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Long-term Impacts of Professional Development on Teachers Using a Math-enhanced Curriculum in Agricultural Power and Technology: A 10-Year Retrospect

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Abstract

Professional development (PD) on approaches to curriculum integration (CI) continues to be essential for teachers to stay abreast of developments to improve student performance in their courses while also supporting learning and achievement in core subjects. We aimed to explore and derive meaning from the shared experiences of six agriculture teachers who participated in the Math-in-CTE Study conducted from 2003 to 2005. Seven interpretive themes emerged from the teachers' experiences. Even though 10 years had elapsed since the PD, participants reported still using aspects of the 7-element pedagogic approach learned and teaching all or portions of the math-enhanced lessons they developed. The need existed to continue to provide PD on CI but challenges to maximizing its impact were evident at the school level. Teachers of core subjects need to serve as long-term collaborators and school leaders should strive to support communities of practice focused on CI.

Keywords: professional development, curriculum integration, agricultural education, math-in-CTE

Introduction

Professional development (PD) is critical to ensure educators stay abreast of developments in teaching and learning that may enhance the effectiveness of their instructional behaviors (Blank, Alas, & Smith, 2008; Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet, Porter, Desimone, Birman, & Yoon, 2001). Yoon, Duncan, Lee, Scarloss, and Shapley (2007) argued that PD equips teachers with improved pedagogical skills, which leads to better teaching and ultimately enhances student academic achievement. Further, PD also provides opportunities for networking, collaboration, feedback, and fosters teamwork among teachers (Harwell, 2003; Quick, Holtzman, & Chaney, 2009).

Hunzicker (2010) posited that "[e]ffective professional development engages teachers in learning opportunities that are supportive, job-embedded, instructionally-focused, collaborative, and ongoing" (p. 2). Teacher PD often occurs in a number of ways and may include relatively brief or one-time only inservice training workshops (Desimone et al., 2002). To be effective, however, it is important to extend PD over long periods of time, to make it coherent, content-focused, and learner-centered, to encourage collective participation, and to actively engage the teachers (Garet et al., 2001; Quick et al., 2009). Efficacious PD, therefore, is not a one-time phenomenon but rather should be a continual and even an *organic process* (Harwell, 2003; Tate, 2009) that involves ongoing assessments to evaluate long-term impacts (Lewis & Pearson, 2007). Many education scholars have advocated for curriculum integration [CI] (Barefield, 2005; Bean, 1995, 1996; Etim, 2005; Pearson et al., 2010; Stone III, Alfred, & Pearson, 2008) implying that teachers participate in PD on approaches to implementing CI in their teaching.

Curriculum integration is based on the need for learners to recognize *and* comprehend relationships between different subjects so their understanding can be applied to solving problems and facing challenges encountered in real-life situations (Bean, 1996; Vars, 1991, 2001). Good (as cited in Shoemaker, 1989) posited that CI "cuts across subject matter lines to focus upon comprehensive life problems or broad areas of study that bring together the various segments of the curriculum into meaningful association" (p. 5). Shoemaker (1989) asserted that Good's approach to CI was interdisciplinary, i.e., by which teaching and learning occurred holistically around common themes or concepts. Bean (1995) concluded that "[c]urriculum integration, in theory and practice, transcends subject-area and disciplinary identifications" (p. 618). Unfortunately, because of the segmented nature of teacher preparation and some teachers' perceptions of the need to *protect their subjects*, many instructors experience challenges with practicing CI, because it necessitates teamwork and collaboration with others, which not all educators are eager to embrace (Barefield, 2005).

The essence of CI is for teachers and students to develop multiple perspectives or lenses through which they seek to find solutions to real-world problems using the knowledge and concepts learned in school (Bean, 1995, 1996; Jacobs, 1989). To that end, the Association for Career and Technical Education [ACTE] (2006) in its report, *Reinventing the American High School for the 21st Century*, recommended teachers work together across all subjects in the delivery of academic concepts to ensure students are made aware of the applicability of content learned in the real-world. Therefore, rather than students and teachers looking at each subject as a separate entity to solve a problem, CI promotes the transfer of learning from one subject to another to find solutions to challenges encountered in everyday life (Jacobs, 1989; Lake, 1994; Pearson et al., 2010). Further, CI stands to motivate learners, create positive student attitudes toward learning, and lead to increased academic achievement (Barefield, 2005; Kain, 1993).

ACTE (2006) also urged for the integration of mathematics "into science and career/ technical classrooms" (p. 7) to ensure student success in both "academic and career/technical studies" (p. 7). But to increase students' motivation to understand math concepts, teachers need to develop math content around themes that interest the learners (Choike, 2000), which implies the salient need for PD to support achieving that end. ACTE (2006) also reported:

> [T]he National Research Center for Career and Technical Education discovered that when combining professional development with a pedagogic framework to identify and teach the mathematics that is inherent in CTE curricula, students who received enhanced instruction scored significantly higher on standardized math tests than students who received their regular curriculum. (p. 14)

This phenomenological study aimed to assess teachers' views of the long-term impact of

PD on their efforts at CI, i.e., using an integrated curriculum and complementary pedagogic approach to teach agricultural power and technology [APT] (Parr, Edwards, & Leising, 2006, 2008, 2009; Young, Edwards, & Leising, 2008, 2009) to improve students' math performance. This work is follow-up to a larger investigation and intervention conducted from 2003 to 2005, the *Math-in-CTE Study* (Lewis & Pearson, 2007; Pearson et al., 2010; Stone III et al., 2008). Of the 16 experimental group, agricultural education teachers who participated in the earlier study, five were still teaching and one had retired at the end of 2013-2014 school year. The six teachers served as the study's population approximately 10 years after their having received intensive PD (15 days during two years) on how to integrate curriculum involving APT and math. During that intervention, the teachers created 17 math-enhanced lessons for teaching APT.

Purpose of the Study

This study's purpose was to explore, and derive meaning from, the shared experiences of agricultural education teachers who participated in the *Math-in-CTE Study* conducted in the state of Oklahoma from 2003 to 2005. The study also sought to determine the extent to which teachers were still using the 7-element pedagogic approach to CI they learned and practiced as participants in the *Math-in-CTE Study*, including their collaboration with math teachers. Two main questions guided the inquiry: (a) What had been the teachers' experiences with regard to the integration of a math-enhanced curriculum in their teaching of APT? (b) Were the relationships established between the agricultural education teachers and their collaborating math teachers sustained long-term? Other questions were also asked as teachers shared their experiences during the six interviews.

Emergent Theoretical Lens

To ensure transparency and validity in a phenomenological study, Lester (1999) urged researchers "to work through from the findings to the theories" (p. 2). Further, Guba (1981) asserted that "[a]dherents of the *naturalistic paradigm* [emphasis added] prefer to have the theory emerge from the data themselves" (p. 78). In this study, two theories, i.e., human capital theory (Becker, 1994; Mincer, 1981; Schultz, 1972) and the theory of planned behavior (Ajzen 1987, 1991; Ajzen & Madden, 1986), emerged from findings describing the participants' experiences in regard to using a math-enhanced curriculum in teaching APT. Human capital theory posits that if individuals and societies invest in their human resources, e.g., through education and on-the-job training, such investments yield economic returns to both (Sweetland, 1996; Zula & Chermack, 2007). Further, if society is to keep pace with the current trends in a globalized economy, its human resources must stay abreast of the latest developments in technologies and professional practices (Margolis, Plug, Simonnet, & Vilhuber, 2004; Mincer, 1989; Woodhall, 1987).

Theory of planned behavior posits that a person's intent to execute a given behavior is influenced by three attributes, i.e., attitudes, subjective norms, and perceived control, in regard to the behavior in question (Ajzen 1987, 1991; Ajzen & Madden, 1986). The attitude an individual has toward implementing a specific behavior will determine if it is put to use (Ajzen 1987, 1991; Ajzen & Madden, 1986). In addition, the social pressures and expectations an individual experiences to execute given behaviors, i.e., the influence of subjective norms manifested by societies and peers, affects the person's actions, as does an individual's perception of control based on prior experiences and anticipated challenges (Ajzen 1987, 1991; Ajzen & Madden, 1986). We integrated these theories to ground the study and derive meaning about the participants' shared experiences regarding the phenomenon.

Methodology

A phenomenological approach was used to conduct this qualitative inquiry (Creswell, 2013; Moustakas, 1994) with the aim of finding a "common meaning for several individuals of their lived experiences of a concept or phenomenon" (Creswell, 2013, p. 76) and to distill its *essence* (Merriam, 2009; Moustakas, 1994). Phenomenology is a flexible approach to inquiry (Carl, 2001), which accords researchers the opportunity to examine in detail any themes or ideas that may emerge during the course of participants' interviews. Researchers' "prior beliefs about a phenomenon of interest are temporarily put aside, or bracketed, so as not to interfere with seeing or intuiting the elements or structure of the phenomenon" (Merriam, 1998, p. 16). Bracketing also helps to mitigate any pre-existing biases that may impact the quality or outcomes of the research (Tufford & Newman, 2012). A phenomenology study involves both description and interpretation of the findings to acquire a "deeper understanding of the nature or meaning of our everyday experiences" (Van Manen, 1990, p. 9) or of the individuals' *related experiences.* Callison (2001), however, asserted that any two individuals are unlikely to have exactly the same experiences, but their experiences may be related and, therefore, reinforce a comprehensive understanding of the overarching phenomenon.

The researchers submitted an application for research on human subjects to Oklahoma State University's Institutional Review Board, which approved the study. Thereafter, the lead researcher sent electronic recruitment messages to six teachers, who participated in the *Math-in-CTE Study* for APT and its PD from 2003 to 2005, requesting their participation in the research study. The teachers were selected purposefully (Groenewald, 2004). According to Polkinghorne (1989) and Creswell (2013), interviewing 5 to 25 individuals who have experienced a phenomenon is appropriate to explore their lived experiences. All six teachers agreed to participate, including one female and five male high school agriculture teachers in Oklahoma. The face-to-face interviews were conducted during two days of the teachers' state professional development conference in August of 2014.

A semi-structured interview protocol was used by the lead researcher, including two main guiding questions, and other questions emerged during the course of the interviews (Groenewald, 2004; Lincoln & Guba, 1985; Yin, 2011). The interviews were audio recorded (Lincoln & Guba, 1985). The length of interviews varied from 45 minutes to one hour until no new information surfaced, i.e., *data saturation* was reached (Groenewald, 2004). During the interviews, the lead researcher wrote down key points and themes that arose, i.e., memoing (Groenewald, 2004, 2008; Lincoln & Guba, 1985). Memoing includes "field notes recording what the researcher hears, sees, experiences and thinks in the course of collecting and reflecting on the process" (Groenewald, 2004, p. 13). Lincoln and Guba (1985) posited that field notes "can be flagged for important items to which the interviewer wishes to return" (p. 272).

The interviews were transcribed verbatim (Yin, 2011). During transcription, the participants were identified by pseudo names to protect their identities. The participants were sent transcribed copies of the interviews via electronic mail to verify their responses and to make clarifications as needed, i.e., *member checking* (Groenewald, 2004; Lincoln & Guba, 1985). Member checking helps to verify the authenticity of the transcriptions and thereby increases the data's trustworthiness and credibility (Harper & Cole, 2012; Lincoln & Guba, 1985; Moustakas, 1994). After having received no response from the participants to the first correspondence, a follow-up message was sent. Two participants replied confirming that the transcriptions were correct. Thereafter, follow-up telephone calls were made to the remaining four participants to verify if they had received their messages with the transcribed interviews. Two of these participants confirmed receiving the transcriptions and agreed that what had been transcribed was correct. The other two participants did not provide feedback.

During data analysis, equal weight was placed on the participants' statements, i.e., *horizonalization* was done (Merriam, 2009; Moustakas, 1994), before reducing the data to significant statements. The statements were highlighted, organized, and categorized into codes using the qualitative software program ATLAS/ti. "A code in qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data" (Saldaña, 2009, p. 3). The codes were aggregated into themes based on the lead researcher's judgments (Moustakas, 1994; Ryan & Bernard, 2003). Focus was placed on two categories of codes, i.e., *WHAT* the participants experienced and *HOW* they experienced the phenomenon (Creswell, 2013). The themes that emerged from the different codes were analyzed to develop the *essence of the phenomenon*. Husserl (as cited in Moustakas, 1994) described an *essence* as a "common or universal [attribute], [and] the condition or quality without which a thing would not be what it is" (p. 100).

Ensuring Quality and Ethics in the Study

The researcher is the *instrument* in qualitative research (Guba, 1981; Lincoln & Guba, 1985; Merriam, 1998). It is prudent, therefore, that the researcher maintains high ethical standards throughout the research process to ensure the participants' rights are respected and protected (Lincoln, 1995; Lincoln & Guba, 1985; Tracy, 2010; Yin, 2011). The researchers followed the eight procedural guidelines espoused by Tracy (2010) to ensure quality in the study: "(a) worthy topic, (b) rich rigor, (c) sincerity, (d) credibility, (e) resonance, (f) significant contribution, (g) ethics, and (h) meaningful coherence" (p. 839). The lead researcher bracketed his perceived knowledge or opinions (Merriam, 1998; Moran, 2000; Tufford & Newman, 2012) about the study to increase the likelihood of objectively analyzing the data and limit the influence of any preconceived biases he may have held. To ensure credibility and trust, member checking of the participants' interview transcriptions was done to verify accuracy of the information and make changes if needed (Guba, 1981; Harper & Cole, 2012; Lincoln & Guba, 1985; Moustakas, 1994).

In addition, triangulation of the data was addressed by comparing the findings with related studies, e.g., Lewis and Pearson, 2007; Parr et al., 2006, 2008, 2009; and Young et al., 2008, 2009. Rich rigor was obtained through careful collection and analysis of the data (Tracy, 2010). Tracy (2010) posited that "sincerity as an end goal can be achieved through self-reflexivity, vulnerability, honesty, transparency, and data auditing" (p. 841). The lead researcher kept a journal where he recorded his introspections during the study (Guba, 1981; Tracy, 2010). Further, the other researcher acknowledges having been part of the *Math-in-CTE Study* in which the teachers received PD on CI. To avoid his potential biases impacting the study's credibility, he did not participate in collection and analysis of the data.

Although findings from a phenomenological study are not generalizable, they may be transferable to others who experience a similar phenomenon (Lincoln & Guba, 1985). "*Transferability* is achieved when readers feel as though the story of the research overlaps with their own situation and they intuitively transfer the research to their own action" (Tracy, 2010, p. 845). By describing a study's participants, readers are given a better understanding of who provided the data and, therefore, a basis on which to make judgments about how similar they are to individuals to whom readers may wish to relate the findings (De Lay & Swan, 2014).

Description of the Study's Participants

Six agriculture teachers took part in the study, including five males and one female. Their ages ranged from 37 to 59 years, and years of professional service varied from 13 to 33. *Participant #1 (Jason):* A male teacher, age 59, with almost 33 years of teaching experience; he holds a bachelor's degree and a master's degree in agricultural education. *Participant #2 (Mark):* A male teacher, age 50, with 25 years of teaching experience; he holds a bachelor's degree in agriculture and a master's degree in educational administration. *Participant #3 (Ann):* A female teacher, age 37, with 16 years of teaching experience; she holds a bachelor's degree in agricultural education and a master's degree in educational administration. *Participant #4 (Frank)*: A male teacher, age 49, with 26 years of teaching experience; he holds a bachelor's degree in agricultural education. *Participant #5 (Peter):* A male teacher, age 47, with almost 25 years of teaching experience; he holds a bachelor's degree in agricultural education and a master's degree in education (option in educational leadership). *Participant #6 (Brian)*: A male teacher, age 38, with 13 years of teaching experience; he holds a bachelor's degree in animal science and a master's degree in education.

Findings

The data were organized by various codes; the codes were later sorted into seven interpretive themes with sub-themes (Moustakas, 1994). Lester (1999) and Moran (2000) asserted that a phenomenology is more about description than explanation. Lester (1999) added that "[t]he findings can be reported robustly, and my usual preference is to include direct quotes - both 'soundbites' and more extensive quotes - from participants to illustrate points" (p. 3). Lester's (1999) preference was followed in reporting the findings of this study.

Theme #1: Trainers of other teachers

Sharing knowledge with other teachers: All participants interviewed indicated they had shared the benefits of CI with their teacher peers. In support of this theme, Ann confided: "I have shared information [on CI] with my fellow agriculture teachers that teach in surrounding towns and through our agriculture teachers groups." Ann added: "We have a professional development [activity] every Wednesday and I have shared with my local school teachers and in fact [we] developed some lessons." Mark said that he had shared the knowledge he acquired about CI with about 20 to 25 teachers. Jason explained that together with his math teacher partner, they had provided PD on CI to nearly 190 teachers through various workshops.

> I was asked to share at the national agriculture teachers' workshop in St. Louis, Missouri and I have shared it in Minneapolis-St. Paul, where we did a workshop for teachers . . . and [at] a high school in Florida. My math teacher and I went to those places to share our experiences [on CI] and how that works.

Frank maintained that, although he had shared his knowledge of CI with about 15 to 20 teachers, he was not sure how many used it. Frank added: "Some of them have actually implemented what we shared with them. Others have showed no interest." Peter said he had trained about 90 teachers through various workshops: "[W]e have had three of them and we had approximately 30 [teachers] in each one."

Mentorship of aspiring teachers: All of the participants acknowledged having mentored aspiring teachers, i.e., preservice teachers, on various aspects of CI by sharing the lessons they developed during the *Math-in-CTE Study's* PD and by explaining its benefits. Jason stated that many of the aspirants were surprised by how much math they taught in agriculture: "When I first used curriculum integration, the question I received was, 'why are we doing math?' And they [, i.e., the student teachers,] later realized that we did more [math] than they thought." Jason shared further: "Some of them would say, I don't want to do too much work, and I would say, well this is the kind of work we did for you. It just makes it easier for you to use and they [would] go 'okay.'"

Mark noted that training student teachers on CI had equipped them with new ideas and concepts to incorporate in their classrooms, especially because some lessons were already made. Ann encouraged most of her student teachers to "think outside the box" in regard to CI and she had mentored what she called "three-day teachers," i.e., preservice students who came to her program for three days of early field-based teaching experience. Peter said that "definitely I have shared the lessons we developed with my student teachers." Frank and Brian also confirmed that they had shown student teachers various ways of integrating math when teaching agriculture.

Theme #2: Teamwork and collaboration with other educators

All of the participants indicated that because of the PD they forged strong relationships with their math teacher partners. (During the *Math-in-CTE Study*, agriculture teachers were paired with math teachers for the purposes of a) interrogating the APT curriculum for math content that could be enhanced, (b) developing math-enhanced APT lessons that used the 7-element pedagogic approach, (c) critiquing the math content of the lessons, and (d) math teachers serving as school-based math resources for the agriculture teachers [Young, 2006].) According to Brian, his cooperating math teacher had helped recruit students: "I have helped convey some of my lessons in her class and she has been able to earmark some kids that would be excellent agriculture students for me." Frank asserted he had an excellent relationship with his math teacher until that individual left his school a year after the PD: "[F]or him to see that we are kind of teaching the same thing, teaching it in a more practical way than he was teaching it, really kind of opened his eyes." Ann explained that she still had a vibrant working relationship with her math teacher: "We still try to tie agriculture to her [math] classes and math to mine so that students link and learn concepts better." Jason indicated that because of the teamwork and collaboration with his math teacher, she realized how much higher math he was already teaching in agriculture:

> I remember during one of the lesson plans we did, we were talking about differences in slopes, rise over run, talked about roof angles . . . [and] my math teachers understood how numbers worked but they didn't know how to apply the numbers in real life . . . . I had to explain to them . . . . They learned and we learned; it was a good situation.

Theme #3: Increased respect for agriculture teachers from their academic teacher peers and students

Because of the collaboration, many of the academic teachers came to appreciate how much work agriculture teachers do, including teaching content that integrates several subjects. This finding supports a related study by Lewis and Pearson (2007) who reported that "[w]orking together to develop the lessons had given both the CTE and math teachers increased respect for what their colleagues were teaching" (p. 40). Ann stated that working with other teachers had helped them build rapport and enabled "the regular teachers to get away from the idea that the agriculture teachers never teach . . . [and] other teachers realize that we really do teach stuff and it is usable stuff." Related to Ann's point, Peter shared: "I think it [, i.e., the PD,] helped the math teacher I was working with to understand our program better, helped bridge the gap and [with] administration, as well." In addition, Frank reported: "It helped a great deal for him [, i.e., the math teacher,] to understand what we are doing in agriculture. Too many of the regular teachers think that we are not teaching anything."

Some of the participants also reported students expressing *aha moments* when working with certain math concepts they had ostensibly learned in other courses but may not have understood well until taught that content using real-world examples derived from agriculture. Jason described: "I see aha moments and the kid goes 'oh, now I understand what you are saying.' So that's what the science teacher was trying to tell me. That has helped a lot." According to Brian, because of CI, students realize that math is one of his strong areas: "[T]hey realize that math is probably one of my stronger suits . . . when you look at what I teach and how I teach it in relation to the core concept."

Theme #4: Increased student motivation and learning achievement

The participants perceived that by teaching their curriculum in an integrated way most of their students were more motivated and eager to learn, which they suspected meant higher academic achievement by those pupils. The students experience the same concepts in their core courses and in agriculture and they say "we saw that in math yesterday" (Ann). Ann's point was echoed by Jason: "That was on the plant test, I never knew what they were talking about. Now, I know how to work the problem and I know I got it right [on the science test]." And Frank added: "I think students understand concepts better when it is taught in both classrooms in two different ways." In addition, Mark stated:

> I have had them in class; they are passing their tests, their biology and their math. And for the others if they don't have me, their chances of passing are minimal. This is because . . . the more repetition that they have, whether its genetics or Pythagorean Theorem, or math as a whole, the more that they do it, the more proficient they are . . . .

Moreover, according to Jason, integration of math in his agriculture courses had helped reinforce some of the concepts students learned in their math courses; thus, students are able to transfer concepts from one subject to solve a problem in another. On one occasion, for example, Jason's math teacher visited his class while he was teaching the principles of land judging and evaluation, and the students were supposed to calculate the slope of a field:

> [S]he kept saying rise over run. The kids looked at her and asked rise over run? Can we use it here? She said yes. . . . [The math teacher] had already taught the concept but it had not been reinforced in real-life and the kids couldn't realize that they could use it in agriculture.

The use of real-world examples and more practical terms when teaching math concepts in agriculture helped students stay focused and motivated (Barefield, 2005; Choike, 2000; Kain, 1993). In support, Brian stated: "I think that one of the biggest problems is when you start using math terms, it shuts the kids off." Further, Peter asserted that CI had helped to reduce test anxiety among students as they prepared for the American College Testing [ACT] examination: "The ease of knowing real-life situations . . . [in which] you can put math to use has helped them . . . with math on [the] ACT test." Ann elaborated:

> I think definitely it is less stress on them . . . and may be this teacher is teaching it differently than the other teacher. Students learn differently although it's the same thing being taught. . . . They learn concepts in core classes that we can put to hands-on [, i.e., practical use,] and they catch on to those concepts faster.

Theme #5: Using the 7-element pedagogic approach learned during the *Math-in-CTE Study*

All of the participants interviewed agreed they were still using some of the 7-element pedagogic approach to CI (Lewis & Pearson, 2007; Young et al., 2008, 2009), as developed during the *Math-in-CTE Study's* PD from 10 years before. Two participants acknowledged using all seven of the elements developed as the study's teaching approach. Ann said: "I try to use them with the majority of my lessons; agriculture mechanics is the easiest class [in which] to use the seven elements with mathematics." Mark added: "I have integrated those lesson plans [using the 7-element pedagogic approach] into my regular classroom all the time. Every time I get new kids, they go through that." However, the other participants explained they used only two to five of the 7-elements depending on the content they were teaching. Brian indicated that he uses about one-half of the 7-element pedagogic approach: "I am just using pieces and parts as needed. I would say I am using 50%." Frank said he taught two to three aspects of the lessons developed each year depending on the content. His favorite lessons were "calculating perimeter to build a fence, [and a lesson on the] cost of harvesting wheat."

Theme #6: Challenges encountered with CI, teacher collaboration, and students

The participants elaborated on a number of challenges encountered with other teachers and students regarding their use of an integrated curriculum approach. *Unreceptive teachers:* The participants indicated that some of their peers were not receptive to using CI. They wanted to maintain the *independence* of their subjects and thought the idea of integration diminished their curriculum's integrity and uniqueness (Barefield, 2005). Further, they asserted that CI needed more class time to implement. Lewis and Pearson (2007) reported *lack of enough time* as one factor that limited teachers' use of the 7-element pedagogic approach to CI. Further, Frank opined that some teachers are more concerned with the content they need to teach in a given semester than taking on what some perceived as an extra load: "[Teachers] are worried about teaching what is on the test." And Jason added: "[A] couple of them are not interested."

Mark expressed that sometimes math teachers insist on using math terms which are hard for students to comprehend. In support, Brian stated:

> [Y]ou know math teachers want to use math terms and math terms only. . . . You know terminology is the biggest barrier. I think that one of the biggest problems is when you start using math terms, it shuts the kids off.

High turnover among math teachers: Another challenge participants experienced was high turnover among their math teachers. Some explained that most of the math teachers with whom they were paired during the PD workshops left the profession or joined other schools, and the teachers hired as replacements did not stay for long. Frank stated that in the last 10 years he had worked with about seven different math teachers, and also noted not every teacher was interested in CI. The math teacher with who he worked during the PD left his school a year later.

Negative attitudes of students toward mathematics: Three of the six participants indicated some students have a very negative attitude toward math and mentioning any term related to math shut them down (Pearson et al., 2010). Ann stated: "Generally speaking, kids have a negative attitude towards math . . . [and ask] why are we doing it here [in agriculture] again?" Frank maintained that, although most of the "students understand high level math; they do not understand the practical uses of math." Peter indicated he frequently had challenges with students using math in agriculture depending on their math ability.

Theme #7: Solutions suggested for the challenges encountered

The participants suggested a need to provide regular PD workshops for teachers; a recommendation also supported by education scholars, e.g., Harwell, 2003; Hunzicker, 2010; Tate, 2009; and Yoon et al., 2007. They recommended teachers of subjects other than math also be trained on CI, especially instructors of other core subjects such as science. The participants perceived that would help create awareness among teachers about the benefits of using integrated curricula, improve teamwork and collaboration between teachers of different subjects, and lead to enhancing students' academic achievement. In support, Jason shared: "I think if every [agriculture] teacher would have the opportunity to sit down with a math teacher, science, and English teachers . . . we can work together to show how much they do to support me in getting these kids educated."

According to Peter, because a lot of time had passed since the *Math-in-CTE Study's* PD, it would be useful to do it again with different teachers:

> I think it would be beneficial to do it all again, we got a lot out of it. I think with updates in technology 10 years down the line, it could be beneficial to try it again. . . . We would do it with different teachers this time, may be a science one like we did with math.

In addition, Mark proposed that all aspiring agriculture teachers should have instruction on approaches to CI because it would be very beneficial for them:

> I think this is something they need to do with the young teachers. . . . [They should] go through a boot camp and show them how to utilize these math theories in their classroom[s] because every teacher would benefit from this who is teaching agriculture mechanics and agriculture as a whole.

To motivate students, Frank recommended that students learning math concepts through a math-enhanced curriculum in APT should receive a math credit. He perceived this would help reduce the negative views some students express when math concepts are taught in agriculture courses and motivate them to learn, knowing they would receive course credit. Further, Jason acknowledged the overlap between math and agriculture was more than he had thought: "The overlap in math was more than I ever dreamt of. [For example,] doing angles and measuring of distances, making sure something is square by measuring [it]."

Emergent Essence of the Phenomenon

Teacher PD is important because it stands to yield positive and tangible results to schools, to teachers, and, most important, to students (Garet et al., 2001; Harwell, 2003; Quick et al., 2009; Yoon et al., 2007). As farmers fertilize and cultivate their fields to expand yields, PD enables teachers to stay abreast of developments in their subjects and equips them with better pedagogical skills and tools (Blank et al., 2008; Desimone et al., 2002; Garet et al., 2001), which increases the likelihood of improving student learning, i.e., *their yields*. Such was this study's *essence* regarding the PD of agriculture teachers and its lasting impacts on their use of CI.

Conclusions

The participants described positive experiences with and resulting from their PD experiences on using a math-enhanced curriculum to teach APT. The teachers had continued to use some of the lessons developed during their training and aspects of the 7-element pedagogic approach. In a one-year follow-up study conducted after the 2005-2006 school year, Lewis and Pearson (2007) found that 73% of the experimental group teachers, including teachers of agriculture, had used "the method and materials from the study" (p. ix).

Some of the relationships agriculture teachers developed with their math teacher partners had continued and others ended because the math teachers retired, transferred to other schools, or left the profession. Using CI enabled the participants to develop a spirit of teamwork and collaboration with math teachers and, in some cases, instructors of other academic subjects (Barefield, 2005; Harwell, 2003; Quick et al., 2009). The interactions around CI enabled their teacher peers, especially math teachers, to gain a better understanding of and appreciation for the work done by agriculture teachers.

All of the participants had provided PD on CI to teachers of agriculture, to teachers of other subjects, and to preservice teachers. Further, it was expressed that the participants' math teacher partners gained a better understanding of how various math concepts can be applied to real-life situations in agriculture. They lamented, however, that math teacher turnover created a challenge to their attempts at CI and because some teachers resisted collaboration.

The teachers perceived the use of a math-enhanced curriculum to teach APT improved their students' understanding and application of math concepts in real-world contexts (Barefield, 2005; Bean, 1995, 1996; Etim, 2005; Jacobs, 1989; Vars, 1991), and through agriculture in particular (Parr et al., 2006, 2008, 2009; Young et al., 2008, 2009). They expressed that the CI approach learned through their PD experiences improved students' motivation for learning and ultimately their math achievement (Barefield, 2005; Kain, 1993; Yoon et al., 2007). However, the knowledge they had of how students performed in their math courses was mainly anecdotal.

Implications and Recommendations

Based on the participants' shared experiences, a need exists to continue to provide agriculture teachers with PD (Harwell, 2003; Hunzicker, 2010; Tate, 2009; Yoon et al., 2007), especially in regard to using integrated curricula and approaches to teach agriculture. Teachers other than only math instructors should be included in future PD to help them understand the benefits of CI that uses agriculture as the learning context, e.g., science teachers (Pearson, Young, & Richardson, 2013). Follow-up with the participants of such PD should be made regularly to assist in mitigating the challenges teachers may experience when implementing CI. Addressing issues early may help mitigate some of the unintended and undesirable consequences of CI which sometimes arise during the process of implementation and the related attempts to collaborate with other teachers (Bean, 1995; Loepp, 1999; Vars, 1991, 2001). More effort is needed to reduce the high attrition rates among teachers, especially if return-on-investments [ROIs] (Mincer, 1981, 1989; Schultz, 1972; Sweetland, 1996; Zula &

Chermack, 2007) made in preparing and inservicing teachers on approaches to CI are to be fully realized.

Teacher collaboration on CI and other curriculum-based approaches to improving student learning implies teacher relationships and collegiality, which is unlikely to occur without time *and* opportunities to share, discuss, and learn from one another. School leaders should foment and support communities of practice (Wenger, 1998; Yamagata-Lynch, 2001; Young, 2006) formed around approaches to CI (Lewis & Pearson, 2007; Pearson et al., 2010) and lesson study (Alvine, Judson, Schein, & Yoshida, 2007) as well as other interventions calibrated to enhance student learning. Again, time and other resources must be allocated to this end, including opportunities for relationship-building among teachers, which implies the maintenance of stable, campus-based teacher cohorts over time.

Agriculture and math teachers should strive to use terms their students can understand. Pearson et al. (2010) posited that "[c]onnecting occupational vocabulary to the language of math can open students['] and teachers['] eyes to the math they already know" (p. 21). If both teachers use similar, familiar, and proper terminology in their classrooms, the likelihood of students comprehending the concepts taught stands to increase.

Further, teamwork and collaboration among stakeholders, especially teachers and administrators, is critical in ensuring teachers apply the knowledge and skills acquired from PD (Garet et al., 2001). If stakeholders are supportive of CI, i.e., an enabling *subjective norm* is established and nurtured (Ajzen 1987, 1991; Ajzen & Madden, 1986), the aims of teacher PD are more likely to be achieved, which should improve student learning. Because differences existed among participants in their intensity and frequency of using the 7-element teaching approach and related lessons, more research is needed to identify subjective norms and planned behaviors (Ajzen 1987, 1991; Ajzen & Madden, 1986) that may increase teachers' persistence in executing principles of PD long after their training ends.

Finally, the participants perceived their attempts to integrate curriculum had improved students' academic achievement and motivation (Barefield, 2005; Kain, 1993), i.e., a positive ROI in human capital (Mincer, 1981, 1989; Schultz, 1972; Sweetland, 1996; Zula & Chermack, 2007) may have been derived from the teachers' PD. However, what they knew about the impact of their approach to CI on students' math performance outside of the agriculture program was limited. To that end, we recommend more studies be conducted to evaluate the impact of teacher PD on student learning behaviors and outcomes, including approaches to CI, and the results be shared with all stakeholders.

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