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Investigating the Effects of a Math-Enhanced Agricultural Teaching Methods Course

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Numerous calls have been made for agricultural education to support core academic subject matter including mathematics. Previous research has shown that the incorporation of mathematics content into a teaching methods course had a positive effect on preservice teachers' mathematics content knowledge. The purpose of this study was to investigate the effects of a math-enhanced agricultural education teaching methods course on preservice agricultural education teachers' mathematics ability, personal mathematics efficacy, mathematics teaching efficacy, and personal teaching efficacy. Results indicated that preservice teachers' mathematics ability increased after the math-enhanced teaching methods course. Interestingly, personal mathematics efficacy decreased while mathematics teaching efficacy and personal teaching efficacy increased slightly after the math-enhanced teaching methods course. Based on the results of this study, peer-teaching that utilizes the seven components of a math-enhanced lesson may be an appropriate means to improve the mathematics ability of preservice agricultural education teachers.

Keywords: mathematics; math; preservice teachers; self-efficacy; teaching methods; teacher education

Increasing the mathematics proficiency of American students continues to be a top priority (National Commission on Mathematics and Science Teaching for the 21st century, 2000; National Research Council, 2001, 2007, 2011) almost thirty years after the National Commission of Excellence in Education (1983) released *A Nation at Risk: The Imperative for Educational Reform*. The National Commission of Excellence in Education called for additional instructional time, an increase in graduation rates, higher academic standards, and better-quality teacher education programs (Vinovskis, 2009). However, a plethora of recent research has shown that U.S. students are not proficient in mathematics (National Center for Educational Statistics, 2000a, 2000b, 2004, 2009a, 2009b, 2010, 2011). Likewise, the lack of mathematics proficiency among Florida students is well recognized, and in 2010, 56% of Florida 10th graders experienced little to partial success in mathematics (Florida Department of Education, 2010). In addition, the Michigan State University Center for Research in Mathematics and Science Education (2010) stated that preservice teachers are ill-prepared to teach a rigorous mathematics curriculum and that teacher education should provide training in mathematics and the methods of teaching mathematics. Therefore, the Michigan State University Center for Research in Mathematics and Science Education (2010) called for the U.S. educational system to "break the vicious cycle in which we find ourselves" (p. 3), where elementary and secondary teachers that are not proficient in mathematics produce students that are not proficient in mathematics, who then then become teachers themselves and lack the necessary content knowledge to effectively teach mathematics. Consistent with the Michigan State University Center for Research in Mathematics and Science Education, Stripling and Roberts (2012a) found that Florida preservice agricultural education teachers were not proficient in mathematics standards within the agricultural curricula and are therefore ill-prepared to teach mathematics found naturally within the secondary agricultural education curricula.

Based on the aforementioned findings and recommendations, this study will seek to improve the mathematics ability of Florida preservice agricultural education teachers by incorporating the seven components of a math enhanced lesson (Stone, Alfeld, Pearson, Lewis, & Jensen, 2006) into the agricultural education teaching methods course at the University of Florida. In addition, this study will investigate the effects that a math-enhanced agricultural education teaching methods (MEAETM) course will have on personal mathematics efficacy, mathematics teaching efficacy, and personal teaching efficacy. Moreover, this study will contribute to priority 3 (sufficient scientific and professional workforce that addresses the challenges of the 21st century) and priority 5 (efficient and effective agricultural education programs) of the American Association for Agricultural Education's national research agenda (Doerfert, 2011).

Theoretical Framework/Literature Review

The theoretical framework for this study was Bandura's (1986) social cognitive theory. According to Bandura, social cognitive theory explains cognitive changes or learning over a lifetime and emphasizes that most cognitive skills are socially cultivated. In addition, Bandura purported that human thought and behavior are influenced by direct and observational experiences and physiological factors. Therefore, human behavior is influenced by personal experiences and are "retained in neural codes, rather than being provided ready-made by inborn programming" (Bandura, 1986, p. 22). With that in mind, "social cognitive theory encompasses a large set of factors that operate as regulators and motivators of established cognitive, social, and behavioral skills" (Bandura, 1997, p. 35). Thus,

> people are neither driven by inner forces nor automatically shaped and controlled by external stimuli. Rather, human functioning is explained in terms of a model of triadic reciprocality in which behavior, cognitive and other personal factors, and environmental events all operate as interacting determinants of each other. (Bandura, 1986, p. 18)

Bandura also stated that the interacting determinants (behavior, internal personal factors, and the external environment) influence each other bidirectionally, but their influences are not equal. Operationalized for this study, behavior is the teaching of contextualized mathematics, external environment is the teacher education program, and personal factors are self-efficacy and mathematics ability (Figure 1).

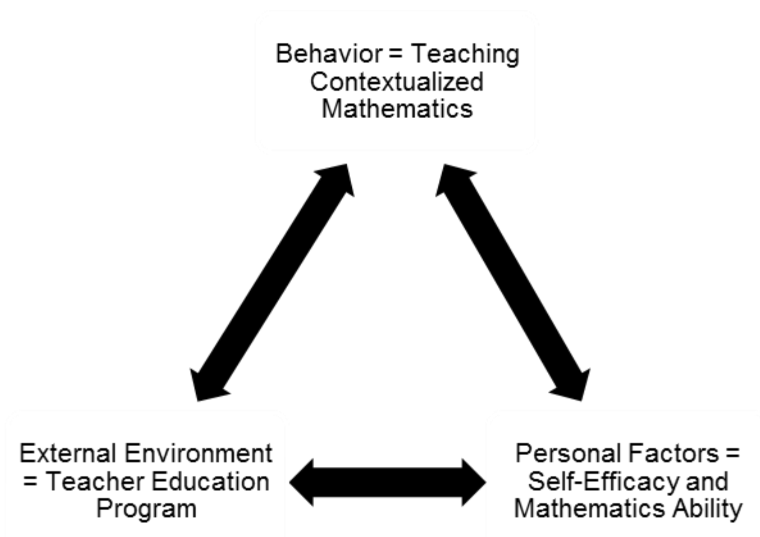

Figure 1. Triadic reciprocality model. Adapted from Bandura (1986).

Behavior – Teaching Contextualized Mathematics

In the context of this study, teaching contextualized mathematics in the teaching methods course is considered a behavior that is influenced bidirectionally by personal and environmental determinants. For example, teaching agriculture was influenced by the National Research Council's (1988) call to emphasize academic skills through an integrated curricula and to become more than a vocational discipline, which influenced agricultural instruction in secondary and postsecondary settings (Phipps, Osborne, Dyer, & Ball, 2008). Previous research has indicated that preservice teachers are ill-prepared and lack sufficient mathematics content knowledge to teach mathematical concepts (Frykholm, 2000; Fuller, 1996; Goulding, Rowland, & Barber, 2002; Michigan State University Center for Research in Mathematics and Science Education, 2010; Miller & Gliem, 1996; Stacey, Helme, Steinle, Baturo, Irwin, & Bana, 2001; Stoddart, Connell, Stofflett, & Peck, 1993; Stripling & Roberts, 2012a, 2012b; Wilburne & Long, 2010), thus theoretically impacting the behavior of teaching mathematics.

Parnell (1996) claimed that "the basis for good teaching is combining an information rich subject matter content with an experience rich context of application" (p. 1), and Prescott, Rinard, Cockerill, and Baker (1996) purported that academic and vocational subjects should be integrated to maximize learning opportunities. With this in mind, Stone et al. (2006) experimentally investigated the Math-in-CTE model, which was developed as a means for enhancing mathematics instruction in Career and Technical Education (CTE). The study consisted of 236 CTE teachers, 104 mathematics teachers, and 3,950 secondary students. At the core of the model was a partnership formed between CTE and mathematics teachers in which the mathematics teachers aided the CTE teachers in developing math-enhanced lessons and were available for support before and after the lessons. As a result of instruction in secondary schools that utilized the math-enhanced lessons, the researchers discovered that technical skill acquisition was not diminished and that the CTE students' mathematics content knowledge increased. Congruently, research in the field of agricultural education has supported the effectiveness of math-enhanced curricula that utilizes the seven elements of a math-enhanced lesson as a model for teaching contextualized mathematics (Parr, Edwards, & Leising, 2006, 2008; Young, Edwards, & Leising, 2009).

Personal Factors

In social cognitive theory, personal factors influence the external environment and behavior (Bandura, 1986). More specifically, in the context of this study, a preservice teacher's self-efficacy and mathematics ability are personal factors that affect the behavior of teaching mathematics and the environment of the teacher education program. Correspondingly, the National Council of Teachers of Mathematics (NCTM; as cited in Benken & Brown, 2008) posited that teachers of mathematics should have an "integrated, connected view of mathematics, rather than a procedural, rule-based view" (p. 1). Similarly, Darling-Hammond and Bransford (2005) described three types of knowledge that are required for effective teaching: (a) subject matter knowledge, (b) pedagogical knowledge, and (c) pedagogical content knowledge. In the context of this study, mathematics ability and personal mathematics efficacy are measures of subject matter knowledge, personal teaching efficacy is a measure of pedagogical knowledge, and personal mathematics efficacy is a measure of pedagogical content knowledge.

Self-efficacy

Self-efficacy is one example of a personal factor that according to Bandura (1997) "occupies a pivotal role…because it acts upon the other classes of determinants" (p. 35). More explicitly, self-efficacy influences the activities one selects, motivation, knowledge acquisition, analytical thinking, and one's talents (Bandura, 1986). Self-efficacy is defined as one's judgment about one's ability to perform a behavior or task (Bandura, 1997). Thus, a student's self-efficacy regulates their learning and impacts their academic accomplishments (Bandura, 1993). Furthermore, teacher or teaching efficacy is a more specific type of self-efficacy (Stripling, Ricketts, Roberts, & Harlin, 2008), and is a teacher's belief in his/her capability to facilitate the learning environment and produce desired learning outcomes (Guskey & Passaro, 1994; Soodak & Podell, 1996). Teachers who are more efficacious persevere through challenges in the learning environment (Goddard, Hoy, & Woolfolk Hoy, 2004) and put forth more effort in designing learning activities (Allinder, 1994).

Previous research with preservice teachers found that teacher education programs should scaffold teaching experiences, thus reducing instances where preservice teachers lower their self-perceptions of what constitutes excellent teaching (Tschannen-Moran, Hoy, & Hoy K., 1998). In developing teacher efficacy, teacher education programs should provide opportunities for preservice teachers to state personal beliefs related to teaching and learning and then expand and integrate new knowledge into existing beliefs (Kagan, 1992). Specific to agricultural education, Knobloch (2001) discovered that peer-teaching increased preservice teacher's teaching efficacy, and student teaching has been shown to have a positive effect on teaching efficacy (Harlin, Roberts, Briers, Mowen, & Edgar, 2007; Roberts, Harlin, & Ricketts, 2006; Roberts, Harlin, & Briers, 2008; Stripling et al., 2008). What is more, Roberts, Mowen, Edgar, Harlin, and Briers (2007) found that teaching efficacy was negligibly related to personality type, and Roberts et al. reported that placing two agricultural education preservice teachers at one internship site did not significantly affect teaching efficacy.

Mathematics ability

A plethora of research exists that underscores the mathematics deficiency among the nation's preservice teachers (Adams, 1998; Ball & Wilson, 1990; Bryan, 1999; Even, 1990, 1993; Frykholm, 2000; Goulding et al., 2002; Matthews & Seaman, 2007; Michigan State University Center for Research in Mathematics and Science Education, 2010; Miller & Gliem, 1996; Stacey et al., 2001; Stoddart et al., 1993; Stripling & Roberts, 2012a, 2012b; Wilburne & Long, 2010). Correspondingly, research conducted with agricultural education preservice teachers has also revealed mathematical deficiencies (Miller & Gliem, 1996; Stripling & Roberts, 2012a, 2012b). To that end, Miller and Gliem (1996) found that preservice teachers at The Ohio State University scored 37.1% on an instrument used to measure agricultural mathematics problem solving ability. Likewise, Stripling and Roberts (2012a) reported that preservice teachers at the University of Florida averaged 35.6% on a mathematics assessment that was based on the national secondary agricultural education standards. Using the same assessment as Stripling and Roberts (2012a), Stripling and Roberts (2012b) reported that a randomly selected sample of preservice teachers from U.S. agricultural teacher education programs revealed that the nations' preservice agricultural education teachers are not proficient in mathematics, and the population mean on the mathematics assessment was estimated to be between 28.5% and 48.5% with 95% confidence. Lastly, research in agricultural education has shown that an agricultural education teacher's mathematics ability is significantly associated with their students' mathematics ability (Persinger & Gliem, 1987).

External Environment – Teacher Education Program

According to Bandura (1986), the external environment is influenced by behavior and internal personal factors. For this study, the external environment is the agricultural teacher education program at the University of Florida. Considerable disagreement and debate surround the purpose of teacher education (Hansen, 2008); nevertheless, Myers and Dyer (2004) stated that the "goal of preservice teacher education is to make the most effective use of the time available to prepare future educators for the task awaiting them" (p. 47). In regard to teaching mathematics, teacher education programs should aid preservice teachers in fostering positive philosophies and attitudes about teaching and learning mathematics (Charalambous, Panaoura, & Philippou, 2009). To that end, teacher education programs have been shown to influence how beginning teachers dialogue about teaching and learning mathematics (Ensor, 2001) and that research-proven mathematics instructional practices incorporated into a teacher education program positively affect student achievement (Berry, 2005). Burton, Daane, and Gieson (2008) further found that adding 20 minutes of mathematics content instruction into a teaching methods course positively affected mathematics content knowledge of preservice teachers. Research has also discovered that mathematics content knowledge was improved when preservice teachers experience content, teaching methods, and field experiences concurrently (Wilcox, Schram, Lappan & Lanier, 1991). Specific to agricultural teacher education, The *National Standards for Teacher Education in Agriculture* (American Association for Agricultural Education, 2001) suggested that general education should comprise one-third of the agricultural education program hours and should develop theoretical and practical understandings. Mathematics was specifically mentioned as an expectation of coursework within general education, yet recommendations for mathematics instruction and content knowledge were not given. Swortzel (1995) recommended that calculus and statistics/data analysis should be required, and this recommendation is supported by research that has found a substantial association between advanced mathematics or calculus and mathematics ability (Stripling & Roberts, 2012b). However, Swortzel's article was the only reference found that recommended specific mathematics coursework for agricultural teacher education. Also, consistent with the disagreement mentioned above, variability exists in agricultural teacher education programs (McLean & Camp, 2000; Swortzel, 1999). For example, Swortzel (1999) reported that U.S. agricultural education programs were found in colleges of agriculture, education, and business or technology and credit hours for a four year degree ranged from 120-148. Moreover, McLean and Camp (2000) reported that the top 10 peer nominated agriculture teacher education programs had substantial variations in their required coursework or programs of studies. For example, McLean and Camp discovered 118 different topics were being taught with only 44 of the topics being taught in at least 50% of the programs.

Purpose

The purpose of this study was to investigate the effects of a MEAETM course on preservice agricultural education teachers' mathematics ability, personal mathematics efficacy, mathematics teaching efficacy, and personal teaching efficacy.

Four null hypotheses were used to guide this inquiry:

H_{01}: There is no significant difference in the mathematics ability of preservice agricultural education teachers before and after the MEAETM treatment.

H_{02}: There is no significant difference in the personal mathematics efficacy of preservice agricultural education teachers before and after the MEAETM treatment.

H_{03}: There is no significant difference in the mathematics teaching efficacy of preservice agricultural education teachers before and after the MEAETM treatment.

H_{04}: There is no significant difference in the personal teaching efficacy of preservice agricultural education teachers before and after the MEAETM treatment.

Methodology

Definition of Terms

The following terms were operationally defined for this study:

- The teaching method course was operationally defined as a teaching and learning methods course that "focuses on the selection and use of teaching strategies, methods/approaches, and techniques; evaluating learning; and managing learning environments for teaching agricultural subjects in formal educational settings" (Roberts, 2009, p. 1).
- Mathematics ability is defined as the students' scores on the *Mathematics Ability Test* (Stripling & Roberts, 2012a).
- Personal mathematics efficacy is the self-belief in one's capabilities to solve mathematics problems. Personal mathematics efficacy was defined as the student's score on 8 items contained in the *Mathematics En-*

hancement Teaching Efficacy Instrument by Jansen (2007).

- Mathematics teaching efficacy is a person's self-belief about their capabilities to teach mathematics. Mathematics teaching efficacy was defined as the student's score on 13 items contained in the *Mathematics Enhancement Teaching Efficacy Instrument* by Jansen (2007).
- Personal teaching efficacy is a person's self-belief about their capabilities to teach. Personal teaching efficacy was defined as the student's score on 12 items contained in the *Mathematics Enhancement Teaching Efficacy Instrument* by Jansen (2007).

Research Design

This study was preexperimental and utilized a one-group pretest-posttest design (Campbell & Stanley, 1963). The research design is shown below:

$$O_1 \qquad X \qquad O_2$$

Threats to internal validity are history, maturation, testing, instrumentation, and possibly statistical regression (Campbell & Stanley, 1963). History is a limitation of this study, however, it should be noted that no participants were enrolled in a mathematics course during this study. Maturation and testing are also noted as limitations of this study; however, to reduce the influence of testing the posttests were given at the beginning of the 2011 semester instead of the end of the 2010 semester. Instrumentation was controlled by using a scoring rubric that was made by two secondary mathematics experts and by utilizing one scorer. Lastly, statistical regression is only a threat if subjects are selected based on extreme scores (Campbell & Stanley, 1963). In this study, the participants were not selected because of extreme scores.

Sample

The target population for this study was preservice agriculture teachers in their final year of a teacher education program at the University of Florida's main campus. For this study, the sample was a purposive convenience sample that was conceptualized as a slice in time (Oliver & Hinkle, 1981), and according to Gall, Borg, and Gall (1996), when convenience sampling is used the researcher should provide a comprehensive description of the sample and describe the reasons for selection. To that end, the sample was selected based on previous research, which discovered that Florida preservice agricultural education teachers were not proficient in the mathematics content of the cross-referenced NCTM sub-standards (Stripling & Roberts, 2012a). The sample consisted of 22 preservice agricultural education teachers, 17 females and 5 males, that volunteered to participate and signed an informed consent that was approved by the University of Florida's Institutional Review Board. The small sample size is a limitation of this study. The participants' average age was 22 years old (*SD* = 1.41), and 21 of the participants described their ethnicity as white and one as other. Twenty of the participants were completing an undergraduate degree, and the remaining two participants were completing a graduate degree. The mean university grade point average was 3.53 (*SD* = 0.46).

Instrumentation

The participants agreed to complete the *Mathematics Ability Test* (Stripling & Roberts, 2012a) and the *Mathematics Enhancement Teaching Efficacy Instrument* (Jansen, 2007). The *Mathematics Ability Test* consist of 26 open-ended mathematical word problems and was utilized because it was developed based on the previously mentioned 13 NCTM sub-standard that are cross-referenced with the National Agriculture, Food and Natural Resources Career Cluster Content Standards (National Council for Agricultural Education, 2009). The instrument took approximately 60 minutes to complete and the reliability or the Cronbach's alpha coefficient was reported by Stripling and Roberts (2012a) to be .80. Additionally, the researchers stated that a panel of experts comprised of two secondary mathematics experts and university agricultural teacher education and mathematics faculty representing three universities established face and content validity. The 26 open-ended mathematical word problems of the *Mathematics Ability Test* were scored as in-correct, partially correct, or correct using a rubric that, according to Stripling and Roberts, was developed by two secondary mathematics experts. The *Mathematics Enhancement Teaching Efficacy Instrument* was developed and validated during a doctoral dissertation at Oregon State University and is divided into three constructs: (a) personal mathematics efficacy, (b) mathematics teaching efficacy, and (c) personal teaching efficacy. The instrument utilizes a different rating scale for each construct – personal mathematics efficacy (1 = *not at all confident* to 4 = *very confident*), mathematics teaching efficacy (1 = *strongly disagree* to 5 = *strongly agree*), and personal teaching efficacy (1 = *nothing* to 9 = *a great deal of influence*; Jansen, 2007). Jansen (2007) reported that face and content validity were established by a panel of experts and that the Cronbach's alpha coefficients for the personal mathematics efficacy, mathematics teaching efficacy, and personal teaching efficacy constructs to be .84, .88, and .91, respectively. Scores for each construct were calculated by averaging the corresponding items after reverse coding items 2, 4, 5, 7, 9, 10, 11, and 13. The *Mathematics Enhancement Teaching Efficacy Instrument* took 8-12 minutes to complete.

Furthermore, each instrument was administered before and after the treatment utilized in this study. More specifically, the *Mathematics Ability Test* was administered the second week of the Fall 2010 semester and the first week of the Spring 2011 semester. The *Mathematics Enhancement Teaching Efficacy Instrument* was administered week three of the Fall 2010 and Spring 2011 semesters. Since the instruments were administered during instructional time, the preservice teachers were informed that volunteering to complete the instruments would not positively or negatively affect their course grade

Treatment – MEAETM

The treatment for this study was devised by the researchers and was incorporated into the Fall 2010 agricultural education teaching methods course at the University of Florida as a potential means to improve the mathematics ability of the preservice teachers enrolled in the course. The treatment consisted of three parts. First, the researcher prepared and delivered a lecture to the preservice teachers that explained and demonstrated how to use the National Research Center for Career and Technical Education's seven components of a math-enhanced lesson (Stone et al., 2006) to teach mathematical concepts in the context of agriculture (Figure 2). Second, each preservice teacher was randomly assigned two of the thirteen NCTM sub-standards that have been cross-referenced to the National Agriculture, Food and Natural Resources Career Cluster Content Standards.

Third, the preservice teachers were required to teach the two NCTM sub-standards to their peers using the seven components of a math-enhanced lesson (Stone et al., 2006). Therefore, each preservice teacher participated in the math-enhanced lesson lecture, integrated mathematics content that corresponds to their randomly assigned NCTM sub-standards into two of the normally required peer-teaching lessons of the teaching methods course, and participated in each other's math-enhanced peer-teaching lessons. In summary, beyond what was previously required in the teaching methods course at the University of Florida the treatment added the following three elements: (a) a lecture on the seven components of a math-enhanced lesson, (b) random assignment of the NCTM sub-standards among the preservice teachers, and (c) requiring two of the peer-teaching lessons to be math-enhanced.

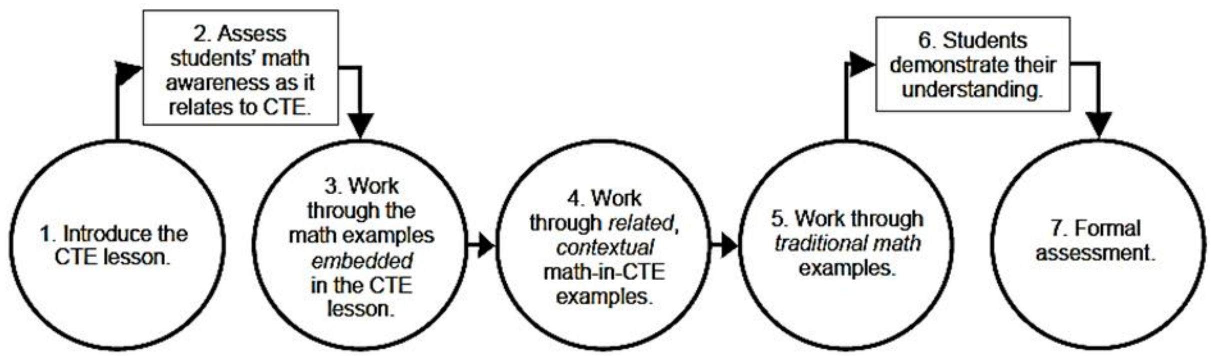

Figure 2. The National Research Center for Career and Technical Education: 7 Elements of a Math-Enhanced Lesson model (Stone et al., 2006, p. 13).

Data Analysis

Demographic and mathematics background data were summarized using descriptive statistics. Paired samples *t* tests were utilized to determine if a significant difference existed in mathematics ability, personal mathematics efficacy, mathematics teaching efficacy, and personal teaching efficacy scores from before to after the MEAETM treatment, and according to Agresti and Finlay (1997), *t* tests are appropriate for small sample sizes. In addition, Dunlap, Cortina, Vaslow, and Burke's (1996) formula for calculating effect size was also used to correct for overestimation due to the correlation between measures.

Findings

Mathematics Ability

The pretest results revealed that 19 (86.4%) of the preservice teachers answered fewer than 50% of the items correctly on the mathematics ability instrument (Table 1). The mean score was 34.4% or 8.93 (*SD* = 3.78) on the 26 item instrument, and the scores ranged from 9.6% to 63.5%. The posttest results revealed that 63.6% of the preservice teachers answered fewer than 50% of the items correctly, and the mean score was 46.5% or 12.09 (*SD* = 4.25). The posttest scores ranged from 23.1% to 86.5%.

Table 1
Analysis of Scores on the Mathematics Ability Test

Number correct (out of 26) range	% correct range	*f*		% of students	
		Pretest	Posttest	Pretest	Posttest
2.5 – 5.5	9.6 – 21.2	5	0	22.7	0.0
6.0 – 9.0	23.1 – 34.6	8	6	36.3	27.3
9.5 – 12.5	36.5 – 48.1	6	8	27.3	36.4
13.0 – 16.5	50.0 – 63.5	3	6	13.6	27.3
21.5 – 22.5	82.7 – 86.5	0	2	0.0	9.1

Note. Pretest mean score 8.93 (*SD* = 3.78); posttest mean score 12.09 (*SD* = 4.25), out of 26 possible.

In addition, an analysis of hypothesis one revealed a 12.15% increase in scores after the MEAETM treatment (Table 2), and the increase in mathematics ability scores after the treatment was significantly different (p = .00). Thus, the null hypothesis was rejected. The practical significance of the difference was assessed using Cohen's *d*, and the effect size was .78, which is a medium effect size according to Cohen (as cited in Kotrlik, Williams, & Jabor, 2011).

Table 2
Summary of Paired Samples t test

	Mean difference	*SD*	*SE*	*t*	*p*	*d*
Math ability posttest – pretest	12.15	10.97	2.34	5.19	.00	.78

Mathematics Enhancement Teaching Efficacy

As depicted in Table 3, pretest results indicated that the preservice teachers in this study were confident in their mathematics ability (personal mathematics efficacy, *M* = 3.46, *SD* = .39), moderately efficacious in their ability to teach mathematics (mathematics teaching efficacy, *M* = 3.37, *SD* = .71), and perceived themselves as having "*Quite a Bit of Influence*" in affecting student learning (personal teaching efficacy, *M* = 7.25, *SD* = .72). Posttest results revealed that the preservice teachers were confident in their mathematics ability (personal mathematics efficacy, *M* = 3.35, *SD* = .65), moderately efficacious in their ability to teach mathematics (mathematics teaching efficacy, *M* = 3.45, *SD* = .60), and perceived themselves as having "*Quite a Bit of Influence*" in affecting student learning (personal teaching efficacy, *M* = 7.34, *SD* = .80).

Table 3
Mathematics Enhancement Teaching Efficacy Scores

	Personal Mathematics Efficacy (PME)		Mathematics Teaching Efficacy (MTE)		Personal Teaching Efficacy (PTE)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Pretest	3.46	.39	3.37	.71	7.25	.72
Posttest	3.35	.65	3.45	.60	7.34	.80

Note. Scales: personal mathematics efficacy (1 = *not at all confident* to 4 = *very confident*), mathematics teaching efficacy (1 = *strongly disagree* to 5 = *strongly agree*), and personal teaching efficacy (1 = *nothing* to 9 = *a great deal of influence*; Jansen, 2007).

Furthermore, analysis of hypotheses two, three, and four revealed a .11 point decrease on a 4-point scale in personal mathematics efficacy, a .09 point increase on a 5-point scale in mathematics teaching efficacy, and a .09 point increase on a 9-point scale in personal teaching efficacy after the MEAETM treatment (Table 4). However, the mean differences were not statistically significant. Thus, the null hypotheses were not rejected.

Table 4
Summary of Paired Samples t tests – Self-Efficacy

	Mean difference	*SD*	*SE*	*t*	*p*
PME posttest – pretest	-.11	.52	.11	1.00	.33
MTE posttest – pretest	.09	.90	.20	.45	.66
PTE posttest – pretest	.09	1.06	.23	.37	.72

Conclusions/Implications/Recommendations

The MEAETM treatment had a positive effect on the preservice agricultural education teachers' mathematics ability scores, and the practical significance of the difference in the scores was described as medium (*d* = .78). Consistent with Burton et al. (2008), the incorporation of mathematics into a teaching methods course may significantly increase the mathematics ability of preservice teachers. The results of this study were also consistent with Pascarella and Terenzini (2005), which stated that peer interaction that reinforce academics "appear to influence positively knowledge acquisition and academic skill development during college" (p.

121). Furthermore, these results support Bandura's (1986) social cognitive theory, and the belief that cognitive skills can be socially cultivated. With that in mind, this study suggests that peer-teaching that utilizes the seven components of a math-enhanced lesson (Stone et al., 2006) may be an appropriate means to improve the mathematics ability of preservice agricultural education teachers. Therefore, the authors recommend that the MEAETM treatment be incorporated into the agricultural education teaching methods course at the University of Florida. Due to the limited scope of this study, future research should further investigate the effects of mathematics peer-teaching on preservice teachers' mathematics ability.

Furthermore, the preservice teachers were confident in their personal mathematics efficacy before and after the MEAETM treatment. This is very interesting since the self-efficacy data was collected after the administrations of the mathematics ability instrument and despite a mean pretest ability average of 34.4% and a mean posttest average of 46.5%. Theoretically, Bandura's (1986) social cognitive theory would suggest that confidence in personal mathematics efficacy should positively influence the behavior of teaching mathematics found naturally in the secondary agricultural curricula. On the other hand, Bandura's social cognitive theory would also suggest that low mathematics ability should negatively influence the behavior of teaching mathematics in the secondary agricultural curricula. Thus, future research should seek to explain this disconnect between personal mathematics efficacy and mathematics ability among the preservice teachers. With that in mind, it is conceivable that even after the treatment of this study that the preservice teachers are ill-informed of the level of mathematics present in the secondary agricultural education standards. Therefore, future research should examine preservice teachers' perceptions of the mathematics found naturally in the secondary agricultural curricula. Additionally, research should inquire into the development of personal mathematics efficacy and investigate factors that influence personal mathematics efficacy among preservice agricultural teachers. The aforesaid research is vital, since personal mathematics efficacy is a preservice teacher's perception of their mathematics content knowledge, which Darling-Hammond and Bransford (2005) would call subject matter knowledge. Subject matter knowledge is an essential type of knowledge for effective teaching (Darling-Hammond & Bransford, 2005).

What is more, the preservice teachers were moderately efficacious in mathematics teaching efficacy and efficacious in personal teaching efficacy before and after the treatment. This fact is encouraging because mathematics teaching efficacy is a measure of the preservice teachers' perceptions of their ability to teach mathematics, and personal teaching efficacy is a measure of the preservice teachers' perceptions of their ability to teach in general. However, why are preservice teachers moderately efficacious in teaching mathematics when they are not proficient in mathematics after the treatment of this study? Future research should examine this issue. Additionally, research should seek to determine if the MEAETM treatment has an impact on the teaching of mathematics content in secondary agricultural classes once the preservice teachers graduate. Also, are the preservice teachers more likely to successfully integrate mathematics after graduation as a result of the MEAETM treatment, and do the preservice teachers with the highest mathematics ability scores produce students with higher scores like the secondary agriculture teachers in Persinger and Gliem (1987)? Furthermore, the authors recommend that additional empirical research be conducted to validate the effectiveness of the MEAETM treatment in other preservice agricultural teacher populations. The authors also recommend that a quasi-experimental research design be utilized to further examine the effectiveness of the MEAETM treatment. Moreover, future research should determine if mathematics can be effectively and efficiently integrated into other agricultural teacher education courses. To that end, it is plausible, that the summative effect of small changes made to agricultural teacher education coursework, which emphasizes mathematics integration may produce preservice agricultural education teachers that are proficient in mathematics and aid the agricultural education profession in answering the numerous calls to assist in improving secondary students' mathematics achievement. However, agricultural teacher educators must be willing to integrate mathematics into agricultural teacher education coursework and be willing to provide assistance when preservice teachers encounter mathematical difficulties or be able to suggest sources of support and remediation.

References

Adams, T. L. (1998). Prospective elementary teachers' mathematics subject matter knowledge: The real number system. *Action in Teacher Education, 20*(2), 35-48.

Agresti, A., & Finlay, B. (1997). *Statistical methods for the social sciences* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

Allinder, R. M. (1994). The relationship between efficacy and the instructional practices of special education teachers and consultants. *Teacher Education and Special Education, 17*, 86-95.

American Association for Agricultural Education. (2001), *National standards for teacher education in agriculture*. Retrieved from http://aaaeonline.org/files/ncatestds.pdf

Ball, D. L., & Wilson, S. M. (1990). *Knowing the subject and learning to teach it: Examining assumptions about becoming a mathematics teacher Research Report 90-7.* (Eric No. ED 323207). Retrieved from http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERIC Servlet?accno=ED323207

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist, 28*(2), 117-148. doi: 10.1207/s15326985ep2802_3

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: Freeman.

Benken, B. M., & Brown, N. (2008). Integrating teacher candidates' conceptions of mathematics, teaching, and learning: A cross-university collaboration. *IUMPST: The Journal*, *1*, 1-15. Retrieved from http://www.k-12prep.math.ttu.edu/journal/contentknowledge/benken01/article.pdf

Berry, B. (2005). The future of teacher education. *Journal of Teacher education, 56*(3), 272-278. doi: 10.1177/0022487105275843

Bryan, T. J. (1999). The conceptual knowledge of preservice secondary mathematics teachers: How well do they know the subject matter they will teach? *Issues in the Undergraduate Mathematics Preparation of School Teachers, 1*, 1-12. Retrieved from http://www.k-12prep.math.ttu.edu/journal/journal.shtml

Burton, M., Daane, C. J., & Gieson, J. (2008). Infusing mathematics content impact a methods course: Impacting content knowledge for teaching. *Issues in the Undergraduate Mathematics Preparation of School Teachers: The Journal*. *1*, 1-12.

Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental designs for research.* Boston, MA: Houghton Mifflin.

Charalambous, C. Y., Panaoura, A., & Philippou, G. (2009). Using the history of mathematics to induce changes in preservice teachers' beliefs and attitudes: insights from evaluating a teacher education program. *Educational Studies in Mathematics, 71*, 161-180. doi: 10.1007/s10649-008-9170-0

Darling-Hammond, L., & Bransford, J. (2005). *Preparing teachers for a changing world*. San Francisco, CA: Jossey-Bass.

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. Retrieved from http://aaaeonline.org/files/research_agenda/AAAE_NRA_(2011-15)_full_report.pdf

Dunlap, W. P., Cortina, J. M., Vaslow, J. B., & Burke, M. J. (1996). Meta-analysis of experiments with matched groups of repeated measures designs. *Psychological Methods, 1*(2), 170-177. doi: 10.1037/1082-989X.1.2.170

Ensor, P. (2001). From preservice mathematics teacher education to beginning teaching: A study in recontextualizing. *Journal for Research in Mathematics Education, 32*(3), 296-320. Retrieved from http://www.jstor.org/stable/749829

Even, R. (1990). Subject matter knowledge for teaching and the case of functions. *Educational Studies in Mathematics, 21*, 521-544.

Even, R. (1993). Subject-matter knowledge and pedagogical content knowledge: Prospective secondary teachers and the function concept. *Journal for Research in Mathematics Education, 24*(2), 94-116.

Florida Department of Education. (2010). *Mathematics scores statewide comparison for 2001 to 2010*. Retrieved from http://fcat.fldoe.org/mediapacket/2010/pdf/2010MathComparison.pdf

Frykholm, J. (2000). A missing piece in secondary mathematics teacher education. *Focus on Learning Problems in Mathematics*, *22*(1), 27-44.

Fuller, R. A. (1996, October). *Elementary teachers' pedagogical content knowledge of mathematics* (ERIC No. ED 401270). Paper presented at the Mid-Western Educational Research Association Conference, Chicago, Illinois. Retrieved from http://eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?accno=ED401270.

Gall, M. D., Borg, W. R., & Gall, J. P. (1996). *Educational research: An introduction* (6th ed.). New York, NY: Longman.

Goddard, R. D., Hoy, W. K., & Woolfolk Hoy, A. (2004). Collective efficacy beliefs: Theoretical developments, empirical evidence, and future directions. *Educational Researcher, 33*(3), 3-13.

Goulding, M., Rowland, T., & Barber, P. (2002). Does it matter? Primary teacher trainees' subject knowledge in mathematics. *British Educational Research Journal, 28*(5), 689- 704.

Gusky, T. R., & Passaro, P.D. (1994). Teacher efficacy: A study of construct dimensions. *American Educational Research Journal, 31*, 627-643.

Hansen, D. T. (2008). Values and purpose in teacher education. In M. Chochran-Smith, S. Feiman-Newser, J. McIntyre, & K. E. Demers (Eds.), *Handbook of research on teacher education: Enduring questions in changing context* (pp. 10-26). New York, NY: Routledge.

Harlin, J. F., Roberts, T. G., Briers, G. E., Mowen, D. L., & Edgar, D. W. (2007). A longitudinal examination of teaching efficacy of agricultural science student teachers at four different institutions. *Journal of Agricultural Education, 48*(3), 78-90. doi: 10.5032/jae.2007.03078

Jansen, D. J. (2007). *Validation of an instrument for mathematics teaching efficacy of pacific northwest agricultural educators* (Doctoral dissertation). Retrieved from http://ir.library.oregonstate.edu/jspui/handle/1957/7689

Kagan, D. M. (1992). Implications of research on teacher belief. *Educational Psychologist, 27*(1), 65-90.

Knobloch, N. A. (2001). The influence of peer teaching and early field experience on teaching efficacy beliefs of preservice educators in agriculture. *Proceedings of the 28th Annual National Agricultural Educational Research Conference, 28*, 119-131.

Kotrlik, J. W., Williams, H. A., & Jabor, M. K. (2011). Reporting and interpreting effect size in quantitative agricultural education research. *Journal of Agricultural Education, 52*(1), 132-142. doi: 10.5032/jae.2011.01132+

Matthews, M. E., & Seaman, W. I. (2007). The effects of different undergraduate mathematics courses on the content knowledge and attitude towards mathematics of preservice elementary teachers. *Issues in the Undergraduate Mathematics Preparation of School Teachers: The Journal*, *1*, 1-16.

McLean, R. C., & Camp, W. G. (2000). An examination of selected preservice agricultural teacher education programs in the united states. *Journal of Agricultural Education*, *41*(2), 25-35. doi: 10.5032/jae.2000.02025

Michigan State University Center for Research in Mathematics and Science Education. (2010). *Breaking the cycle: An international comparison of U. S. mathematics teacher preparation.* Retrieved from http://www.educ.msu.edu/content/sites/usteds/documents/Breaking-the-Cycle.pdf

Miller, G., & Gliem, J. A. (1996). Preservice agricultural educators' ability to solve agriculturally related mathematics problems. *Journal of Agricultural Education, 37*(1), 15-21. doi: 10.5032/jae.1996.01015

Myers, B. E., & Dyer, J. E. (2004). Agricultural teacher education programs: A synthesis of the literature. *Journal of Agricultural Education, 45*(3), 44-52. doi: 10.5032/jae.2004.03044

National Center for Education Statistics. (2000a). *The condition of education 2000* (NCES 2000-062). Retrieved from http://nces.ed.gov/programs/coe/

National Center for Education Statistics. (2000b). *NAEP 1996 Trends in Academic Progress* (NCES 97–985r). Retrieved from http://nces.ed.gov/nationsreportcard

National Center for Education Statistics. (2004). *The condition of education 2004* (NCES 2004-077). Retrieved from http://nces.ed.gov/programs/coe/

National Center for Education Statistics. (2009a). *The condition of education 2009* (NCES 2009-081). Retrieved from http://nces.ed.gov/programs/coe/

National Center for Education Statistics. (2009b). *The nation's report card: mathematics 2009* (NCES 2010–451). Retrieved from http://nces.ed.gov/programs/coe/

National Center for Education Statistics. (2010). *The condition of education 2010* (NCES 2010-028). Retrieved from http://nces.ed.gov/programs/coe/

National Center for Education Statistics. (2011). *The nation's report card: Grade 12 reading and mathematics 2009 national and pilot state results* (NCES 2011–455). Retrieved from http://nces.ed.gov/nationsreportcard/pdf/main2009/2011455.pdf

National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for educational reform*. Washington, DC: Government Printing Office.

National Commission on Mathematics and Science Teaching for the 21st Century. (2000). *Before it's too late*. Retrieved from http://www2.ed.gov/inits/Math/glenn/report.pdf

National Council for Agricultural Education. (2009). *National agriculture, food and natural resource career cluster content standards.* Retrieved from http://www.teamaged.org/council/

National Research Council. (1988) *Understanding agriculture: New directions for education*. Washington, DC: The National Academy Press.

National Research Council. (2001). *Adding it up: Helping children learn mathematics*. Washington, DC: The National Academy Press.

National Research Council. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Washington, DC: National Academies Press.

National Research Council. (2011). *Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics.* Washington, DC: The National Academies Press.

Oliver, J. D., & Hinkle, D. E. (1981, December). *Selecting statistical procedures for agricultural education research*. Paper presented at the 8th Annual National Agricultural Education Research Meeting, Atlanta, GA.

Parnell, D. (1996). Cerebral context. *Vocational Education Journal, 71*(3), 18-21.

Parr, B. A., Edwards, M. C., & Leising, J. G. (2006). Effects of a math-enhanced curriculum and instructional approach on the mathematics achievement of agricultural power and technology students: An experimental study. *Journal of Agricultural Education, 47*(3), 81-93. doi: 10.5032/jae.2006.03081

Parr, B. A., Edwards, M. C., & Leising, J. G. (2008). Does a curriculum integration intervention to improve the mathematics achievement of students diminish their acquisition of technical competence? An experimental study in agricultural mechanics. *Journal of Agricultural Education, 49*(1), 61-71. doi: 10.5032/jae.2008.01061

Pascarella, E.T., & Terenzini, P. T. (2005). *How college effects students: A third decade of research*. San Francisco, CA: John Wiley and Sons, Inc.

Persinger, K. M., & Gliem, J. A. (1987). Mathematical problem-solving skills of high school vocational agriculture teachers and students (ERIC No. 289975). *Proceedings of the14th Annual National Agricultural Education Research Meeting, 14*, 200-207. Retrieved from http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?accno=ED289975

Phipps, L. J., Osborne, E. W., Dyer, J. E., & Ball, A. (2008*). Handbook on agricultural education in public schools* (6th ed.). Clifton Park, NY: Thompson Delmar Learning.

Prescott, C., Rinard, B., Cockerill, J., & Baker, N. W. (1996). Science through workplace lenses. *Educational Leadership, 53*(8), 10-13.

Roberts, T. G. (2009). *AEC 3200: Instructional techniques in agricultural and vocational education*. Unpublished course syllabus. University of Florida, Gainesville, FL.

Roberts, T. G., Harlin, J. F., & Briers, G. E (2008). Peer modeling and teaching efficacy: The influence of two student teachers at the same time. *Journal of Agricultural Education, 49*(2), 13-26. doi: 10.5032/jae.2008.02013

Roberts, T. G., Harlin, J. F., & Ricketts, J. C. (2006). A longitudinal examination of teaching efficacy of agricultural science student teachers. *Journal of Agricultural Education,47*(2), 81-92. doi: 10.5032/jae.2006.02081

Roberts, T. G., Mowen, D. L., Edgar, D. W., Harlin, J. F., & Briers, G. E. (2007). Relationships between personality type and teaching efficacy of student teachers. *Journal of Agricultural Education, 48*(2), 92-102. doi: 10.5032/jae.2007.02092

Stacey, K., Helme, S., Steinle, V., Baturo, A., Irwin, K., & Bana, J. (2001). Preservice teachers' knowledge of difficulties in decimal numeration. *Journal of Mathematics Teacher Education, 4*(3), 205-225.

Stripling, C., Ricketts, J. C., Roberts, T. G., & Harlin, J. F. (2008). Preservice agricultural education teachers' sense of teaching self-efficacy. *Journal of Agricultural Education, 49*(4), 120-130. doi: 10.5032/jae.2008.04120

Stripling, C. T., & Roberts, T. G. (2012a). Florida preservice agricultural education teachers' mathematics ability and efficacy. *Journal of Agricultural Education*, *53*(1), 109-122. doi: 10.5032/jae.2012.01109

Stripling, C. T., & Roberts, T. G. (2012b). Preservice agricultural education teachers' mathematics ability. *Journal of Agricultural Education*. *53(3), 28-41. doi:10.5032/jae.2012.03028.*

Stoddart, T., Connell, M., Stofflett, R., & Peck, D. (1993). Reconstructing elementary teacher candidates' understanding of mathematics and science content. *Teaching and Teacher Education, 9*(3), 229-241.

Stone, J. R. III, Alfeld, C., Pearson, D., Lewis, M. V., & Jensen, S. (2006). *Building academic skills in context: Testing the value of enhanced math learning in CTE.* Retrieved from http://136.165.122.102/UserFiles/File/Math-in-CTE/MathLearningFinalStudy.pdf

Soodak, L. C., & Podell, D. (1996). Teacher efficacy: toward the understanding of a multi-faceted construct. *Teaching and Teacher Education*, *12*(4), 401-411.

Swortzel, K. A. (1995). *Program for the preparation of preservice agricultural education teachers for the twenty-first century* (Eric No. 389 676). Education Resources Information Center. Retrieved from http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?accno=ED389676

Swortzel, K. A. (1999). Current status of preservice teacher education programs in agriculture. *NACTA Journal*, *43*(1), 37-43.

Tschannen-Moran, M., Woolfolk Hoy, A., & Hoy K.W. (1998). *Teacher efficacy: Its meaning and measure. Review of Educational Research, 68*, 202-248.

Vinovskis, M. A. (2009). *From a nation at risk to no child left behind: National education goals and the creation of federal education policy*. New York, NY: Teachers College Press

Wilburne, J. M., & Long, M. (2010). Secondary pre-service teachers' content knowledge for state assessments: Implications for mathematics education programs. *Issues in the Undergraduate Mathematics Preparation of School Teachers: The Journal, 1*, 1-13.

Wilcox, S. K., Schram, P., Lappan, G., & Lanier, P. (1991). *The role of a learning community in changing pre-service teachers' knowledge and beliefs about mathematics education* (Research Report 91-1). East Lansing: MI, Michigan State University, National Center for Research on Teacher Education.

Young, R. B., Edwards, M. C., & Leising, J. G. (2009). Does a math-enhanced curriculum and instructional approach diminish students' attainment of teaching skills? A year-long experimental study in agricultural power and technology. *Journal of Agricultural Education, 50*(1), 116-126. doi: 10.5032/jae.2009.01116

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