate the reliability of the instrument. All constructs but horizon content knowledge were found to have at least .70 reliability, which is appropriate for the social sciences (Nunnally, 1967). The horizon content knowledge construct had .60 reliability, but due to the exploratory nature of the study this construct was retained (Nunnally, 1967). Test re-test was used to estimate the reliability of the sources of content knowledge. Fifteen teachers were contacted ten weeks apart and the percent agreement was greater than 78% for all content knowledge sources.

Data were collected May 2013 via Qualtrics. An internet survey was used to reach the most people in an economical and timely fashion. The Dillman, Smyth, and Christian (2009) tailored design method for online surveys was used. An initial contact was made and four follow up e-mail reminders were sent. The response rate was $n = 62$ (29%) after four reminders. Consequently, 15 non-respondents were randomly sampled and contacted via telephone to participate in the study (Miller & Smith, 1983). Respondents and non-respondents were then compared for statistical differences utilizing the Mann-Whitney *U* test. All six constructs of the Hill et al. (2008) model were compared and no statistical differences were found between the two groups. As a result, the 15 non-respondents were included for a total response rate of 35% ($n = 77$). Data for objectives one and two were analyzed using means and standard deviations. Stepwise multiple linear regressions utilizing a backwards approach were calculated for objective three. The alpha level was established at .05 *a priori*. An examination of histograms and scatterplots showed no assumptions were violated for constructs yielding significant models. Additionally, examining tolerance factors and VIFs showed no concern of multicollinearity between any of the constructs.

Findings

Objective 1

The following content knowledge sources for teachers were found (see Table 1). The average number of years spent teaching was 12.77 years (*SD* = 8.98), ranging from 1-35 years of teaching experience. Four areas were reported as somewhat effective on average as a source of content knowledge (scale of 1-6) that contributed to effective agriculture teaching and two areas were reported as effective on average as a source of content knowledge. On the job teaching experience (*M* = 5.55, *SD* = 0.59) and previously agriculturally related jobs or internships (*M* = 5.13, *SD* = 0.85) were reported as effective on average as a source of content knowledge. High school agriculture experience when the teacher was a high school student (*M* = 4.88, *SD* = 1.28), teacher preparation program (university training) (*M* = 4.87, *SD* = 0.96), internet and other media (*M* = 4.70, *SD* = 0.85), and lastly, professional development workshops (*M* = 4.65, *SD* = 0.91) were reported as somewhat effective on average as a source of content knowledge.

Table 1

Descriptive Statistics of Sources of Agricultural Content Knowledge (n = 77)

Source of content knowledge	*M*	*SD*
Years teaching	12.77	8.98
Perceptions of source[1]:		
High school agriculture experience	4.88	1.28
Teacher preparation program	4.87	0.96
On the job teaching experience	5.55	0.59
Previous agriculturally related jobs or internships	5.13	0.85
Internet and other media	4.70	0.85
Professional development	4.65	0.91

[1]Scale: 0 = Not Applicable, 1= Very ineffective, 2 = Ineffective, 3 = Somewhat ineffective, 4 = Somewhat effective, 5 = Effective, and 6 = Very effective.

Objective 2

The perceived PCK of agriculture teachers was examined for each of the six major constructs from the Hill et al. (2008) model (see Table 2). Teachers were asked to self-select a unit they felt confident in teaching and then answer questions relating to each construct based on that self-identified unit. Their perceived ability to perform a task was rated on a scale of 1-5 with one being to no extent and 5 being to great extent. The common content knowledge construct (*M* = 4.64, *SD* = 0.35), horizon content knowledge construct (*M* = 4.55, *SD* = 0.44), specialized content knowledge construct (*M* = 4.48, *SD* = 0.39), knowledge of content and teaching construct (*M* = 4.38, *SD* = 0.48), knowledge of content and students construct (*M* = 4.28, *SD* = 0.48), and knowledge of content and curriculum construct (*M* = 4.23, *SD* = 0.59), all fell within the real limits of fair extent.

Table 2

Perceived PCK of Agriculture Teachers by Construct (n = 77)

Knowledge Construct	*M*	*SD*
Common Content Knowledge (CCK)	4.64	0.35
Horizon Content Knowledge (HCK)	4.55	0.44
Specialized Content Knowledge (SCK)	4.48	0.39
Knowledge of Content and Teaching (KCT)	4.38	0.48
Knowledge of Content and Students (KCS)	4.28	0.48
Knowledge of Content and Curriculum (KCC)	4.23	0.59

Scale: 1 = To no extent, 2 = To little extent, 3 = To some extent, 4 = To fair extent, and 5 = To great extent.

Objective 3

Separate stepwise multiple regressions using a backwards approach were calculated to evaluate whether the seven sources of content knowledge (teaching experience, high school agriculture experience, university training, previous agriculture related jobs or internships, professional development workshops, internet and other media, and years spent teaching) were necessary to predict each of the six knowledge base constructs. For the common content knowledge construct at step 5 (the final step) of the analysis: high school agriculture experience, teaching experience, and professional development workshops were all significantly related to common content knowledge $F_{3,68} = 5.55$, $p < .01$. The R^2 indicated 19.7% of the variance in common content knowledge could be accounted for by a linear combination of high school agriculture experience, teaching experience, and professional development workshops. The remaining variables did not enter into the equation at step 5 of the analysis. For the knowledge of content and students construct at step 6 (the final step) of the analysis: years spent teaching and agriculturally related jobs and internships were both significantly related to knowledge of content and students $F_{2, 69} = 8.99$, $p = .00$. The R^2 indicated 20.7% of the variance in knowledge of content and students could be accounted for by a linear combination of years spent teaching and agriculturally related jobs and internships. The remaining variables did not enter into the equation at step 6 of the analysis. For the knowledge of content and teaching construct, at step 5 (the final step) of the analysis: years spent teaching, professional development workshops, and university training were all significantly related to knowledge of content and teaching $F_{3, 68} = 4.09$, $p = .01$. The R^2 indicated 15.3% of the variance in knowledge of content and teaching could be accounted for by a linear combination of years spent teaching, professional development workshops, and university training. The remaining variables did not enter into the equation at step 5 of the analysis. For the knowledge of content and curriculum construct, at step 7 (the final step) of the analysis: university training was significantly related to knowledge of content and curriculum $F_{1, 70} = 5.05$, $p = <.03$. The R^2 indicated 6.7% of the variance in knowledge of content and curriculum could be accounted for by university training. The remaining variables did not enter into the equation at step 7 of the analysis. For the specialized content knowledge and horizon content knowledge constructs, there was not a statistically significant predictive model.

Table 3

Stepwise Multiple Regression Analysis of CCK as the Dependent Variable and Sources of Content Knowledge as Independent Variables at Step 5 of the Analysis

Variable	*β*	Std. Error	*t*	*p*
High School Agriculture Experience	.31	.03	2.82	.01
Teaching Experience	.26	.07	2.36	.02
Professional Development Workshops	-.30	.04	-2.69	.01

Note. R^2 = .19

Table 4

Stepwise Multiple Regression Analysis of KCS as the Dependent Variable and Sources of Content Knowledge as Independent Variables at Step 6 of the Analysis

Variable	*β*	Std. Error	*t*	*p*
Years Spent Teaching	.29	.06	2.68	.01
Agriculturally Related Jobs and Internships	.30	.01	2.72	.01

Note. R^2 = .20

Table 5

Stepwise Multiple Regression Analysis of KCT as the Dependent Variable and Sources of Content Knowledge as Independent Variables at Step 5 of the Analysis

Variable	*β*	Std. Error	*t*	*p*
Years Spent Teaching	.24	.06	2.10	.04
Professional Development Workshops	-.23	.06	-1.99	.05
University Training	.26	.01	2.33	.02

Note. R^2 = .15

Table 6

Stepwise Multiple Regression Analysis of KCC as the Dependent Variable and Sources of Content Knowledge as Independent Variables at Step 7 of the Analysis

Variable	*β*	Std. Error	*t*	*p*
University Training	.26	.07	2.25	.03

Note. R^2 = .06

Discussion

The researchers acknowledge that this study is limited to teachers' perceptions about the effectiveness of their sources of content knowledge and their perceptions of their pedagogical content knowledge for each construct within the Hill et al. (2008) model. Additionally, findings from the perceived PCK bases were based on a lesson that the teachers self-determined to have expertise in the content. It should also be noted that future studies should consider eliminating teachers with less than five years' experience because that is when expertise begins to be achieved (Darling-Hammond & Bransford, 2005) and teachers with less than five years may have limited PCK development.

Five sources of content knowledge derived from the literature (high school agriculture experience, university training, previous agriculture related jobs or internships, professional development workshops, and internet and other media) were perceived as effective sources of content knowledge by teachers. In addition, there is a wide range of years of teaching experience for Missouri agriculture teachers. One source, teaching experience, was perceived as a very effective source of content knowledge. Teaching experience also had a small variance at the upper end which indicates everyone found some value in this source. This is consistent with literature stating the strongest impact on the development of teachers is classroom experience (Van Driel et al., 2002).

On average, teachers' rated their common content knowledge and horizon content knowledge abilities as "to a great extent" for a self-identified unit they felt competent in teaching the content. Specialized content knowledge was also highly rated, "to a fair extent" for the teachers of Missouri. The three constructs that make up the content knowledge portion of the Hill et al. (2008) model were rated higher on average by teachers than the three PCK constructs. This was expected because content knowledge is first needed before PCK can develop (Darling-Hammond & Bransford, 2005). The teachers' perceived ability for all six constructs was "to at least a fair extent", which was expected for a unit they felt competent in. Knowledge of content and curriculum had the lowest average while it was still "to a fair extent"; it had a wide range of variability. With high scores in teachers' perceived ability of common content knowledge, evidence indicates knowledge of curriculum as the issue. Recommendations include professional development for current teachers on developing curriculum and doing so with rich agriculture depth. In particular, such curriculum should be written with the content area experts.

Multiple linear regressions yielded statistically significant models for common content knowledge, knowledge of content and students, knowledge of content and teaching, and knowledge of content and curriculum constructs. For common content knowledge, high school agriculture experience, teaching experience, and professional development workshops were all significant predictors. If many teachers are relying on their high school agriculture experience as a primary source of knowledge this could be problematic as agriculture continues to evolve. Years of teaching experience for participants in this study ranged from 1-35 years, so it is reasonable to conclude that many teachers could be operating from outdated content knowledge if they are relying on their high school agriculture experience. Further investigation into the role that high agriculture experience has in the development of common content knowledge is needed.

For knowledge of content and students, years spent teaching and agriculturally related jobs and internships were significant predictors. It is possible that teachers are relying on industry experience that relates to training and instruction and transferring it for use with students in the classroom. Additionally, why is university training not a significant predictor for knowledge of content and students? Perhaps university training programs should examine their role in the development of preservice teachers' knowledge of content and students. For knowledge of content and teaching, years spent teaching, professional development workshops, and university training programs were all significant predictors. It is recommended that professional development initiatives and university training programs continue to provide opportunities for preservice and inservice teachers' knowledge of content and teaching development. Additionally, because of the importance of agriculturally related jobs and internships, it is recommended that preservice teachers receive more real world experiences through their teacher preparation programs.

For knowledge of content and curriculum, the sole predictor was university training programs. If university programs are one of the primary sources for a teacher to develop knowledge of content and curriculum, then perhaps a greater emphasis should be placed on curriculum development within agriculture content areas for preservice teachers. The wide range of variability in teachers' ratings of their knowledge of content and curriculum further substantiates the need for a focus on knowledge of content and curriculum at the preservice level within university training programs.

Six of the seven sources of content knowledge were significant predictors for at least one of the constructs. Professional development, years spent teaching, and university preparation appeared more than once. This is consistent with literature supporting the effects of these sources (Darling-Hammond, 2000; Baumert et al., 2010). Emphasis on these as sources of knowledge is recommended in developing teachers' knowledge bases, including enhanced professional development opportunities and examination into current teacher preparation programs PCK development initiatives. Internet and other media was the only source of content knowledge that was not a significant predictor for any construct. Perhaps this knowledge is embedded within other sources such as university course work, day to day teaching experience, and professional development workshops.

Despite high averages of perceived ability by teachers, there were no significant models explaining specialized content knowledge and horizon content knowledge. If the seven content sources investigated were not significant predictors of these two constructs, then where are teachers gaining this knowledge they reported having to fair or great extent? It is recommended future research investigate other possible predictors of these knowledge bases, so these sources can be identified and enhanced. In addition, the reliability of the pilot test for horizon content knowledge was lower than was preferred. It is possible the horizon content knowledge construct, which originated as a mathematical concept, may have little carry over to agriculture. Horizon content knowledge for mathematics is important due to the sequential nature of the discipline, while agriculture classes can stand alone. Horizon content knowledge may not need to be included in future agriculture models for PCK.

This study has scratched the surface in examining agriculture teachers' PCK. Further research should include examining lessons teachers do not feel competent in to see how content knowledge and PCK are lacking. Going beyond perceptions of teachers and using a test or other instrument to measure PCK will also be an important future step, but this may be challenging due to the topic-specific nature of PCK (Darling-Hammond & Bransford, 2005; Etkina, 2010; Hashweh, 2005) and the fact that PCK for agricultural education has yet to be defined. Examination into the process from the source of content knowledge to the development of PCK in teachers utilizing qualitative methods could aid in preparation of future teachers.

References

Angell, C., Ryder, J., & Scott, P.H. (2005). Becoming an expert teacher: Novice physics teachers' development of conceptual and pedagogical knowledge. Paper presented at the European Science Education Research Association Conference, Barcelona, Spain.

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

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

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

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

Bereiter, C., & Scardamalia, M. (1993). *Surpassing ourselves: An inquiry into the nature and implications of expertise*. La Salle, IL: Open Court.

Birkenholz, R. J. & Harbstreit, S. R. (1987). Analysis of the inservice needs of beginning vocational agriculture teachers. *Journal of the American Association of Teacher Educators in Agriculture, 28*(1), 41-49.

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

Boyd, D., Grossman, P., Lankford, H., Loeb, S., & Wyckoff, J. (2008). Teacher preparation and student achievement (NBER Working Paper No. W14314). Cambridge, MA: National Bureau of Economic Research.

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

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

Claycomb, D. M., & Petty, G. C. (1983). A three year longitudinal study of the perceived needs for assistance as ranked by vocational agriculture instructors. *Journal of the American Association of Teacher Educators in Agriculture, 42*(4), 28-33.

Clermont, C. P., Borko, H., & Krajcik, J. S. (1994). Comparative study of the pedagogical content knowledge of experienced and novice chemical demonstrators. *Journal of Research in Science Teaching*, *31*(4), 419-441. doi:10.1002/tea.3660310409

Council for Accreditation of Educator Preparation. (2013). CAEP 2013 standards for accreditation of educator preparation. Retrieved from: http://www.caepnet.org/standards

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches*. Thousand Oaks, CA: Sage Publications.

Darling-Hammond, L. (2000). How teacher education matters. *Journal of Teacher Education, 51*(3), 166-173. doi:10.1177/0022487100051003002

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

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

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2009). *Internet, Mail, and Mixed Mode Surveys* (3rd ed.). New Jersey: John Wiley & Sons Inc.

Doerfert, D. L. (Ed.) (2011). *National research agenda: American Association for Agricultural Education's research priority areas for 2011-2015*. Lubbock, TX: Texas Tech University, Department of Agricultural Education and Communications.

Edwards, M. C., & Thompson, G. (2010). Designing technical agriculture curriculum. In R. M. Torres, T. Kitchel, & A. L. Ball (Eds.), *Preparing and advancing teachers in agricultural education* (pp. 113-128).The Ohio State University Columbus, OH: Curriculum Materials Service.

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

Feistritzer, C. E. (2011). Profile of teachers in the U. S. 2011. *National Center for Education Information.*

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

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

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

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

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

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

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

Hiebert, J., Morris, A. K., Berk, D., & Jansen, A. (2007). Preparing teachers to learn from teaching. *Journal of Teacher Education, 58*(1), 47-61.

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

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

Koehler, M. & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)?. *Contemporary Issues in Technology and Teacher Education, 9*(1), 60-70.

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement, 30*, 607-610.

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

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

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

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

Miller, L. E., & Smith, K. L. (1983). Handling nonresponse issues. *Journal of Extension, 21*(5), 45-50.

Mundt, J.P., & Connors, J.J. (1999). Problems and challenges associated with the first years of teaching agriculture: A framework for preservice and inservice education. *Journal of Agricultural Education, 40*(1), 38-48. doi:10.5032/jae.1999.01038

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

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

Nunnally, J. C. (1967). *Psychometric theory* (1st ed.). New York: McGraw-Hill.

Schneider, R. M., & Plasman, K. (2011). Science teacher learning progressions: A review of science teachers' PCK development. *Review of Educational Research, 81*(4), 530-565. doi:10.3102/0034654311423382

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

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

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

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

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

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