Journal of Agricultural Education, 55(3), 1-16.
doi: 10.5032/jae.2014.03001

Effects of Mathematics Integration in a Teaching Methods Course on Mathematics Ability of Preservice Agricultural Education Teachers

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Abstract

The purpose of this study was to determine the effects of incorporating mathematics teaching and integration strategies (MTIS) in a teaching methods course on preservice agricultural teachers' mathematics ability. The research design was quasi-experimental and utilized a nonequivalent control group. The MTIS treatment had a positive effect on the mathematics ability scores of the participants, and a statistically significant difference was found based upon the MTIS treatment. Based on the results of this study, the MTIS treatment should be considered for use in an agricultural teaching methods course to increase the mathematics ability of preservice agricultural education teachers.

Keywords: math; mathematics; preservice; STEM; teacher education

> An increasing number of jobs at all levels—not just for professional scientists—require knowledge of STEM [Science, Technology, Engineering, and Mathematics]. In addition, individual and societal decisions increasingly require some understanding of STEM, from comprehending medical diagnoses to evaluating competing claims about the environment to managing daily activities with a wide variety of computer-based applications. (National Research Council, 2011, p. 3)

However, employers are finding American job applicants do not possess the mathematics and problem-solving skills needed to be successful, and therefore, are turning to international students to fill their STEM positions (National Research Council, 2011). This is not surprising given the fact that the lack of mathematics proficiency among U.S. students is well documented (National Center for Educational Statistics, 2009, 2010, 2011). Furthermore, many preservice teachers, who will be charged with improving the mathematical ability of American students, are not proficient in mathematics, and this has created a troubling cycle in which teachers that are not proficient in mathematics are producing students with mathematical deficiencies, who then become the next generation of mathematics deficient teachers (Michigan State University Center for Research in Mathematics and Science Education, 2010). Similarly, research in agricultural education has shown preservice agricultural education teachers are not proficient in mathematics and are ill-prepared to make a meaningful contribution to the mathematics education of America's students (Stripling & Roberts, 2012a, 2012b, 2013; Miller & Gliem, 1996). These findings are troubling since there have been numerous calls for all subject areas to contribute to the learning of academic content. To that end, emphasis is being placed on how agricultural education can contribute to the learning of core academics and research is needed to identify the best methods

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agricultural teacher education can use to prepare preservice teachers for this role (Myers & Dyer, 2004). Thus, the fundamental problem this study will address is the lack of mathematics proficiency among preservice agricultural education teachers. This study will investigate the effectiveness of the mathematics teaching and integration strategies (MTIS) treatment as a method for improving the mathematics ability of Florida preservice teachers by incorporating the MTIS treatment into the agricultural teaching methods course at the University of Florida.

Theoretical Framework and Literature Review

Bandura's (1986) social cognitive theory served as the theoretical framework for this study. Social cognitive theory seeks to explain the cognitive developmental changes experienced by people during a lifetime and provides a foundation for social learning (Bandura, 1989). Social cognitive theory asserts that cognitive development includes multifaceted sequences over time, and that most cognitive skills are socially cultivated (Bandura, 1986). Thus, people have the ability to shape direct and vicarious experiences into many forms within biological limits (Bandura, 1986). "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). Furthermore, human thought and conduct are influenced by the interaction of experiential and physiological factors (Bandura, 1986). "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). In addition, Bandura (1986) described behavior using the framework of triadic reciprocality (Figure 1) among behavior, environmental influences, and personal factors.

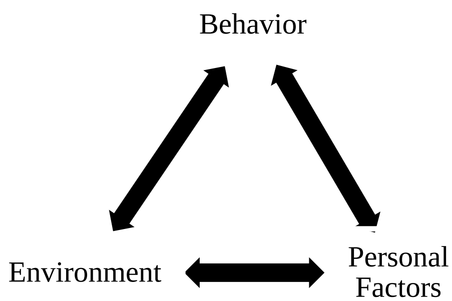

Figure 1. Triadic reciprocality model (Bandura, 1986, p. 24).

The interacting determinants of the triadic reciprocality model influence each other bidirectionally (Bandura, 1986). However, according to Bandura (1997), the reciprocal interactions are not of equal strength, and one determinant may demonstrate dominance over the others; although, in most situations, the determinants are vastly interdependent. Furthermore, time is needed for casual factors to exercise their influence, and that time makes it possible for one to study or understand the reciprocal causations (Bandura, 1997). For this study, the behavior of teaching contextualized mathematics, the environments of the teacher education program and the teaching methods course, and the personal factor of mathematics ability influence each other bidirectionally (Figure 2).

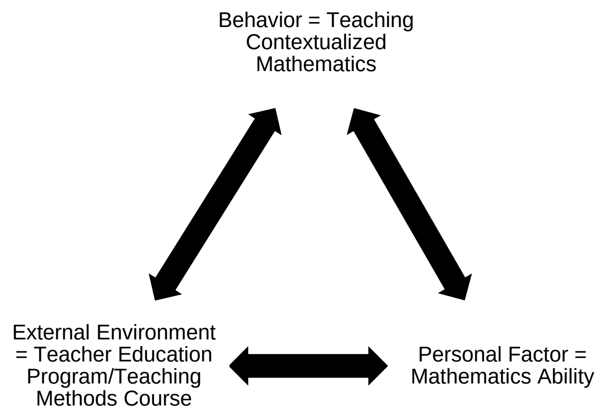

Figure 2. Triadic reciprocality model. Adapted from Bandura (1986).

Behavior: Teaching Contextualized Mathematics

When examined through the theoretical lens of social cognitive theory (Bandura, 1986) teaching mathematics found naturally in agriculture or contextualized mathematics is influenced bidirectionally by environmental and personal determinants within triadic reciprocal causation (Bandura, 1986). The behavior of teaching agriculture has also been influenced by the call to integrate academic subjects within career and technical education. Furthermore, expectations and ideals endorsed by current reform efforts in mathematics education (e.g., NCTM, 2000) challenge prospective teachers in their thinking about mathematics teaching and learning. Teachers are asked to teach in ways that promote an integrated, connected view of mathematics, rather than a procedural, rule-based view. (Benken & Brown, 2008, p. 1)

As a result, emphasis has been placed on teaching academic subjects in context (Shinn et al., 2003). Contextualized learning advocates neither general education nor career education can be taught in isolation but must be integrated to maximize the benefit for the learner (Prescott, Rinard, Cockerill, & Baker, 1996). Secondary agricultural education is an authentic context "rich with opportunities for learning mathematics" (Shinn et al., 2003).

The mathematics integration literature specific to agricultural education is limited. However, several studies have been conducted to test the effectiveness of the Math-in-CTE model (Stone, Alfeld, Pearson, Lewis, & Jensen, 2006). In a study of 38 secondary agricultural classes, Parr, Edwards, and Leising (2006) sought to determine if students that participated in a "mathematics-enhanced high school agricultural power and technology curriculum…would develop a deeper and more sustained understanding of selected mathematical concepts than students who participated in the traditional curriculum, thus resulting in less need for postsecondary mathematics remediation" (p. 84). Results indicated students who took part in the math-enhanced curriculum were less likely to need postsecondary remediation. In a similar study published in 2008, Parr, Edwards, and Leising investigated if students in a math-enhanced agricultural power and technology course would differ significantly from students in a traditional agricultural power and technology course in their technical skill acquisition. Parr et al. (2008) reported no significant difference in technical skills. In a third study investigating the effects of a math-enhanced agricultural power and technology curriculum, Parr, Edwards, and Leising (2009) did not find a significant difference in the mathematics ability of secondary students. Parr et al. (2009) hypothesized that this may have been due to the fact "of incomplete implementation of the treatment as reported by some experimental teachers coupled with an intervention time frame of only one semester" (p. 1).

The Young, Edwards, and Leising (2008, 2009) inquiries were very similar to the studies of Parr et al., (2006, 2008, 2009). Young et al. (2008) sought to determine if math-enhanced agricultural power and technology curriculum would significantly increase the mathematical ability of secondary students compared to a traditional mathematics agricultural power and technology curriculum. Results did not show a significant statistical difference in mathematics ability between the experimental and control groups. In 2009, Young et al. published a second study that mirrored Parr et al. (2008). However, this investigation was a one year analysis verses a semester long analysis. The results also mirrored the results of Parr et al. (2008) in which technical competence was not diminished by the math-enhanced curriculum.

Personal Factor: Mathematics Ability

Only a few studies that investigated the mathematics ability of preservice agricultural education teachers were found. Stripling and Roberts (2012a) sought to determine the mathematics ability of preservice teachers at the University of Florida during the Fall 2010 semester. Stripling and Roberts reported that the preservice teachers averaged 35.6% on a 26 item agricultural mathematics instrument and concluded that the preservice teachers were not proficient in agricultural mathematics concepts.

Similarly, Stripling and Roberts (2012b) investigated the mathematics ability of the nation's preservice agricultural teachers. Based on their sampling criteria, Stripling and Roberts reported the population mean was estimated with 95% confidence to be in the range of 28.5% to 48.5%. As a result, Stripling and Roberts concluded preservice agricultural education teachers are not proficient in mathematics. Furthermore, Stripling and Roberts 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.

In a pre-experimental study, Stripling and Roberts (2013) investigated the effects of a math-enhanced agricultural teaching methods course on preservice teachers' mathematics ability. Stripling and Roberts found the math-enhanced agricultural teaching methods course had a positive effect on the preservice agricultural educations teachers' mathematics ability scores. Stripling and Roberts posited peer-teaching that utilizes the seven components of a math-enhanced lesson may be an appropriate means to improve preservice teachers' mathematics ability and suggested that a quasi-experimental research design be utilized to further examine the effectiveness of math-enhanced agricultural teaching method courses.

Consistent with Stripling and Roberts (2012a, 2012b, 2013), Miller and Gliem (1996) reported preservice agricultural education teachers averaged 37.1% on a mathematics problem-solving ability instrument. Miller and Gliem also reported preservice teachers with higher scores had completed advanced mathematics courses, completed a fewer number of mathematics courses, and possessed higher ACT math scores. The researchers concluded the "preservice agriculture educators were not capable of applying basic mathematics skills to agricultural problems" (Miller & Gliem, 1996, p. 19).

Environment: Teacher Education Program and the Teaching Methods Course

In the context of social cognitive theory and triadic reciprocality, the teacher education program is the underlying environment for preservice teachers to develop into effective educators. "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" (Myers & Dyer, 2004, p. 47). More specifically, teacher education programs should "create opportunities for prospective teachers to develop productive beliefs and attitudes toward teaching and learning mathematics"

(Charalambous, Panaoura, & Philippou, 2009, p. 161). Ensor (2001) found beginning teachers drew upon their experiences in a teacher education program to develop “a professional argot – a way of talking about teaching and learning mathematics” (p. 296). Berry (2005) stated research-proven instructional strategies in mathematics and literacy make a difference in student achievement as teacher educators incorporate the strategies into the teacher education program. However, preservice teachers sometimes finish their academic program with trivial changes in their content knowledge, teaching, and learning beliefs (Kagan, 1992; Seaman, Szydlik, Szydlik, & Beam, 2006). One cause is teacher education programs do not connect pedagogy and academic content throughout the teacher education program (Ishler, Edens, & Berry, 1996). To that end, the *National Standards for Teacher Education in Agriculture* (American Association for Agricultural Education, 2001) only indicate mathematics is an expectation within general education and guidelines for connecting pedagogy and academic content throughout the teacher education program were not given. Moreover, Myers and Dyer (2004) reported a gap in the literature on how preservice agricultural teacher education programs should prepare preservice teachers to contribute to the learning of core academic subjects.

In addition to the teacher education program, the teaching methods course is theoretically expressed as part of the physical and social environment from a social cognitive prospective. Furthermore, in the context of this study, the behavior of micro-teaching is theoretically a component of the social environment. The environment is not conceptualized as a fixed entity but is shaped by personal and behavioral influences (Bandura, 1989). Thus, micro-teaching influences the environment of the teaching methods course. To that end, Bandura (1986) stated not only do people learn from their actions, they can also learn by vicarious experiences or by observational learning. Observational learning allows a person to develop generalizations that can be used to influence future behavior without having to learn by experimentation or trial and error (Bandura, 1986). According to Bandura, most human behaviors are learned by observing others, and observational learning increases one’s knowledge and cognitive skills.

The literature specific to an agricultural education teaching methods course is limited. Ball and Knobloch (2005) examined agricultural education teaching methods courses to identify the reading required, the types of assignments given, and the teaching methods taught. The researchers found Newcomb, McCracken, and Warmbrod’s (1986) or Newcomb, McCracken, Warmbrod, and Whittington’s, (1993) *Methods of Teaching Agriculture* was the most frequently required reading source. Additionally, the most frequent assignments were lesson plans and micro-teaching. Ball and Knobloch also found 22 different teaching methods were taught among the teaching methods courses. However, the researchers found teacher educators only spend on average 20.8% of their course on teaching methods. A study by Cano and Garton (1994a) sought to determine the personality type of preservice agricultural education teachers enrolled in an agricultural teaching methods course and determined all personality types were represented. As a result, Cano and Garton (1994a) suggested teacher educators use “teaching approaches effective with all of the learning preferences” (p. 11).

In a related study, Cano and Garton (1994b) purported preservice teachers of agriculture need to have an understanding of how learning styles affect teaching and learning and should be “taught how to adapt their teaching style to be inclusive of the various learning styles of students” (p. 9). Stripling, Ricketts, Roberts, and Harlin (2008) examined the impact of the teaching methods course on teaching efficacy. Stripling et al. found instructional strategies, student engagement, classroom management, and overall teaching efficacy increased from before the teaching methods course to after the teaching methods course and from after the teaching methods course/before student teaching to after student teaching. In addition, Stripling and Roberts (2013) investigated the impact of a math-enhanced agricultural teaching methods course on personal mathematics efficacy, mathematics teaching efficacy, and personal teaching efficacy. Stripling and Roberts reported the preservice teachers’ personal mathematics efficacy decreased while mathematics teaching efficacy and personal teaching efficacy increased. However, the researchers stated the changes in self-efficacy were not statistically significant.

Purpose and Hypothesis

The purpose of this study was to determine the effects of incorporating mathematics teaching and integration strategies (MTIS) in a teaching methods course on preservice agricultural teachers' mathematics ability. The following null hypothesis was used to guide this inquiry, and a significance level of .05 was determined *a priori*.

H_{01} – There is no significant difference in the mathematics ability of preservice agricultural education teachers based upon the MTIS treatment.

Methodology

Research Design

This research was quasi-experimental and utilized a nonequivalent control group design (Campbell & Stanley, 1963). The research design was illustrated by Campbell and Stanley (1963) and is shown below:

$$\begin{array}{ccc} O_1 & X & O_2 \\ \hline O_1 & & O_2 \end{array}$$

Figure 3. Research Design.

According to Campbell and Stanley, selection interaction effects and possibly regression are threats to the internal validity of the nonequivalent control group design. Selection interaction effects are when other threats to interval validity interact with the selection of groups in multiple-group, quasi-experimental designs and are mistaken for the effect of the treatment (Campbell & Stanley, 1963). Thus, selection interaction effects are a limitation of this study. Statistical regression is the selection of participants based upon extreme scores (Campbell & Stanley, 1963). This was not an issue in this study. Participants were not selected based on extreme scores. Furthermore, the following possible threats to internal validity are controlled by the nonequivalent control group design: history, maturation, testing, instrumentation, selection, and mortality (Campbell & Stanley, 1963).

This design was utilized because random assignment of subjects was not possible due to the fact the subjects under investigation self-registered for a section of the teaching methods course at the University of Florida that best fit their schedule of classes. To that end, the students self-registered for one of three sections of the teaching methods course, and the MTIS treatment was randomly assigned to two of the sections, which resulted in an experimental group of 13 preservice teachers and a control group of 6 preservice teachers. The authors recognize sample size is a limitation of this study. Therefore, the findings of this study should not be generalized beyond the sample, unless data confirms the sample is representative of other populations of preservice agricultural education teachers.

The agricultural education teaching methods course at the University of Florida is organized into lectures and labs and is the instructional methodology 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). The lectures are utilized to deliver content information related to teaching methods, strategies, and approaches. The labs are utilized to allow the preservice teachers to deliver micro-teachings to their peers, and the micro-teachings are based on the content discussed in the lectures. The MTIS treatment utilized in this study was assigned to the teaching methods lab sections randomly. The treatment group was administered the MTIS, and the control group received the same instruction except for the MTIS. The composition of the teaching methods course and the treatment are discussed further in the procedures sub-section.

Furthermore, the following student characteristics were included in this study as antecedent variables: gender, grade point average, number and type of mathematics courses completed in high school and college, grade received in last mathematics course completed, and age of the preservice agricultural teachers. The aforementioned variables were examined to determine if differences were present between the control and experimental groups. Chi-square tests were used to determine if significant differences existed between the groups for categorical data, and independent samples t-tests were used to determine if significant differences existed between the groups for continuous data. No statistically significant differences were found between the control and experimental groups in regard to the antecedent variables.

Population and Sample

The target population for this study was Florida preservice agricultural education teachers. The accessible population for this study was present undergraduate students in their final year of the agricultural teacher education program at the University of Florida. For this study, the accessible population was a convenience sample, which was conceptualized as a slice in time (Oliver & Hinkle, 1982). Gall, Borg, and Gall (1996) stated convenience sampling is appropriate as long as the researcher provides a detailed description of the sample used and the reasons for selection. To that end, the sample was selected based on Stripling and Roberts' (2012a, 2013) studies, which found Florida preservice teachers were not proficient in mathematics.

The sample consisted of 19 preservice agricultural education teachers, 16 females and 3 males. The average age of the sample was 21.5 years old (SD = 1.12) with a range of 20 to 25. All of the participants described their ethnicity as white and were seniors in an undergraduate agricultural education program. Their self-reported mean college grade point average was 3.44 (SD = 0.28) on a 4-point scale. The number of college level mathematics courses completed by the participants ranged from one to five with a mean of 3.02 (SD = 1.09), and two of the participants reported that they had not completed a mathematics course since high school. Thus, the time since the participants' last math course ranged from the previous semester in college to their senior year in high school or about four years prior. Lastly, 31.6% received an A, 21.1% a B+, 26.3% a B, and 21.4% a C in their highest level of mathematics successfully completed in college, and the highest mathematics course most often completed during college was introductory statistics.

Instrumentation and Data Collection

The *Mathematics Ability Test* (Stripling & Roberts, 2012b) was utilized in this study. The *Mathematics Ability Test* is a researcher-developed instrument that was developed based on the 13 National Council of Teachers of Mathematics (NCTM) sub-standards (Carpenter & Gorg, 2000) that are cross-referenced with the *National Agriculture, Food and Natural Resources Career Cluster Content Standards* (National Council for Agricultural Education, 2009). The instrument consists of 26 open-ended mathematical word problems or two items for each cross-referenced NCTM sub-standard, and the sum of the 26 items measures one construct – mathematics ability. According to Stripling and Roberts (2012b), the *Mathematics Ability Test* was pilot tested during the Fall 2010 semester at the University of Florida. The pilot test consisted of 25 preservice agricultural education teachers and yielded a Cronbach's alpha coefficient of .80 for the mathematics ability construct. Stripling and Roberts also reported face and content validity of the instrument was established by a panel of experts consisting of agricultural education and mathematics faculty from three universities and two secondary mathematics experts. A demographic section was added to the *Mathematics Ability Test* and the participants self-reported gender, age, ethnicity, grade point average, number of math courses taken, highest level of mathematics taken, and grade received in last mathematics course completed. Additionally, one of the researchers and a mathematics expert individually scored the *Mathematics Ability Test*, and items were scored incorrect, partially correct (students set the problem up correctly but made a calculation error), or correct. The scorers used a rubric that was developed by two secondary mathematics experts to score each item. Since more than one scorer was utilized, inter-rater reliability was assessed using Cohen's Kappa, and the analysis yielded a Cohen's Kappa of .95.

The data collection period of this study was during the Fall 2011 academic semester. Data were collected from preservice agricultural teachers during their final year of an agricultural teacher education program at the University of Florida. The agricultural education preservice teachers agreed to participate and complete the *Mathematics Ability Test* by signing an informed consent, which was approved by the Institutional Review Board at the University of Florida. Participants were informed the researchers would protect their privacy rights by ensuring confidentiality and appropriate storage of data. Also, since students received and completed the instrument during an agricultural education course, they were informed that participation in the study would not have an impact on their course grades. A script was also developed and read to standardize administration, minimize error variance, and experimenter effects. The *Mathematics Ability Test* (Stripling & Roberts, 2012b) took the participants approximately 60 minutes to complete and was administered twice: (a) week 2 of the semester; and (b) week 16 of the semester.

Procedures

The treatment of this study was devised by the researchers and was incorporated into the teaching methods course during the final year of a teacher education program at the University of Florida. The MTIS treatment consisted of three parts. First, one researcher prepared and delivered a lecture to the treatment group of preservice teachers, which 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; Figure 4) to teach contextualized mathematics concepts. The lecture was reviewed by an expert on the seven components of a math-enhanced lesson to ensure validity. Second, each preservice agricultural education teacher in the treatment group was randomly assigned two of the 13 NCTM sub-standards (Carpenter & Gorg, 2000) that have been cross-referenced to the *National Agriculture, Food and Natural Resources Career Cluster Content Standards*. Third, the preservice teachers in the treatment group were required to teach the two NCTM sub-standards to their peers in the treatment group using the seven components of a math-enhanced lesson (Stone et al., 2006). Therefore, each preservice teacher in the treatment group participated in the math-enhanced lesson lecture, integrated mathematics into two of the eight normally required micro-teachings of the teaching methods course, and observed their peers teaching up to 12 math-enhanced lessons, while role-playing as a secondary student. For this study, a math-enhanced lesson is defined as an agricultural lesson that incorporates Stone et al.'s (2006) seven components of a math-enhanced lesson. In summary, beyond what was previously required in the teaching methods course 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 micro-teaching lessons to be math-enhanced.

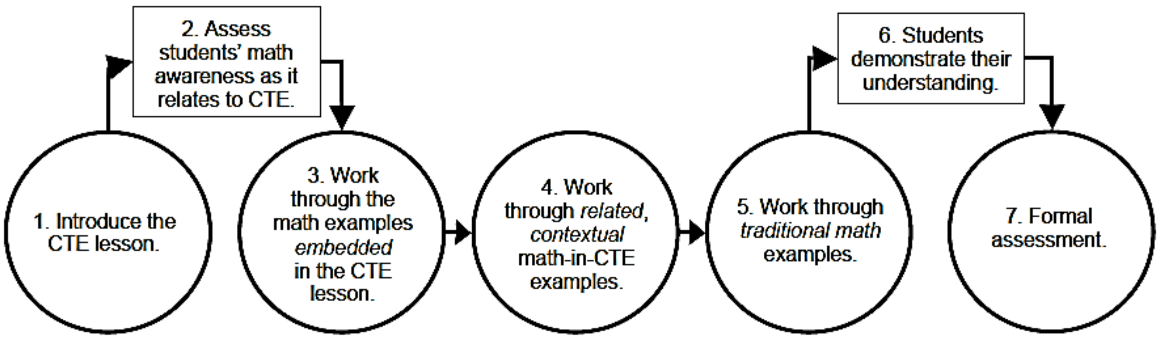

Figure 4. The National Research Center for Career and Technical Education: 7 Elements of a Math-Enhanced Lesson model (Stone et al., 2006, p. 13).

Analysis of Data

Frequencies, means, and standard deviations were calculated to summarize demographics and the mathematics ability scores of the preservice agricultural education teachers. ANCOVA was also used to determine if a significant difference existed in mathematics ability based upon the MTIS treatment. Partial eta squared was used to calculate effect size, and Huck's (2008) descriptors were utilized to describe the effect (.01 is a small effect size, .06 is a medium effect size, and .14 is a large effect size).

According to Huck (2008), the use of inferential statistics is appropriate for this type of research. Huck stated that inferential statistics can be used with a current sample to make inferences to an abstract population – population that is comprised of present and future members. Huck (2008) also purported that abstract populations exists "hypothetically as a larger 'mirror image' of the sample" (p. 102) or current accessible populations. Furthermore, Huck stated that abstract populations can be conceptualized from convenience samples that are described in detail. Consistent with Huck; Gall, Gall, & Borg (2003) justified the use of inferential statistics with a convenience sample. Gall et al. stated that "inferential statistics can be used with data collected from a convenience sample if the sample is carefully conceptualized to represent a particular population" (p. 176). Demographic data from the previous year of graduating preservice teachers at the University of Florida supported that the convenience sample was representative of the target population. In addition, qualitative data from the teacher educators at the University of Florida confirmed that the convenience sample was representative of the target population.

Findings

As depicted in Table 1, the control group's pretest mathematics ability scores week 2 of the teaching methods course averaged 45.51% (*SD* = 9.32), and the pretest scores ranged from 30.77% to 57.69%. At the end of the teaching methods course or week 16, the control group's posttest mathematics ability scores averaged 45.19% (*SD* = 11.26), and the posttest scores ranged from 30.77% to 59.62%. The control group's mathematics ability mean decreased 0.32% from week 2 to week 16 of the teaching methods course.

The experimental group's pretest mathematics ability scores increased from week 2 to week 16 of the teaching methods course (Table 1). The pretest scores averaged 38.31% (*SD* = 11.03), and the pretest scores ranged from 23.08% to 59.62%. At the end of the teaching methods course or week 16, the experimental group's posttest mathematics ability scores averaged 45.71% (*SD* = 11.69), and the posttest scores ranged from 36.54% to 69.23%. The experimental group's mathematics ability mean increased 7.40% from week 2 to week 16 of the teaching methods course.

Table 1

Mathematics Ability Means

	Pretest		Posttest		Difference posttest – pretest	
	M	*SD*	*M*	*SD*	*M*	*SD*
Control group	45.51	9.32	45.19	11.26	– 0.32	5.36
Experimental group	38.31	11.03	45.71	12.69	7.40	6.56

The hypothesis that there is no significant difference in the mathematics ability of preservice agricultural education teachers based upon the MTIS treatment was tested using an ANCOVA. The analysis revealed a significant difference in the mathematics ability of preservice agricultural education teachers based upon the MTIS treatment, while controlling pretest mathematics ability scores, $F(1, 16) = 5.36$, $p < .05$ (Table 2). Thus, the control group's adjusted posttest mean score ($M = 40.25$, $SE = 2.72$) was significantly lower than the experimental group's adjusted posttest mean ($M = 47.99$, $SE = 1.81$; Table 3). The practical significance of the difference was assessed using a partial eta squared, and the effect size was .25, which is a large effect according to Huck (2008). Based on the statistically significant difference in adjusted posttest mean and the large effect size, the null hypothesis was rejected.

Table 2

ANCOVA summary

	SS	*df*	*MS*	*F*	*P*	η_p^2
Group	221.00	1	221.00	5.36	.03	.25
Error	660.21	16	41.26			

Table 3

Adjusted Posttest Mathematics Ability Means

	M	*SE*
Control group	40.25	2.72
Experimental group	47.99	1.81

Conclusions and Implications

Descriptive statistics indicated that the treatment had a leveling effect on the mathematics ability of the preservice teachers enrolled in the teaching methods course. During week 2 of the teaching methods course, the experimental group's pretest mathematics ability scores were lower than the control group's pretest mathematics ability scores. By week 16 of the teaching methods course, the experimental and the control groups' posttest mathematics ability scores were within a few tenths of a percentage point. This may suggest that the MTIS treatment is effective at providing some remediation to preservice teachers with lower mathematics ability scores.

In addition, the MTIS treatment had a positive effect on the mathematics ability scores of the preservice teachers, and the practical significance of the difference in the scores was described as large ($\eta_p^2 = .25$). This finding is consistent with Stripling and Roberts (2013) who reported a math-enhanced agricultural teaching methods course significantly increased the mathematics ability scores of preservice agricultural education teachers at the University of Florida. Further, this finding is consistent with Berry (2005) who stated that research-proven instructional strategies in mathematics and literacy make a difference in student achievement as teacher educators incorporate the strategies into the teacher education program.

The results of this study also support Bandura's (1986) social cognitive theory, which purports cognitive skills can be socially cultivated, and that environment and behavior influences personal factors. In this study, the results suggests that the environment or the math-enhanced teaching methods course and the behaviors of developing math-enhanced lessons, teaching those lessons to peers, and role-playing as secondary students within the teaching methods course positively influences the personal factor of mathematics ability. This may also support Bandura's assertion that observational learning increases one's knowledge and cognitive skills. Moreover, the findings of this study suggests micro-teachings that utilizes the seven components of a math-enhanced lesson (Stone et al., 2006), developing math-enhanced lessons, and role-playing as secondary students during math-enhanced lessons in an agricultural teaching methods course can be an appropriate means to improve the mathematics ability of preservice agricultural education teachers.

Recommendations for Teacher Education

Based on the findings of this study, the following recommendations were made for agricultural teacher education:

1. The MTIS treatment should be considered for use in an agricultural teaching methods course to increase the mathematics ability of preservice agricultural teachers.
2. Agricultural educators should consider integrating content related to mathematics and mathematics instruction into teacher education courses.

Recommendations for Future Research

Based upon the findings of this study, the following recommendations for further research were made:

1. Due to the limited scope of this study, replication that uses preservice teachers from other teacher education programs should be conducted to further validate the effectiveness of the MTIS treatment in increasing the mathematics ability of preservice teachers.
2. A major component of the treatment of this study was the preparation of math-enhanced lessons by the preservice teachers, micro-teachings of math-enhanced lessons delivered by the preservice teachers, and the preservice teachers role-playing as secondary students during the micro-teachings. To that end, is the value of this component of the treatment in the preservice teachers preparing the lessons, teaching the lessons, participating as students in the lessons, or a combination of these activities? Future research should further investigate the effects of preparing math-enhanced lessons, teaching math-enhanced lessons, and participating in micro-teachings of math-enhanced lessons on preservice teachers' mathematics ability.
3. Future research should seek to determine if the use of the MTIS treatment in an agricultural teaching methods course impacts the teaching of mathematics in the secondary agricultural classes of the preservice teachers after graduation.
4. Future research should seek to determine if mathematics can be effectively and efficiently integrated into other agricultural teacher education courses.
5. Future research is warranted to investigate why preservice teachers have such low mathematics ability.

6. Future research should seek to determine the effects of having an expert in contextualized mathematics deliver instruction to preservice teachers on the teaching of contextualized mathematics.

Discussion

The authors believe a philosophical discussion that should take place within agricultural teacher education is how to best prepare preservice teachers for meeting the demands of teaching a subject that contributes to the STEM disciplines. How should the profession ensure beginning agricultural education teachers are prepared to make a meaningful contribution? Agricultural teacher education programs are limited in the number of credit hours available in a program of study for teacher preparation. So, is the incorporation of STEM content such as the teaching of contextualized mathematics and science into agricultural teacher education coursework appropriate or the best way to prepare preservice teachers for teaching STEM related subject matter? If so, what information or content will be removed from current teacher education courses to allow for the incorporation of STEM content?

Regardless of the answer to the aforementioned question, the authors believe the incorporation of STEM content into agricultural teacher education is appropriate because of the nature of agriculture. Agriculture is an applied science. For that reason, the authors believe the incorporation of STEM content is essential for developing the pedagogical content knowledge of preservice teachers. Research in teacher education has shown that the *subject matters*, and that "subject-specific pedagogical knowledge…enables teachers to represent the subject matter so that it will be accessible to learners" (Darling-Hammond, 2006, p. 82). Thus generic pedagogy alone does not fully prepare preservice agricultural education teachers for teaching the science of agriculture; therefore, there is a need for teaching methods to be taught within the context of the subject (Darling-Hammond, 2006). As the role of the secondary agricultural teacher has changed from vocational education to career and technical education that emphasize core academics and seeks to create informed citizens (Phipps et al., 2008), agricultural teacher education programs must also change to meet the demands of the changing role of the secondary agricultural education teacher.

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