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Mathematics Efficacy and Professional Development Needs of Tennessee Agricultural Education Teachers

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Abstract

School-based agricultural education programs are recognized as contributors to teaching contextualized mathematics and supporting STEM education. This study examined the mathematics teaching efficacy and professional development needs of Tennessee school-based agricultural education teachers related to teaching contextualized mathematics. Tennessee agricultural education teachers were moderately efficacious in Personal Mathematics Teaching Efficacy and Mathematics Teaching Outcome Expectancy, and this may negatively impact the teaching of mathematical concepts found in Tennessee's agricultural education curricula. Also, similarities and differences were found in the teachers' professional development needs based upon mathematics teaching efficacy. Future research should seek to discover factors impacting the development of mathematics teaching efficacy among school-based agricultural education teachers. We also recommend professional development related to teaching contextualized mathematics be tailored to the different needs of teachers by states or regions.

***Keywords*:** STEM; mathematics; math; mathematics teaching efficacy; professional development

Introduction

According to the National Research Council (2001), "mathematics is a realm no longer restricted to a select few. All young Americans must learn to think mathematically, and they must think mathematically to learn" (p. 1). Similarly, employers have noted the need for workers with greater proficiency in mathematics and problem-solving (National Academy of Sciences, 2017). Yet, the percentage of fourth, eighth, and 12th grade students scoring proficient or higher in mathematics is well below 50%, and the average United States student's mathematics and science literacy scores are well below other developed countries (National Academy of Sciences, 2017). This lack of proficiency is not a new challenge. In 1983, the National Commission on Excellence in Education released, *A Nation at Risk: The Imperative for Educational Reform*. The report stated the United States was being matched and surpassed by other countries educationally, and called for reforms to core academic subjects, higher academic standards, and improved teacher education (Vinovskis, 2009). Educational reform in the 1990s "established national goals, called attention to the need for competent teachers, and spurred the

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creation of content and performance standards" (Stripling, 2012, p.22). The 2000s saw the passage of the No Child Left Behind Act, which emphasized providing highly qualified teachers and the establishment of national accountability, and the development of the Common Core State Standards and Next Generation Science Standards aimed at improving American schools and student achievement (Stripling, 2012). Early assessments in the 21st century have shown increased proficiency in mathematics among secondary students, but a majority still remain below proficient on the National Assessment of Educational Progress mathematics assessments (National Academy of Sciences, 2017).

As a result of deficiencies that continue to persist, a concern regarding a science, technology, engineering, and mathematics (STEM) workforce which are situated for an increase in retirements, and a STEM talent shift from the United States to Asia (Taningco et al., 2008; Zollman, 2012), indicates that the United States is not preparing a sufficient number of students, teachers, and professionals in STEM to meet our future needs (Kuenzi, 2008; National Governors Association, 2007). A workforce proficient in STEM skills is critical to the United States economy and is a "prominent concern in discussions of national competitiveness, education policy, innovation, and even immigration" (National Academy of Sciences, 2017, pp. 57-58). Furthermore, proficiency in STEM knowledge and skills allows individuals to pursue career opportunities and postsecondary studies in STEM and non-STEM fields (National Academy of Sciences, 2017). Many individuals with STEM training, who work in non-STEM fields, purport their jobs have components related to their STEM training, and this provides employers and the economy an opportunity to benefit from STEM trained individuals who work in non-STEM fields (National Academy of Sciences, 2017).

School-based agricultural education has been influenced by these educational reform efforts and has emphasized core academics and STEM education (Hilby, Stripling, & Stephens, 2014; Phipps, Osborne, Dyer, & Ball, 2008). Moreover, the National Research Council (1988) called for agricultural education to prepare students for careers in mathematics and science. More recently, Shinn et al. (2003) published a white paper outlining school-based agricultural education's role in improving students' mathematics achievement, and the American Association for Agricultural Education's National Research Agenda 2016-2020 listed the question, w*hat are effective models for STEM integration in school-based agricultural education curriculum*, as a research priority question under research priority three – *Sufficient Scientific and Professional Workforce that Address the Challenges of the 21st Century* (Stripling & Ricketts, 2016). Furthermore, according to the National Research Council (2009), we are in an era of scientific agriculture that combines basic and applied aspects of the traditional STEM disciplines.

Thus, one should not be surprised that school-based agricultural education has been recognized as a way to increase student learning in STEM arenas (Jansen & Thompson, 2008; Phipps, Osborne, Dyer, & Ball, 2008; Stripling & Ricketts, 2016; Swafford, 2018), with mathematics competencies targeted as an area to be emphasized and improved (Shinn et al., 2003; Stripling & Roberts, 2012a, 2012b, 2013, 2014; Parr, Edwards, & Leising, 2008; Young, Edwards, & Leising, 2009). Researchers in school-based agricultural education also suggest that a mathematics-enhanced curriculum will improve mathematics achievement without diminishing technical skill development and acquisition (Parr et al., 2008; Young et al., 2009). Similarly, Stachler, Young, and Borr (2013) stated core academic integration in career and technical education (CTE) does not decrease the effectiveness of the CTE curriculum.

However, in a national study, Stripling and Roberts (2012b) discovered preservice agricultural education teachers possessed low mathematics ability and thus were not prepared to teach a mathematics-enhanced curriculum. Similarly, in the only study located that measured the mathematics ability of agricultural education teachers, Miller and Gliem (1996) concluded the teachers in their study were not proficient in solving agricultural mathematics problems. Furthermore, the Michigan State

University Center for Research in Mathematics and Science Education (2010) reported our educational system has created a troubling cycle in which teachers who possess mathematical deficiencies, produce students who are not proficient in mathematics, and then these students become the next group of mathematics deficient teachers.

With this in mind, Stripling and Roberts (2012a) called for professional development for both preservice and in-service teachers to build upon and positively develop agricultural educators' self-efficacy and proficiency in mathematics (Stripling & Roberts, 2012a). In response to Stripling and Roberts (2012a), Haynes and Stripling (2014) identified the mathematics professional development needs of Wyoming agricultural education teachers and found similarities and differences based upon the teachers' mathematics teaching efficacy. This study seeks to determine the mathematics teaching efficacy and professional development needs of Tennessee agricultural education teachers related to teaching contextualized mathematics.

Theoretical Framework

Bandura's (1986) social cognitive theory served as the theoretical framework for this study. Social cognitive theory purports cognitive development includes multifaceted sequences over time, and that most cognitive skills are socially cultivated (Bandura, 1986). Thus, social interaction provides a foundation for social learning and the development of cognitive skills (Bandura, 1986). Additionally, social cognitive theory describes five basic human capabilities: (a) symbolizing, (b) forethought, (c) vicarious or observational, (d) self-regulatory, and (e) self-reflective. According to social cognitive theory, humans are extremely adaptable in regards to their respective environments due to an extraordinary symbolizing capability (Latham, 2012), which allows them to draw on past experiences and knowledge to test possible outcomes (Bandura, 1986). While humans do react to their environment, behaviors are regulated by forethought that allows them to guide their actions in response to a desired future (Bandura, 1986; Latham, 2012). Observational capabilities allow individuals to learn by observing behaviors and subsequent consequences of those behaviors (Latham, 2012), which provides humans the ability to learn without trial and error (Bandura, 1986). In regard to self-regulation, most behaviors are a direct reflection of standards set internally and reactions to an individual's own observed (Latham, 2012) or chosen actions (Bandura, 1986). The final capability is self-reflective, and this capability allows humans the ability to analyze an experience and to think about their own thoughts (Bandura, 1986; Latham, 2012).

"Patterns of human behavior are organized by individual experiences and retained in neural codes, rather than being provided ready-made by inborn programming" (Bandura, 1986, p. 22). Bandura's (1986) model of triadic reciprocal causation suggests that "behavior, cognitive and other personal factors, and environmental events all operate as interacting determinants of each other" (p. 18). For this study, we operationalized the reciprocal causation model in accordance to Haynes and Stripling (2014); "behavior is the teaching of contextualized mathematics, external environment is the teacher education program, and personal factors are self-efficacy and mathematics ability" (p. 138).

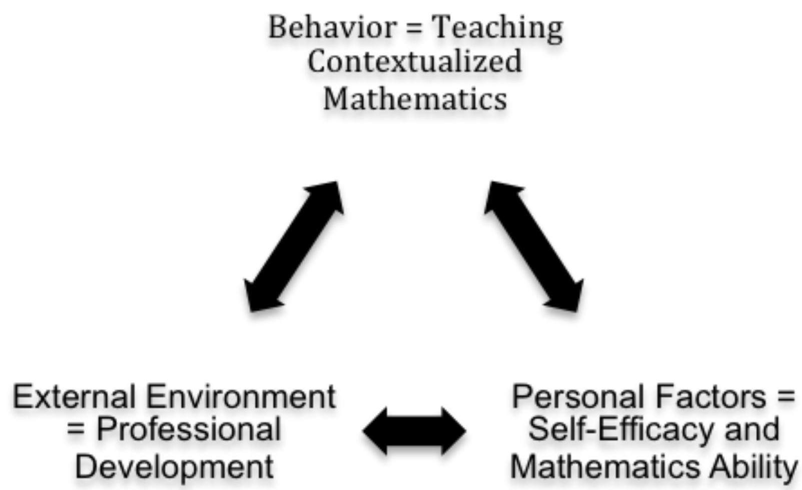

Figure 1. Triadic reciprocal causation model. Operationalized by Haynes and Stripling (2014).

Literature Review

Behavior – Teaching Contextualized Mathematics

The idea of contextualized learning suggests that neither vocational nor general education is completely capable of standing alone but must be integrated to maximize benefits for students (Prescott, Rinard, Cockerill, & Baker, 1996). Teaching mathematics in the context of agriculture provides relevance for learning, while potentially strengthening connections between school and community learning environments (Taylor & Mulhall, 1997). Agricultural education has been based on practical application of knowledge since its inception (Phipps & Osborne, 1988) and provides numerous opportunities for contextualization (Stripling, Ricketts, Roberts, & Harlin, 2008).

The most well know pedagogy for teaching contextualized mathematics in agriculture is the Math-in-CTE model (Figure 2; Stone, Alfeld, Pearson, & Jensen, 2006). This model emphasizes teaching contextualized applications (elements three and four) before general mathematical principles (element five) or mathematics representations similar to what would be found on a standardized test (Stone et al., 2006). This is illustrated in the model by requiring instruction in the original CTE context (element three) and additional contextualized applications (element four) and opportunities for students to demonstrate understanding of mathematical concepts (element six) following contextualized and traditional mathematics examples (elements three, four, and five; Stone et al., 2006).

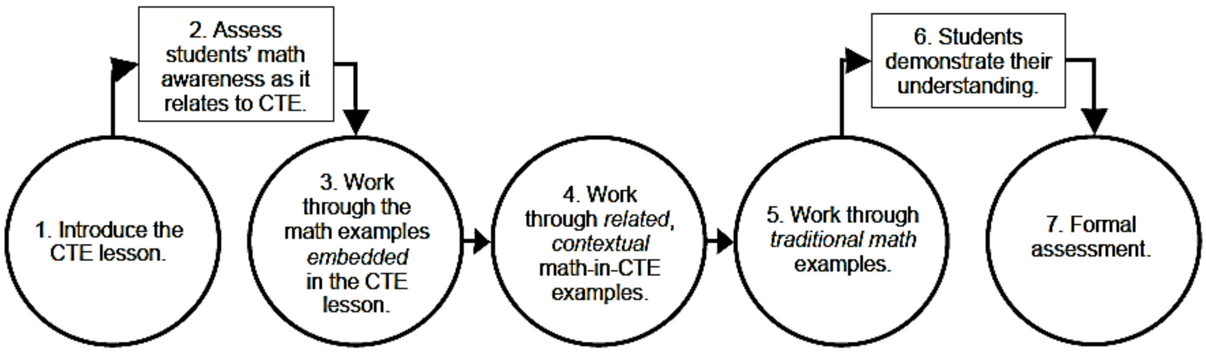

Figure 2. The National Research Center for Career and Technical Education: Seven Elements of a Math-Enhanced Lesson model (Stone et al., 2006, p. 13).

Parr, Edwards, and Leising (2006) reported the use of the Math-in-CTE pedagogy reduced school-based agricultural education students need for postsecondary mathematics remediation. In another study, Parr, Edwards, and Leising (2009) did not find a difference in mathematics ability of school-based agriculture students, but they postulated the incomplete implementation as reported by some participants and the intervention only lasting one semester may account for this finding. In a large CTE study that include school-based agriculture teachers and students, Stone et al. (2006) found teachers and students had positive experiences with the Math-in-CTE model, and teachers believe the model to be effective, a true model of integration, and increased their teaching competencies. Stripling and Roberts (2013, 2014) utilized the pedagogy as part of a treatment designed to increase the mathematics ability of preservice agricultural education teachers in a teaching methods course. They found the treatment to have a positive effect on mathematics ability, but no effect on personal mathematics efficacy and mathematics teaching efficacy.

Personal Factors

Self-efficacy. Self-efficacy is one's personal judgment of his/her capability to perform a task or behavior (Bandura, 1997). These judgements regulate motivation by influencing aspirations and expected outcomes of one's actions (Bandura, 1997). However, according to Bandura (1997) "insidious self-doubts can easily overrule the best of skills" (p.35). In regard to teaching, teacher efficacy is one's belief in their ability to generate desired outcomes in students (Soodak & Podell, 1996). Teachers with higher efficacy persevere through challenges (Goddard, Hoy, & Woolfolk Hoy, 2004) and exert more effort in planning for instruction (Allinder, 1994).

> Greater efficacy leads to greater effort and persistence, which leads to better performance, which in turn leads to greater efficacy. The reverse is also true. Lower efficacy leads to less effort and giving up easily, which leads to poor teaching outcomes, which then produce decreased efficacy. Thus, a teaching performance that was accomplished with a level of effort and persistence influenced by the performer's sense of efficacy, when completed, becomes the past and a source of future efficacy beliefs. (Tschannen-Moran et al., 1998, p. 234).

A teacher's thoughts about their own efficacy to motivate and encourage learning affects the type of classroom and learning environment the individual teacher creates and influences students' academic achievement (Bandura, 1993).

Specific to teaching contextualized mathematics in agriculture, various populations of agriculture teachers have been found to be moderately to very efficacious in mathematics and mathematics teaching efficacy (Haynes & Stripling, 2014; Jansen & Thompson, 2008; Swan, Moore, & Echevarria, 2008). Similarly, preservice agricultural education teachers in Florida and Tennessee were found to be moderately efficacious in mathematics teaching efficacy (Hilby, Stripling, & Stephens, 2014; Stripling & Roberts, 2012a, 2014). However, Hilby et al. (2014) reported preservice agricultural education teachers possessed a false sense of mathematics teaching efficacy as a result of misconceptions of the school-based agricultural education curriculum, appropriate mathematics teaching methods, and their own mathematics knowledge. Hilby et al.'s (2014) results suggested "past success in mathematics and vicarious experiences related to mathematics influence mathematics efficacy beliefs more than current mathematics proficiency" (p. 121).

Mathematics Ability. Many teachers do not possess adequate mathematics subject matter knowledge (Even & Tirosh, 1995; Liu, Rosenstein, Swan, & Khalil, 2008), and this deficiency negatively affects student achievement (Michigan State University Center for Research in Mathematics and Science Education, 2010). This issue is present in both core academic teachers and agricultural education teachers (Haynes & Stripling, 2014).

In regard to agricultural education, Miller and Gliem (1994) concluded agricultural education teachers were not able to solve agricultural mathematics problems and sought to explain the variance in the mathematical ability of agricultural education teachers. The mean score on a mathematical problem-solving, in which algebra was the highest level of mathematics needed to solve the problems, was 66.5% (*SD* = 2.96). The relationship between mathematical problem-solving ability and the following variables were not significant: (a) age and (b) highest level of college mathematics coursework completed (Miller & Gliem, 1994). However, relationships between mathematical problem-solving ability and years of teaching experience, final college grade point average, ACT math score, and attitude toward the inclusion of mathematics concepts in the curriculum and instruction of secondary agriculture programs were significant.

Stripling and Roberts (2012a) reported preservice agricultural education teachers at the University of Florida scored 35.6% on an agricultural mathematics assessment, and associations between the mathematics scores and level of mathematics completed in high school and college suggested advanced mathematics coursework resulted in higher scores. Using the same instrument as Stripling and Roberts (2012a), Stripling and Roberts (2012b) estimated the population mean for the nation's preservice agricultural education teachers, with 95% confidence, to be 28.5% to 48.5%. As a result, they concluded the nation's preservice agricultural education teachers were not proficient in mathematics. Furthermore, Stripling and Roberts (2012b) found preservice teachers that completed an advanced mathematics course scored 19.48 percentage points higher than those that did not complete an advanced mathematics course and those that received an A in their highest college mathematics course scored 6.40 percentage points higher than those that did not receive an A. Congruently, Stripling, Roberts, and Stephens (2014) reported the nation's preservice teachers were only proficient in three of 13 National Council of Teachers of Mathematics content areas present in the National Agriculture, Food and Natural Resources Career Cluster Content Standards.

Moreover, as indicated in the research above, research in agricultural education has revealed a disconnect between teachers' and preservice teachers' mathematics knowledge and efficacy (Haynes & Stripling, 2014; Hilby et al., 2014; Jansen & Thompson, 2008; Miller & Gliem, 1994, 1996; Stripling & Roberts, 2012a, 2012b, 2013, 2014; Stripling, Roberts, and Stephens, 2014; Swan, Moore, & Echevarria, 2008). This research has shown teachers' and preservice teachers possess low mathematics knowledge and moderate to high mathematics efficacy.

External Environment – Professional Development

Different groups of teachers have distinct and different professional development needs (Roberts & Dyer, 2004). When it comes to professional development, there is no one approach that is effective for every population (Estepp, Thoron, Roberts, & Dyer, 2014). However, the importance of quality professional development opportunities for agricultural educators, as well as all teachers cannot be underestimated (Jansen & Thompson, 2008; Young, 2006). Yet, professional development "that is content-focused, intensive, and sustainable" (Stachler, Young, & Borr, 2013, p. 14), while supporting STEM integration in CTE courses seldom exists (Birman et al., 2007). Doolittle and Camp (1999) stated knowledge that is gained and shared among individuals as a result of active participation in social activities and self-reflective experiences, greatly increased the effectiveness of professional development. One such model that subscribes to this philosophy is the Math-in-CTE model (Stone et al., 2006). Stone et al. (2006) reported the following five core principles that emerged from their extensive work in seeking to improve student performance in mathematics: 1. Develop and sustain a community of practice among the teachers; 2. Begin with the CTE curriculum and not the math curriculum; 3. Understand that math is an essential workplace skill; 4. Maximize the math in the CTE curriculum; and 5. Recognize that CTE teachers are teachers of math-in-CTE, and not math teachers. (Stone et al., 2006, p. 83). However, budgetary constraints of CTE teachers (Anderson, Barrick, & Hughes, 1992) are cause for concern in view of the increased funding required for professional development (Desimone, 2009) that subscribes to the philosophies and principle above.

To that end, there has been a large-scale effort to develop curriculum in agricultural education that teaches knowledge and skills in agriculture, while enhancing mathematics, science, and English concepts (Curriculum for Agricultural Science Education, n.d.). This project, the Curriculum for Agricultural Science Education, offers teachers four areas of support: (a) curriculum, (b) intensive professional development, (c) assessment, and (d) certification (Curriculum for Agricultural Science Education, n.d.). Before a teacher is eligible to use the curriculum, they must attend professional development (an institute), which is typically nine days per course to receive certification to teach a course (Curriculum for Agricultural Science Education, n.d.). The cost of the 2018 professional development institutes varied between $2,100-$3,200 (Curriculum for Agricultural Science Education, n.d.).

Purpose and Objectives

The purpose of this study is to examine the mathematics efficacy and professional development needs of Tennessee agricultural education teachers related to teaching contextualized mathematics. The following objectives framed this study:

1. Describe the personal mathematics teaching efficacy of Tennessee agricultural education teachers.
2. Describe the mathematics teaching outcome expectancy of Tennessee agricultural education teachers.
3. Determine the professional development needs of Tennessee agricultural education teachers related to teaching contextualized mathematics.
4. Describe the differences, if any exist, in professional development needs related to teaching contextualized mathematics based upon personal mathematics teaching efficacy and mathematics teaching outcome expectancy.

Methods

Haynes and Stripling (2014) conducted a study of mathematics efficacy and professional development needs of Wyoming agricultural education teachers. This study is a replication of their study in Tennessee and was approved by the University of Tennessee's Institutional Review Board. The research design for this descriptive study was a one-shot case study (Campbell & Stanley, 1963), which was conceptualized as a slice in time (Oliver & Hinkle, 1982). The target population was all school-based agricultural education teachers (*N* = 336) in Tennessee. Contact information for the Tennessee agricultural education teachers was provided by the Tennessee FFA Foundation. Data were collected using the Qualtrics online survey platform and a paper version of the questionnaire. The study was originally intended to be conducted online only, but due to a low response rate a paper version of the questionnaire was used to gather additional responses. The online contacts made, with the agricultural education teachers, were guided by Dillman, Smyth, and Christian's (2009) web survey implementation procedures. Dillman et al. stated little research exists on the optimal combination of contacts and suggested additional contacts are not needed when responses per contact stalls. Thus, four emails were sent to the entire target population: (a) email with a link to the survey, and (b) three reminder emails with a link to the survey. These contacts resulted in 45 useable responses or 13.4% of the target population. Following the online distribution of the questionnaire, we decided to provide agriculture teachers the opportunity to participate in the study at the Tennessee Association of Agriculture Educators summer conference in an attempt to increase the response rate. We distributed the questionnaire during a general session of the conference and this resulted in useable data from an additional 76 agricultural education teachers. In total, we collected data from 121 agricultural education teachers or 36.0% of the target population. As a result of having to modify our data collection protocol, no attempt was made to address nonresponse error as our sample was deemed a convenience sample. Therefore, readers should use caution when generalizing the results beyond the sample.

The questionnaire used was compiled by Haynes and Stripling (2014). The questionnaire consisted of the *Mathematics Teaching Efficacy Beliefs Instrument* (MTEBI; Enochs, Smith, & Huinker, 2000), 20 items developed to understand agricultural education teachers' perceived levels of knowledge and relevance on competencies related to teaching contextualized mathematics or math embedded in the agricultural education curricula, 10 demographic questions, and three survey questions related to professional development delivery preferences, like or dislike for mathematics, and how often the participants taught mathematics concepts. The MTEBI (Enochs et al., 2000) is comprised of two scales that measure the constructs personal mathematics teaching efficacy (PMTE) and mathematics teaching outcome expectancy (MTOE). Enochs, Smith, and Huinker (2000) defined PMTE as self-belief in one's ability to teach mathematics, and MTOE as one's ability to bring about a desired learning outcome as a result of mathematics instruction. The PMTE scale consists of 13 items, and the MTOE scale consists of eight items. All items use a five-point rating scale (1 = *strongly disagree* to 5 = *strongly agree*). Haynes and Stripling modified one item by removing the word elementary from "I understand mathematics concepts well enough to be effective in teaching elementary mathematics" (Enochs et al., 2000, p. 201). Enochs et al. (2000) reported Cronbach's alpha coefficients of .88 for PMTE and .75 for MTOE. Construct scores were calculated by computing a summated mean of corresponding items after reverse coding items 3, 6, 8, 15, 17, 18, 19, and 21. Post-hoc reliabilities for PMTE and MTOE were .86 and .73, respectively. The 20 items developed to measure perceived levels of knowledge and relevance on competencies related to teaching contextualized mathematics or math embedded in the agricultural education curricula were measured using a five-point rating scale (1 = *low knowledge* or *relevance* and 5 = *high knowledge* or *relevance*). Haynes and Stripling reported face and content validity was established by an expert panel consisting of three agricultural education faculty and two high school agricultural education teachers.

Data were analyzed using IBM SPSS version 24. Descriptive statistics (i.e., frequencies, percentages, and means) were used to describe the demographic and mathematics efficacy data. Additionally, based on Stripling and Haynes (2014), low, moderate, and high self-efficacy was defined as 1.00 to 2.33, 2.34 to 3.67, and 3.68 to 5, respectively. To describe the professional development needs, mean weighted discrepancy scores (MWDS; Borich, 1980) were used.

Findings

Objective 1: Describe the Personal Mathematics Teaching Efficacy of Tennessee Agricultural Education Teachers

The summated mean for PMTE was 3.26 (*SD* = 0.59) with a minimum of 1.62 and a maximum of 4.77 on a five-point scale. Seventy-seven of the agricultural education teachers (63.6%) possessed moderate PMTE, and 34 (28.1%) possessed high PMTE. Ten (8.3%) agricultural education teachers possessed low personal mathematics teaching efficacy (Table 1).

Objective 2: Describe the Mathematics Teaching Outcome Expectancy of Tennessee Agricultural Education Teachers

The summated mean for MTOE was 3.50 (*SD* = 0.51) with a minimum of one and a maximum of five on a five-point scale. Eight-one (66.9%) of the agricultural education teachers possessed moderate MTOE, and 39 (32.2%) possessed high MTOE. One (0.8%) of the agricultural education teachers possessed low mathematics teaching outcome expectancy (Table 1).

Table 1

Mathematics Efficacy Scores

			Low		*Moderate*		*High*	
Scale	*M*	*SD*	*f*	%	*f*	%	*f*	%
Personal Mathematics Teaching Efficacy	3.26	0.59	10	8.3	77	63.6	34	28.1
Mathematics Teaching Outcome Expectancy	3.50	0.51	1	0.8	81	66.9	39	32.2

Note. 1.00 to 2.33 = *low efficacy*, 2.34 to 3.67 = *moderate efficacy*, 3.68 to 5 = *high efficacy*.

Objective 3: Determine the Professional Development Needs of Tennessee Agricultural Education Teachers Related to Teaching Contextualized Mathematics

The top five rated professional development items were (a) *teaching SAE financial record keeping* (*MWDS* = 2.85), (b) *teaching math concepts embedded in the agricultural engineering and applied technologies program of study* (*MWDS* = 2.37), (c) *teaching personal financial management* (*MWDS* = 2.35), (d) *teaching math concepts embedded in career development events* (*MWDS* = 2.11), and (e) *teaching math concepts embedded in the agribusiness program of study* (*MWDS* = 2.01). The professional development items MWDS minimum was 0.09 and maximum was 2.85. A complete list of professional development items and MWDS are found in Table 2.

Table 2

Professional Development Mean Weighted Discrepancy Scores

	Knowledge		Relevance		
Item	*M*	*SD*	*M*	*SD*	*MWDS*
Teaching SAE financial record-keeping	3.66	1.08	4.29	0.86	2.85
Teaching math concepts embedded in the Agricultural Engineering and Applied Technologies program of study	3.21	1.27	3.83	1.22	2.37
Teaching personal financial management	3.42	1.16	4.03	1.09	2.35

Table 2

Professional Development Mean Weighted Discrepancy Scores Continued…

Teaching math concepts embedded in Career Development Events	3.59	1.02	4.10	0.93	2.11
Teaching math concepts embedded in the Agribusiness program of study	3.26	1.22	3.78	1.25	2.01
Teaching math concepts embedded in the Food Science program of study	2.97	1.21	3.50	1.37	1.83
Teaching math concepts embedded in the Horticulture Science program of study	3.34	1.24	3.81	1.17	1.82
Locating and selecting reference materials related to math instruction	3.13	1.12	3.55	1.11	1.73
Teaching math concepts in laboratory settings (ex. Land lab, greenhouse, garden, ag mechanics lab, etc.)	3.76	0.97	4.14	0.88	1.72
Teaching math concepts embedded in the Veterinary and Animal Science program of study	3.46	1.18	3.89	1.19	1.56
Teaching math concepts embedded in the Environmental and Natural Resource Management program of study	3.34	1.22	3.75	1.18	1.56
Modifying math instruction for Special Needs Students	3.08	1.06	3.55	1.10	1.47
Designing curricula that utilize agriculture as a context for teaching math concepts	3.37	0.99	3.75	1.00	1.41
Utilizing agriculture as a context for teaching math concepts	3.73	0.93	4.03	0.88	1.19
Motivating students to learn math concepts embedded in the agriculture and natural resources cluster	3.48	0.94	3.77	1.00	1.12
Utilizing the Tennessee academic math standards in agricultural instruction	2.99	1.07	3.32	1.14	1.07
Teaching math concepts using instructional technology	3.26	1.00	3.52	1.02	0.93
Developing lesson plans that utilize agriculture as a context for teaching math concepts	3.41	1.00	3.61	0.99	0.50
Collaborating with other agriculture teachers related to math instruction	3.41	1.06	3.56	1.17	0.46
Collaborating with math teachers	3.31	1.12	3.34	1.15	0.20
Integrating content from the ACT into agricultural instruction	3.38	1.01	3.54	1.13	0.09

Objective 4: Describe the Differences, If Any Exist, in Professional Development Needs Related to Teaching Contextualized Mathematics Based Upon Personal Mathematics Teaching Efficacy and Mathematics Teaching Outcome Expectancy.

Similarities and differences were present in mathematics professional development needs based upon Tennessee agricultural education teachers' PMTE and MTOE. The top five rated professional development items for each group (high/moderate/low PMTE and high/moderate MTOE) are presented in Table 3. One item was rated in the top five of all groups – *Teaching SAE financial record-keeping.* One item was found in the top five of every group except high MTOE – *Teaching math concepts embedded in the Agricultural Engineering and Applied Technologies program of study. Teaching math concepts embedded in the Agribusiness program of study* was found in the low and moderate PMTE groups as well as moderate MTOE. *Locating and selecting reference materials related to math instruction* was only found in the high groups. Lastly, one item was only found in the high

PMTE group (*teaching math concepts in laboratory settings*) and one item in the high MTOE group (*Designing curricula that utilize agriculture as a context for teaching math concepts*).

Table 3

Difference in Professional Development Needs Based Upon Mathematics Efficacy

Group	Item	*MWDS*
Low PMTE	Teaching math concepts embedded in the Agricultural Engineering and Applied Technologies program of study	6.39
	Teaching SAE financial record-keeping	6.20
	Modifying math instruction for Special Needs Students	6.04
	Teaching math concepts embedded in the Agribusiness program of study	5.89
	Utilizing agriculture as a context for teaching math concepts	4.83
Moderate PMTE	Teaching SAE financial record-keeping	3.22
	Teaching math concepts embedded in Career Development Events	2.72
	Teaching math concepts embedded in the Agricultural Engineering and Applied Technologies program of study	2.61
	Teaching personal financial management	2.57
	Teaching math concepts embedded in the Agribusiness program of study	2.10
High PMTE	Teaching personal financial management	1.34
	Teaching SAE financial record-keeping	1.04
	Locating and selecting reference materials related to math instruction	0.90
	Teaching math concepts in laboratory settings (ex. Land lab, greenhouse, garden, ag mechanics lab, etc.)	0.85
	Teaching math concepts embedded in the Agricultural Engineering and Applied Technologies program of study.	0.70
Moderate MTOE	Teaching personal financial management	2.83
	Teaching SAE financial record-keeping	2.73
	Teaching math concepts embedded in the Agricultural Engineering and Applied Technologies program of study	2.43
	Teaching math concepts embedded in the Veterinary and Animal Science program of study	2.10
	Teaching math concepts embedded in the Agribusiness program of study	1.89
High MTOE	Teaching SAE financial management	3.08
	Teaching math concepts embedded in Career Development Events	2.95
	Modifying math instruction for Special Needs Students	2.64
	Designing curricula that utilize agriculture as a context for teaching math concepts	2.50
	Locating and selecting reference materials related to math instruction	2.45

Conclusions and Recommendations

Tennessee agriculture teachers had a mean PMTE of 3.26 (*SD* = 0.48), which is considered moderate efficacy. Only 28.1% of teachers are highly efficacious, which is considerably lower than the 48.4% of Wyoming agricultural education teachers found in Haynes and Stripling (2014). This supports Roberts and Dyer's (2004) assertion that different populations of teachers possess different professional development needs. Additionally, of the 121 Tennessee agriculture teachers surveyed, 81 teachers possessed moderate MTOE, and the mean was 3.49 (*SD* = 0.49). This finding is similar to Hayes and Stripling (2014). Hayes and Stripling found a majority of Wyoming agriculture teachers possessed moderate MTOE. On the other hand, Jansen and Thompson (2008) and Swan, Moore, and Echevarria (2008) reported the agricultural education teachers in their study were extremely efficacious and very confident in their mathematics teaching ability.

PMTE and MTOE are measures of pedagogical knowledge related to teaching mathematics, and pedagogical knowledge is an essential type of knowledge for effective teaching (Darling-Hammond & Bransford, 2005). Furthermore, based on social cognitive theory, moderate PMTE and MTOE may negatively impact the teaching and learning of mathematics within school-based agricultural education. If school-based agricultural education teachers are not prepared for teaching the mathematics found within the agricultural curricula, this will hamper school-based agricultural education's ability to meaningfully contribute to calls for offering and improving STEM education. The Tennessee Department of Education should investigate means, such as the Math-in-CTE model, of offering professional development related to teaching contextualized mathematics and improving mathematics content knowledge and pedagogical knowledge of Tennessee's agricultural education teachers.

Interestingly, the teachers in this study had higher MTOE than PMTE. Thus, the teachers were more confident that their teaching of mathematics would result in a desired outcome than they were in the own ability to teach mathematics. This may suggest the teachers believe their students have a greater capacity to learn mathematics than the opportunity their mathematics teaching abilities afford. This should be encouraging given teachers who have greater expectations for student learning persist longer, provide greater academic focus during instructional time, and provide different types of feedback (Gibson & Dembo as cited in Enochs et al. (2000). Future research is warranted to understand the development of PMTE and MTOE in school-based agricultural education teachers. Future research should also examine the most effective and cost-efficient means of offering professional development on teaching contextualized mathematics in school-based agricultural education.

In regard to professional development needs, *teaching SAE financial record-keeping*, *teaching math concepts embedded in the Agricultural Engineering and Applied Technologies program of study*, *teaching personal financial management*, *teaching math concepts embedded in Career Development Events*, and *teaching math concepts embedded in the Agribusiness program of study* were the top five needs. Furthermore, similarities and differences were found based upon teachers' PMTE and MTOE. Teaching SAE financial record keeping was found in the top five of all mathematics efficacy groups; low PMTE, moderate PMTE and MTOE, and high PMTE and MTOE. Teaching math concepts embedded in the Agricultural Engineering and Applied Technologies program of study was found in the top five of all efficacy groups except high MTOE. Teaching math concepts embedded in the Agribusiness program of study was found in the top five of 60% of efficacy groups. Therefore, we recommend professional development needs related to teaching SAE financial record keeping, teaching math concepts embedded in the Agriculture Engineering and Applied Technologies program of study, and teaching math concepts embedded in the Agribusiness program of study are offered in Tennessee.

Additionally, based on the results of this study, teachers with low PMTE and high MTOE efficacy would benefit from professional development on modifying math instruction for special needs students. Teachers with moderate PMTE and high MTOE would benefit from professional development on teaching math concepts embedded in Career Development Events. While teachers with high PMTE and MTOE would benefit from information on locating and selecting reference materials related to math instruction, and teachers with high MTOE need professional development on designing curricula that utilizes agriculture as a context for teaching math concepts. In contrast, teachers with low PMTE need help in using agriculture as a context for teaching math concepts.

If stakeholder groups in Tennessee such as the Tennessee Department of Education, Tennessee Association of Agricultural Educators, and teacher educators or local universities provide professional development in the aforementioned areas, this should have a positive effect on the mathematics teaching and learning in school-based agricultural education programs as Bandura (1997) claimed the external environment influence behavior. Future research should document the effects and teachers' perceptions of professional development in these areas. Research related to PMTE, MTOE, and professional development needs is warranted in other states given the results of this study were different from Haynes and Stripling (2014), and thus, support, Roberts and Dyers' (2004) statement that different groups of teachers have distinct and different professional development needs. Professional development tailored to the different needs of teachers by states or regions may be key in breaking the vicious cycle described by Michigan State University Center for Research in Mathematics and Science Education (2010) in which teachers who possess mathematical deficiencies, produce students who are not proficient in mathematics, and then these students become the next group of mathematics deficient teachers. Breaking this cycle may also help the United State prevent a STEM talent shift from the United States to Asia as discussed by Taningco et al. (2008) and Zollman (2012).

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