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# Exploring Relationships between Presage Variables of Florida Preservice Agricultural Education Teachers Related to Teaching Contextualized Mathematics

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*The purpose of this exploratory study was to investigate the relationships between mathematics ability, personal mathematics efficacy, mathematics teaching efficacy, personal teaching efficacy, and background characteristics of preservice agricultural education teachers. Data were collected for two years at the University of Florida. Fourteen moderate associations were found between the variables in this study. In addition, categorical differences in mathematics ability, personal mathematics efficacy, mathematics teaching efficacy, and personal teaching efficacy were found related to presage variables of the preservice teachers. Based on the results of this study, further research is warranted to determine the most appropriate means for preparing Florida preservice agricultural education teachers for teaching contextualized mathematics.*

Keywords: preservice, mathematics, math, self–efficacy, teacher education, academics, STEM

Recent national educational reform efforts have sought to improve the teaching of America's teachers, including the teaching of mathematics (Goals 2000: Educate America Act; No Child Left Behind Act of 2001; United States Department of Education, 2010). However, U.S. students continue to underachieve in mathematics (National Center for Educational Statistics, 2000, 2004, 2010, 2011), and many preservice teachers, who will be charged with improving the mathematics ability of American students, are not proficient in mathematics (Michigan State University Center for Research in Mathematics and Science Education, 2010). Supporting the notion that preservice teachers are not prepared to teach mathematical concepts, research in agricultural education has shown preservice agricultural education teachers are not proficient in mathematics (Miller & Gliem, 1996; Stripling & Roberts, 2012a, 2012b, 2013a). This is troubling since mathematical concepts are naturally embedded in state and national agricultural education standards. What is more, agriculture has been acknowledged as a rich environment for teaching and learning mathematics (Conroy, Trumbull, & Johnson, 1999; Shinn et al., 2003), and school–based agricultural education possesses great potential for improving the mathematics proficiency of secondary students through the use of curricula that highlight the mathematical concepts within agricultural education (Parr, Edwards, & Leising, 2006; Stone, Alfeld, Pearson, Lewis & Jensen, 2006).

Developing preservice agricultural education teachers that are proficient in mathematics should aid the U.S. in producing students for careers in the STEM (science, technology, engineering, and mathematics) disciplines. This is a major priority for the U.S. because K–12 STEM education has been linked with "continued leadership and economic growth in the United States" (National Research Council, 2011, p. 3). Furthermore, "current demand for STEM–capable workers surpasses the supply of applicants who have trained for those careers… [, and] 16 of the 20 occupations with the largest projected growth in the next decade are STEM related" (National Research Council, 2011, p. 5). However, the literature base related to how to best prepare preservice teachers for the role of supporting the STEM disciplines is scarce. This study will seek to add to the knowledge base for preparing preservice agricultural education teachers for teaching mathematics found naturally within the agricultural education curricula by exploring the relationships between mathematics ability, mathematics teaching efficacy, personal mathematics efficacy, personal teaching efficacy and selected demographic characteristics of preservice agricultural education teachers. This study will also contribute to the American Association for Agricultural Education's national research priority areas three and five: sufficient scientific and professional workforce that addresses the challenges of the 21st century and efficient and effective agricultural education programs, respectively.

## Theoretical Framework

The model for the study of classroom teaching was used to frame this study (Dunkin & Biddle, 1974). Dunkin and Biddle (1974) differentiated between four categories of variables: presage, context, process, and product. The aforementioned authors theorized presage and context variables have a causative relationship with process variables and process variables have a causative relationship with product variables (Figure 1).

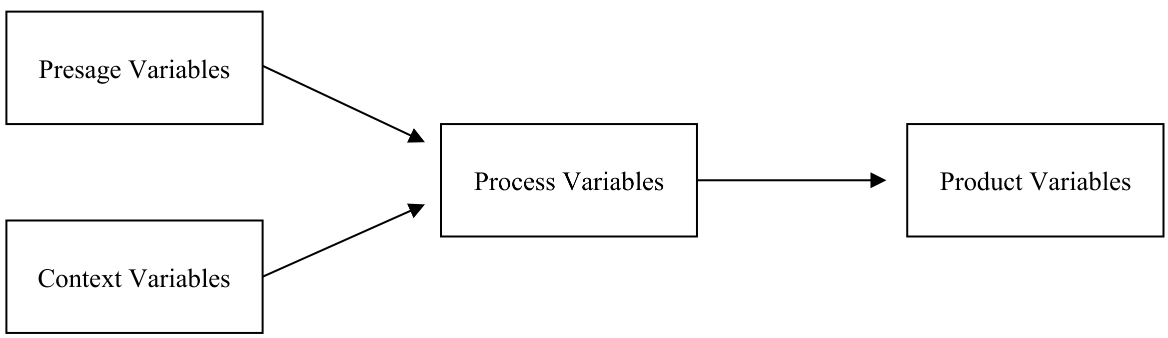


*Figure 1.* Adapted model for the study of classroom teaching.

According to Dunkin and Biddle (1974), presage variables "concern the characteristics of teachers that may be examined for their effects on the teaching process–thus, teacher formative experiences, teacher–training experiences, and teacher properties" (p. 39). Context variables are "characteristics of the environment about which teachers, school administrators, and teacher–educators can do very little" (Dunkin & Biddle, 1974, p. 41). Examples of context variables are community, school, and classroom contexts, student populations, and student formative experiences. Process variables are "the actual activities of classroom teaching – what teachers and pupils do in the classroom" (p. 44), and the interaction of teacher and student classroom behaviors yields observable positive or negative changes in a student's academic learning. Thus, changes in student learning that result from the interaction of the student with classroom activities, the teachers, and other students comprise the final category of variables, product variables.

The National Research Council (2000, 2011, 2013) has also recognized the importance of the variables identified by Dunkin and Biddle (1974). Subject–matter knowledge, pedagogical knowledge, and pedagogical content knowledge (presage variables) were identified by the National Research Council (2000) as types of knowledge needed by teachers for effective classroom instruction. 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 mathematics teaching efficacy is a measure of pedagogical content knowledge (Figure 3).

Context variables were also identified by the National Research Council (2011, 2013); however, the Council views context variables such as national, state, district, and school conditions and cultures as essential to successful K–12 STEM education. Dunkin and Biddle (1974) suggested teachers, school administrators and teacher–educators have little influence in regard to context variables. According to the National Research Council (2011, 2013), national, state, district, and school conditions and cultures *must* focus on STEM education, thus changing the contextual sphere in which teaching occurs. Furthermore, the National Research Council (2011, 2013) purported classroom activities and practices teachers and students engage in (process variables) are also essential to STEM education. Figure 2 is a conceptual model of the National Research Council's vision for improving STEM education; the model also identifies goals or desired outcomes (product variables). With the above theoretical framework and contextual context in mind, this study explored the relationships among several presage variables of preservice agricultural education teachers (See Figure 3).

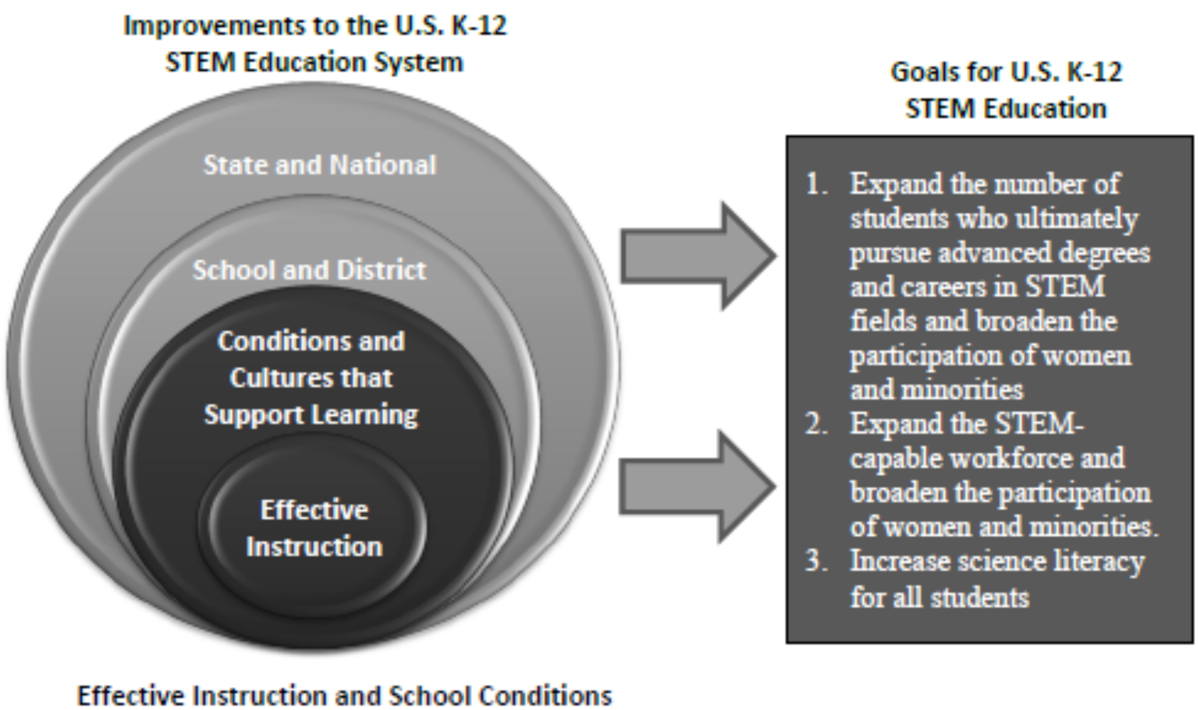


*Figure 2*. Key elements to successful K–12 STEM education (Reproduced with permission from the National Research Council, 2013, p. 7, Courtesy of the National Academies Press, Washington, D.C.)

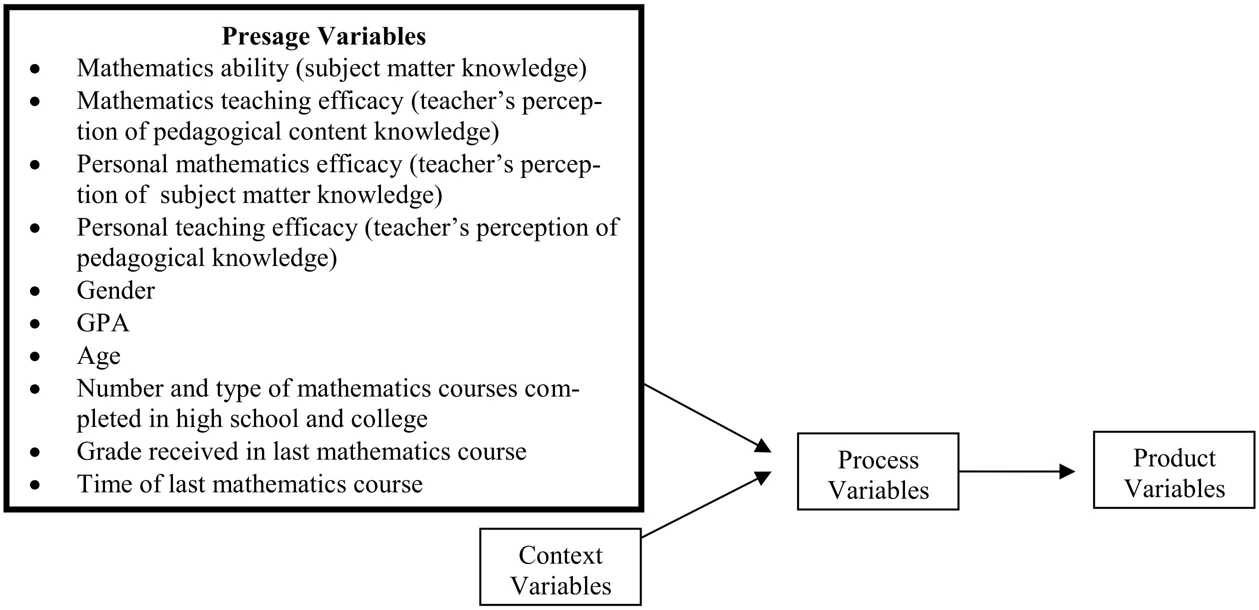


*Figure 3.* Conceptual framework of presage variables under investigation.

## Literature Review

### Agricultural Educators' Mathematics Ability

Persinger and Gliem (1987) investigated the mathematical ability of secondary agricultural education teachers and their students. The sample consisted of 54 teachers and 656 students. The teachers mean score on the 20 question mathematics ability test was 12.35 (*SD* = 4.36) problems solved correctly, or 61.75%. The researchers reported 28% of the teachers solved 50% or less of the problems correctly. Students of the mathematics deficient teachers were also shown to not be competent in mathematics. The average score for the secondary students was 5.6 (*SD* = 4.54) out of 20 or 28%. Persinger and Gliem also reported 82% of the students scored lower than 50%, and the teacher's test score was significantly correlated with the scores of their students.

Similar to Persinger and Gliem (1987), Miller and Gliem (1994) sought to explain the variance in the mathematical ability of secondary agricultural education teachers. A mathematical problem–solving test was developed by the researchers to test mathematics ability, and scores ranged from 26.7% to 100%. The mean score on the test was 66.5% (*SD* = 2.96). The relationships between mathematical problem–solving ability and the following variables were not significant: age and highest level of college mathematics coursework completed. However, the relationships between mathematical problem–solving ability and years of teaching experience, final college grade point average, ACT math score and attitude toward including mathematics concepts in the curriculum and instruction of secondary agriculture programs were significant. Miller and Gliem concluded the teachers in the study were not proficient in solving agriculturally related mathematical problems. Furthermore, the researchers also stated the highest level of mathematics need to solve the problems on the instrument was algebra.

Using the same instrument as Miller and Gliem (1994), Miller and Gliem (1996), investigated the mathematics ability of 49 preservice agricultural education teachers from The Ohio State University. The preservice teachers' scores ranged from 0% to 87%. Miller and Gliem reported 87.8% of the preservice teachers scored lower than 60%, and the mean score was 37.1% (*SD* = 2.92). Grade point average, level of mathematics courses taken, and gender were found to have negligible or low relationships with mathematical problem solving ability. A moderate relationship was found between mathematics ability and number of mathematics courses completed. A substantial positive relationship was found between mathematics ability and ACT math score. 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).

Building upon Persinger and Gliem (1987) and Miller and Gliem (1994, 1996), Stripling and Roberts (2012a) sought to determine the mathematics ability of senior preservice teachers at the University of Florida. Stripling and Roberts reported the preservice teachers averaged 35.6% on a 26 item agricultural mathematics instrument and concluded the preservice teachers were not proficient in agricultural mathematics concepts. Additionally, Stripling and Roberts investigated the associations between the types of mathematics courses completed in high school and college and the preservice teachers' score on the mathematics ability instrument. Results revealed moderate correlations between mathematics ability and basic high school mathematics ($r$ = -.43), advanced high school mathematics ($r$ = .47), basic college mathematics ($r$ = -.46), and advanced college mathematics ($r$ = .40). In addition, Stripling and Roberts reported a low correlation between mathematics ability and intermediate college mathematics ($r$ = .10) and a negligible correlation between mathematics ability and intermediate high school mathematics ($r$ = .03). Therefore, Stripling and Roberts concluded that the aforesaid associations suggest advanced mathematics coursework resulted in higher scores on the mathematics assessment.

Stripling and Roberts (2012b) was the only study found that investigated the mathematics ability of the nation's preservice agricultural teachers. The researchers randomly selected nine teacher education programs, which resulted in a sample of 98 preservice 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. Similar to Stripling and Roberts (2012a), Stripling and Roberts (2012b) reported a substantial correlation between mathematics ability and advanced high school mathematics ($r$ = .50), low correlations between mathematics ability and basic high school mathematics ($r$ = -.24), advanced high school mathematics ($r$ = .25), basic college mathematics ($r$ = -.23), and intermediate college mathematics ($r$ = -.14), and a negligible correlation between mathematics ability and intermediate high school mathematics ($r$ = .06). Additionally, Stripling and Roberts (2012b) observed a low correlation between mathematics ability and receiving a grade of an A ($r$ = .22) or a grade of a B ($r$ = -.11) in highest mathematics course completed in college and negligible correlations between mathematics ability and receiving a C ($r$ = -.09), a D ($r$ = -.04), or an F ($r$ = .01) in highest mathematics course completed in college. 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. Moreover, 39% of the variance in mathematics ability was explained with the following five variables: advanced college mathematics, attending university 1, attending university 7, attending university 8, and a grade of an A in highest college mathematics. According to Stripling and Roberts, the universities were included in the regression model because significant differences were found in the mathematics ability scores between universities.

In an effort to improve the mathematics ability of preservice agricultural education teachers, Stripling and Roberts (2013a) investigated the effects of a math-enhanced teaching methods course on mathematics ability. Stripling and Roberts reported a 12.15% increase in mathematics ability scores after the math-enhanced teaching methods course. The increase was significant, and a medium effect size was reported (Cohen's $d$ = .78). As a result, the authors recommend the math-enhanced teaching methods course should continue to be utilized at the University of Florida.

**Agricultural Educators' Mathematics Self–Efficacy**

Jansen and Thompson (2008) investigated the personal mathematics efficacy, mathematics teaching efficacy, and personal teaching efficacy of Oregon and Washington agricultural education teachers. Jansen and Thompson found the agricultural education teachers were efficacious in personal mathematics efficacy and personal teaching efficacy and moderately efficacious in mathematics teaching efficacy. Additionally, the relationship between personal mathematics efficacy and mathematics teaching efficacy was $r$ = .57, and the relationship between a personal teaching efficacy and mathematics teaching efficacy was $r$ = .23.

Swan, Moore, and Echevarria (2008) examined Idaho agricultural educations teachers' confidence in mathematics and teaching mathematics. The agricultural education teachers were confident in their own mathematics ability and their ability to teach mathematics. Swan et al., also reported the relationship between confidence in mathematics ability and confidence in teaching mathematics was strong ($r$ = .72), which is similar to Jansen and Thompson (2008).

Stripling and Roberts (2012a) sought to describe the mathematics teaching efficacy, personal mathematics efficacy, and personal teaching efficacy of preservice teachers at the University of Florida. The researchers discovered preservice teachers in their final year of a teacher education program were efficacious in personal mathematics efficacy and personal teaching efficacy and moderately efficacious in mathematics teaching efficacy, which is also consistent with Jansen and Thompson (2008). Furthermore, Stripling and Roberts (2013a) reported Florida preservice agricultural education teachers were efficacious in personal mathematics efficacy and personal teaching efficacy and moderately efficacious in mathematics teaching efficacy, and this finding is in agreement with Jansen and Thompson (2008) and Stripling and Roberts (2012a). Additionally, Stripling and Roberts (2013a) investigated the effects of a math–enhanced teaching methods course on personal mathematics efficacy, mathematics teaching efficacy, and personal teaching efficacy. The researchers indicated personal mathematics efficacy decreased while mathematics teaching efficacy and personal teaching efficacy increased slightly after a math–enhanced teaching methods course; the differences in the self–efficacy scores were not statistically significant.

**Research in Other Disciplines**

As with the agricultural education literature, limited research is available specifically on the relationships between presage variables of preservice teachers and mathematics ability and efficacy. With that in mind, mixed results have been reported related to mathematical reasoning in regard to gender. Halat (2008) found a statistically significant difference in gender of preservice secondary mathematics teachers related to the teachers' van Hiele level. "The van Hieles described five levels of reasoning in geometry. These levels, hierarchical and continuous, are level-I (Visualization), level-II (Analysis), level-III (Ordering), level-IV (Deduction), and level-V (Rigor)" (Halat, 2008, p. 2). Halat also reported that male preservice elementary mathematic teachers' scored higher in thinking levels; however, the difference was not statistically significant. Thus, significance was found related to gender in secondary preservice teachers but not preservice elementary teachers.

In a study of preservice elementary teachers, Gliner (1991) found 27% of the variance in mathematical estimation scores were accounted for by preservice teachers' self-perception of success in mathematics, college GPA, years of mathematics study, and enjoyment of mathematics. Additionally, Gliner reported average mathematics grade, gender, and age were not significant predictors of mathematical estimation scores. Matthews and Seaman (2007) found preservice elementary teachers' ACT scores and college GPAs were significant predictors of mathematics content knowledge, and Isiksal (2005) reported a significant difference in preservice middle school mathematics teachers' cumulative GPA in their mathematics and mathematics education coursework based on gender. Females in Isiksal's study possessed higher cumulative mathematics coursework GPAs than males. Furthermore, Isiksal did not find a significant difference in mathematics self-efficacy scores based on gender. Lastly, a few researchers have reported a relationship between mathematics anxiety and mathematics self-efficacy (Bursal & Paznokas, 2006; Gresham, 2008; Swars, Daane, & Giesen, 2006).

### Purpose and Objectives

The purpose of this exploratory study was to investigate the relationships between mathematics ability, personal mathematics efficacy, mathematics teaching efficacy, personal teaching efficacy, and background characteristics of preservice agricultural education teachers. The following objectives framed this study:

1. Compare mathematics teaching efficacy, personal mathematics efficacy, personal teaching efficacy, and mathematics ability in regard to gender, grade point average, number and type of mathematics courses completed in high school and college, grade received in last mathematics course completed, time of last mathematics course, and age of the preservice agricultural education teachers.
2. Determine the magnitudes of the associations among mathematics ability, personal mathematics efficacy, mathematics teaching efficacy, personal teaching efficacy, gender, grade point average, number and type of mathematics courses completed in high school and college, grade received in last mathematics course completed, time of last mathematics course, and age of the preservice agricultural education teachers.

## Methodology

### Research Design and Sample

This study is part of a larger series of studies investigating the mathematics ability and efficacy of Florida preservice teachers (Stripling & Roberts, 2012a, 2013a, 2013b, 2013c). The research design of this nonexperimental exploratory study was descriptive and correlational (Gall, Gall, & Borg, 2007). The target population for this study was Florida preservice agricultural education teachers. The accessible population for this study was preservice teachers in their final year of the agricultural teacher education program at the University of Florida during the 2010–2011 and 2011–2012 academic years. For this study, the accessible population was a convenience sample, which was conceptualized as a slice in time (Oliver & Hinkle, 1982). Gall et al. (2007) 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, 2013a) studies, which found Florida preservice agricultural education teachers were not proficient in mathematics. Thus, there is a need to investigate the development of mathematics ability and self–efficacy of Florida preservice agricultural education teachers.

The sample consisted of 44 preservice agricultural education teachers, 22 females and 22 males. The average age of the sample was 21.8 years old ($SD$ = 1.31) with a range of 20 to 27. Forty–two of the participants described their ethnicity as white, one as black, and one as other. Additionally, 42 of the participants were seniors in an undergraduate agricultural education program, while the remaining two participants were completing a graduate program seeking agricultural education teacher certification. Their self–reported mean college grade point average was 3.41 ($SD$ = 0.65) on a 4–point scale. The number of college level mathematics courses completed by the participants ranged from 0 to 6 with a mean of 2.99 ($SD$ = 1.21), and one of the participants reported that they had not completed a mathematics course since high school. For that reason, the time since the participants' last mathematics course ranged from the previous semester in college to their senior year in high school or about four years prior. The most commonly completed type of mathematics course was intermediate mathematics in high school and college, and a majority of the preservice teachers received a grade of an A or B in their last mathematics course regardless of the level of the mathematics course.

### Instrumentation

Two instruments were used during this study, the *Mathematics Ability Test* (Stripling & Roberts, 2012a) and the *Mathematics Enhancement Teaching Efficacy Instrument* (Jansen, 2007). 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 *Mathematics Ability Test* 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. During item development, the researcher met with a secondary mathematics expert to determine which items from Miller and Gliem's (1996) agricultural problem solving test would meet the requirements of the 13 NCTM sub–standards. The secondary mathematics expert determined seven of Miller and Gliem's 15 items aligned with the 13 NCTM sub–standards, and therefore, all seven items were included on the *Mathematics Ability Test*. The remaining 19 items were developed based on NCTM examples problems (Carpenter & Gorg, 2000). Stripling and Roberts (2012a) reported the reliability of the instrument to be .80, and stated "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" (p. 115).

A demographic section was added to the *Mathematics Ability Test* and the participants self–reported gender, age, ethnicity, grade point average, number of mathematics courses taken, highest level of mathematics taken, and grade received in last mathematics course completed. Additionally, a mathematics expert 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 scorer used a rubric that was developed by two secondary mathematics experts to score each item.

The *Mathematics Enhancement Teaching Efficacy Instrument* was developed and validated during a doctoral dissertation at Oregon State University and is divided into the following three constructs: mathematics teaching efficacy, personal mathematics efficacy, and 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 reported face and content validity was established by a panel of experts that included representatives from Oregon, Utah, and Washington. Exploratory and confirmatory factor analyses were used to verify the construct and discriminate validity of the instrument. Jansen pilot tested the instrument with Utah secondary agricultural teachers and reported the Cronbach's alpha coefficients for the mathematics teaching efficacy, personal mathematics efficacy, and personal teaching efficacy constructs to be .92, .89, and .91, respectively. Jansen also conducted a larger study with a target population of all Oregon and Washington secondary agricultural teachers. The larger study consisted of 230 participants, and Jansen reported the Cronbach's alpha coefficients for the mathematics teaching efficacy, personal mathematics efficacy, and personal teaching efficacy constructs to be .88, .84, 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.

## Data Collection

The data collection period of this study was during the Fall 2010 and 2011 academic semesters. The preservice agricultural education teachers agreed to participate and take the *Mathematics Ability Test* (Stripling & Roberts, 2012a) and the *Mathematics Enhancement Teaching Efficacy Instrument* (Jansen, 2007) by signing an informed consent, which was approved by the Institutional Review Board at the University of Florida. In addition, since students received and completed the instruments during their agricultural teaching methods courses, 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. The *Mathematics Ability Test* took the participants approximately 60 minutes to complete and was administered week two of the semester. The *Mathematics Enhancement Teaching Efficacy Instrument* took the participants approximately 8 minutes to complete and was administered week one of the semester.

**Analysis of Data**

For the purpose of discussion, the terminology proposed by Davis (1971) was used to indicate the magnitude of the correlations. Correlations from .01 to .09 are negligible, .10 to .29 are low, .30 to .49 are moderate, .50 to .69 are substantial, .70 to .99 are very strong, and a correlation of 1.00 is perfect. Pearson correlations were used for continuous data, and point biserial correlations were used for dichotomous data. With that in mind, gender was coded as male (0) or female (1), grade received in most recent college mathematics course was coded as not the grade received (0) or grade received (1), and the types of mathematics courses were coded as not completed (0) or completed (1). The types of mathematics courses completed in high school and college by the preservice agricultural education teachers were categorized into basic, intermediate, and advanced mathematics by a mathematics expert. The mathematics expert categorized algebra, algebra II, and college algebra as basic mathematics, trigonometry, pre–calculus, and statistics as intermediate mathematics, and calculus as advanced mathematics.

## Findings

**Objective 1: Compare mathematics teaching efficacy, personal mathematics efficacy, personal teaching efficacy, and mathematics ability in regard to gender, grade point average, number and type of mathematics courses completed in high school and college, grade received in last mathematics course completed, time of last mathematics course, and age of the preservice agricultural education teachers.**

As shown in Table 1, male preservice agricultural education teachers had slightly higher mathematics teaching efficacy and mathematics ability scores than females, and personal mathematics efficacy and personal teaching efficacy scores were similar among males and females. In regard to the type of mathematics completed in high school, preservice teachers who completed intermediate mathematics had higher personal mathematics efficacy and mathematics ability scores then preservice teachers who completed basic mathematics, and preservice teachers who completed advanced mathematics had higher scores than preservice teachers who completed basic or intermediate mathematics. This trend was not observed in mathematics teaching efficacy or personal teaching efficacy. A similar trend was observed between mathematics ability and the type of mathematics course completed in college. Thus, preservice teachers who completed an advanced mathematic course had higher scores than those who completed an intermediate or basic mathematics course, and preservice teachers that completed an intermediate course had higher scores than those who completed a basic mathematics course. The opposite was found between personal teaching efficacy and the type of mathematics course completed in college. Preservice teachers who completed higher levels of mathematics possessed lower personal teaching efficacy scores.

Furthermore, with the exception of the one preservice teacher that scored a D, preservice teachers with higher grades in their last mathematics course had higher personal mathematics efficacy and mathematics teaching efficacy scores. This trend was not observed in personal teaching efficacy or mathematics ability. Additionally, as the length of time since the last mathematics courses increased, personal teaching efficacy scores increased. This trend was also observed for mathematics teaching efficacy except for preservice teachers whose last mathematics course was 10 or more semesters prior to this study. As for personal mathematics efficacy, preservice teachers who completed a mathematics course more recently had lower scores. In regard to the number of mathematics courses completed in college, preservice teachers who completed more mathematics courses had lower mathematics ability scores than those who completed fewer courses. The opposite was true for mathematics teaching efficacy and personal mathematics efficacy; preservice teachers who completed more mathematics courses in college had higher scores. As for personal teaching efficacy, similar scores were found regardless of the number of mathematics courses completed in college.

Differences in the self–efficacy constructs and mathematics ability were also found for age. Preservice teachers 24 or older had lower mathematics teaching efficacy, personal mathematics efficacy, and mathematics ability scores than those 20–23 years old. This was not the case for personal teaching efficacy. Preservice teachers 24 or older had higher personal teaching efficacy scores than those 20–23 years old. Lastly, preservice teachers with GPAs of 3.0 or higher had higher mathematics teaching efficacy, personal mathematics efficacy, and mathematics ability scores than those with a GPA below a 3.0. This was not the case for personal teaching efficacy. The preservice teachers with the highest personal teaching efficacy scores had GPAs of 3.4 or lower. A complete comparison of the self–efficacy constructs and mathematics ability by demographic characteristics can be found in Table 1.

Table 1

*Comparison of Self–efficacy Constructs and Mathematics Ability by Demographic Characteristics*

| Demographic characteristic | | MTE | | PME | | PTE | | Math ability | |
|---|---|---|---|---|---|---|---|---|---|
| | *f* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Gender | | | | | | | | | |
| Male | 22 | 3.38 | 0.66 | 3.43 | 0.41 | 7.45 | 0.74 | 39.87 | 14.10 |
| Female | 22 | 3.49 | 0.62 | 3.45 | 0.43 | 7.44 | 0.67 | 35.66 | 11.88 |
| Type of math course | | | | | | | | | |
| Basic HS math course | 13 | 3.51 | 0.38 | 3.33 | 0.43 | 7.18 | 0.62 | 30.92 | 9.00 |
| Intermediate HS math course | 21 | 3.44 | 0.59 | 3.46 | 0.38 | 7.68 | 0.64 | 38.37 | 14.04 |
| Advanced HS math course | 9 | 3.50 | 0.90 | 3.60 | 0.47 | 7.38 | 0.79 | 46.81 | 11.42 |
| Basic college math course | 7 | 3.24 | 0.37 | 3.41 | 0.39 | 7.70 | 0.70 | 25.27 | 11.69 |
| Intermediate college math course | 29 | 3.54 | 0.52 | 3.49 | 0.41 | 7.50 | 0.67 | 38.67 | 11.39 |
| Advanced college math course | 7 | 3.43 | 1.02 | 3.34 | 0.49 | 7.10 | 0.71 | 47.26 | 13.59 |
| Grade in last math course | | | | | | | | | |
| Grade of an A | 15 | 3.66 | 0.39 | 3.48 | 0.33 | 7.36 | 0.68 | 36.28 | 15.20 |
| Grade of a B | 19 | 3.43 | 0.74 | 3.49 | 0.49 | 7.49 | 0.70 | 41.19 | 12.52 |
| Grade of a C | 8 | 3.19 | 0.54 | 3.25 | 0.32 | 7.49 | 0.72 | 32.95 | 10.75 |
| Grade of a D | 1 | 3.69 | N/A | 3.88 | N/A | 8.33 | N/A | 38.50 | N/A |
| Time of last math course | | | | | | | | | |
| 1 to 3 semesters | 5 | 2.80 | 0.77 | 3.23 | 0.56 | 7.23 | 0.92 | 43.08 | 10.50 |
| 4 to 6 semesters | 21 | 3.52 | 0.52 | 3.48 | 0.38 | 7.42 | 0.68 | 36.54 | 11.81 |
| 7 to 9 semesters | 10 | 3.70 | 0.58 | 3.46 | 0.45 | 7.48 | 0.56 | 42.31 | 15.34 |
| 10 or more semesters | 7 | 3.47 | 0.51 | 3.50 | 0.38 | 7.77 | 0.76 | 31.87 | 14.94 |
| Number of college math courses | | | | | | | | | |
| 0 | 1 | 3.62 | N/A | 3.38 | N/A | 6.92 | N/A | 46.15 | N/A |
| 1 to 2 | 14 | 3.34 | 0.67 | 3.32 | 0.36 | 7.47 | 0.70 | 43.55 | 12.73 |
| 3 or more | 28 | 3.53 | 0.58 | 3.52 | 0.44 | 7.48 | 0.70 | 34.76 | 12.78 |
| Age | | | | | | | | | |
| 20–23 | 40 | 3.48 | 0.62 | 3.46 | 0.41 | 7.42 | 0.67 | 39.43 | 12.24 |
| 24 or older | 3 | 3.33 | 0.31 | 3.38 | 0.50 | 8.08 | 0.65 | 17.29 | 6.94 |
| GPA | | | | | | | | | |
| 3.5 to 4.0 | 20 | 3.53 | 0.54 | 3.51 | 0.40 | 7.22 | 0.65 | 37.89 | 14.66 |
| 3.0 to 3.4 | 19 | 3.54 | 0.56 | 3.44 | 0.44 | 7.77 | 0.60 | 37.96 | 10.90 |
| 2.5 to 2.9 | 3 | 3.23 | 0.47 | 3.38 | 0.25 | 7.47 | 0.83 | 30.13 | 14.72 |

*Note.* MTE = mathematics teaching efficacy (1 = *strongly disagree* to 5 = *strongly agree*), PME = personal mathematics efficacy (1 = *not at all confident* to 4 = *very confident*), PTE = personal teaching efficacy (1 = *nothing* to 9 = *a great deal of influence*), and HS = high school.

**Objective 2: Determine the magnitudes of the associations among mathematics ability, personal mathematics efficacy, mathematics teaching efficacy, personal teaching efficacy, gender, grade point average, number and type of mathematics courses completed in high school and college, grade received in last mathematics course completed, time of last mathematics course, and age of the preservice agricultural education teachers.**

Moderate associations were discovered between mathematics teaching efficacy and personal mathematics efficacy ($r$ = .38), grade point average ($r$ = .44), and time of last mathematics course ($r$ = .31); personal mathematics efficacy and personal teaching efficacy ($r$ = .38) and grade point average ($r$ = .30); personal teaching efficacy and an intermediate high school mathematics course ($r_{pb}$ = .31); mathematics ability and a basic high school mathematics course ($r_{pb}$ = - .35), advanced high school mathematics ($r_{pb}$ = .35), basic college mathematics course ($r_{pb}$ = - .43), and an advanced college mathematics course ($r_{pb}$ = .32); age and basic college mathematics course ($r_{pb}$ = .40); grade point average and intermediate college mathematics course ($r_{pb}$ = .32); time of last mathematics course and gender ($r_{pb}$ = .41) and receiving a grade of an A ($r_{pb}$ = .38). Several low and negligible associations were also discovered. Those associations along with the moderate associations above are presented in Tables 2 and 3.

Table 2

*Correlations between Continuous Variables*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1. MTE | -- | .38 | .22 | .19 | .29 | .44 | .31 | .10 |
| 2. PME | | -- | .38 | .06 | .16 | .30 | .20 | .05 |
| 3. PTE | | | -- | - .07 | .27 | .06 | .22 | .02 |
| 4. Math ability | | | | -- | - .10 | -.14 | - .22 | - .22 |
| 5. Age | | | | | -- | -.11 | .21 | .14 |
| 6. GPA | | | | | | -- | .29 | .23 |
| 7. Time of last math course | | | | | | | -- | - .23 |
| 8. Number of college math courses | | | | | | | | -- |

*Note.* MTE = mathematics teaching efficacy, PME = personal mathematics efficacy, and PTE = personal teaching efficacy.

Table 3

*Correlations between Continuous and Dichotomous Variables*

| | Gender | Basic HS math course | Intermediate HS math course | Advanced HS math course | Basic College math course | Intermediate College math course | Advanced College math course | Grade of an A |
|---|---|---|---|---|---|---|---|---|
| MTE | .09 | .04 | - .06 | .03 | - .17 | .16 | - .03 | .23 |
| PME | .04 | - .20 | .03 | .18 | - .04 | .13 | - .12 | .04 |
| PTE | - .01 | - .28 | .31 | -.06 | .15 | .07 | - .24 | - .11 |
| Math ability | - .16 | - .35 | .04 | .35 | - .43 | .09 | .32 | - .09 |
| Age | - .18 | .20 | - .09 | - .11 | .40 | - .24 | - .09 | .17 |
| GPA | .10 | .03 | .13 | - .19 | - .12 | .32 | - .28 | .16 |
| Time of last math course | .41 | .05 | .07 | - .14 | .12 | .05 | - .18 | .38 |
| Number of college math courses | - .09 | - .01 | - .19 | .24 | - .02 | - .15 | .22 | - .22 |

*Note*. MTE = mathematics teaching efficacy, PME = personal mathematics efficacy, PTE = personal teaching efficacy, HS was coded as male (0) or female (1), grade received in most recent college mathematics course was coded as not the grade received (1), and the types of mathematics courses were coded as not completed (0) or completed (1).

## Conclusions

This study was framed using Dunkin and Biddle's (1974) model for the study of classroom teaching as a guide for investigating presage variable of preservice agricultural education teachers that theoretically impact classroom activities and learning outcomes. Additionally, this study sought to contribute to the National Research Council's (2013) goals for U.S. K–12 STEM education and the American Association for Agricultural Education's national research agenda by exploring the relationships between presage variables of preservice agricultural education teachers and measures of proficiency in mathematics and the teaching of mathematics.

To that end, slight gender differences were found in regard to mathematics teaching efficacy and mathematics ability, however, the associations with gender were negligible and low, respectively. Thus, gender explains a trivial portion of the variance in mathematics teaching efficacy and mathematics ability. Similarly, Miller and Gliem (1996) also found a negligible relationship between gender and mathematics problem solving ability.

Furthermore, the level of mathematics completed in high school and college may have an effect on mathematics ability. Preservice teachers who completed higher levels of mathematics had higher mathematics ability scores, and the associations between mathematics ability and basic high school mathematics, basic college mathematics, advanced high school mathematics, and advanced college mathematics were moderate. These associations are consistent with Stripling and Roberts (2012a, 2012b) and may suggest that higher levels of mathematics contribute to a higher proficiency in mathematics. On the other hand, one could argue students who have a higher aptitude for mathematics tend to complete higher levels of mathematics and students with lower ability generally complete lower levels of mathematics.

Interestingly, personal mathematics efficacy increased in regard to completing higher levels of mathematics in high school, but not when completing higher levels in college. Mathematics teaching efficacy was similar regardless of the level of mathematics completed in high school and college, and the associations between mathematics teaching efficacy and the level of mathematics were negligible and low. This may indicate the development of mathematics teaching efficacy is not dependent on the type of mathematics course completed in high school or college. For personal teaching efficacy, preservice teachers who completed higher levels of mathematics in college had lower scores; however the associations between personal teaching efficacy and the level of mathematics in college were negligible and low. Therefore, in this study, a small portion of the variance in personal teaching efficacy was explained by the type of mathematics in college.

Higher grades in the preservice teachers' last mathematics course resulted in higher mathematics teaching efficacy and personal mathematics efficacy scores; however this was not the case for personal teaching efficacy and mathematics ability. This may suggest receiving a higher grade encourages the preservice teachers to perceive themselves as more efficacious in teaching and completing mathematical tasks, but the grade received is not an indicator of mathematics ability. Correspondingly, Stripling and Roberts (2012a) reported a disconnect between preservice agricultural education teachers' mathematics ability and efficacy. The preservice teachers in Stripling and Roberts study were found to possess low ability while feeling competent in mathematics and moderately competent in teaching mathematics.

In general, preservice teachers who completed a mathematics course more recently had lower mathematics teaching efficacy, personal mathematics efficacy, and personal teaching efficacy scores. Additionally, the associations between the self–efficacy constructs and time of last mathematics course were low or moderate. Therefore, time of the last mathematics course explains a small portion of the variance in mathematics teaching efficacy, personal mathematics efficacy, and personal teaching efficacy. Coupled with the fact preservice teachers who completed more courses had lower mathematics ability, this may indicate preservice teachers with a lower mathematical aptitude may complete more courses and are taking mathematics courses closer to their graduation date. Correspondingly, there was a moderate positive association between time since last mathematics course and a grade of an A. Similarly, Miller and Gliem (1996) reported preservice teachers with higher mathematics problem–solving scores had completed advanced mathematics courses, completed a fewer number of mathematics courses, and possessed higher ACT math scores.

Preservice teachers 24 or older had lower mathematics teaching efficacy, personal mathematics efficacy, and mathematics ability scores and higher personal teaching efficacy scores than those 20–23 years old. Therefore, the older preservice teachers in this study were less confident in their ability to teach and complete mathematical tasks, but were more confident in their ability to teach in general. This is supported by the moderate association between age and completing a basic mathematics course instead of higher levels of mathematics. This may indicate older preservice teachers are in need of more remediation in mathematics subject matter and pedagogy.

In regard to GPA, generally, preservice teachers with higher GPAs had higher mathematics ability, personal mathematics efficacy, and mathematics teaching efficacy scores, and the associations between GPA and mathematics ability, personal mathematics efficacy, and mathematics teaching efficacy were moderate, moderate, and low, respectively. Thus, in this study, GPA does have some predictive value related to the preservice teachers' mathematics ability and their self–belief in teaching and completing mathematical tasks. This finding is similar to Matthews and Seaman (2007), who found preservice elementary teachers' college GPAs were significant predictors of mathematics content knowledge.

## Recommendations for Future Research

In an incipient area of research, the results of this exploratory study begin to shed light on the development of mathematics ability and efficacy. However, future research is needed to build an empirical knowledge base of these presage variables before sound research-based recommendations for practice can be given. To that end, several areas of future research have been identified and are presented below:

- The comparisons and associations in this study and others (Stripling & Roberts, 2012a, 2012b) suggest there is a relationship between the level of mathematics completed in high school and college and mathematics ability. Future research should seek to further understand this relationship. Do students with a higher aptitude for mathematics complete higher courses? Do advanced mathematics courses such as calculus teach students to solve problems/develop problem solving skills, which then aids in teaching and solving contextualized mathematical scenarios such as those found naturally in the agricultural education curricula?
- Further research is warranted to understand why preservice teachers who completed an advanced mathematics course in college possessed lower personal teaching efficacy scores and to determine if this trend is present in other populations of preservice agricultural education teachers.
- Preservice teachers who received higher grades in their last mathematics course had higher self–efficacy in completing mathematical tasks and teaching mathematics. However, mixed results were found in relation to grades and mathematics ability. Thus, future research should determine if there is merit to requiring preservice teachers to obtain a higher level of competency/grade in their required mathematics coursework.
- Further research should be conducted to determine why preservice teachers who completed mathematics courses later in their program of study had lower self–efficacy in completing mathematical tasks. Are these preservice teachers completing higher levels of mathematics and experiencing failure late in their program of study, repeating lower levels of mathematics because of prior lack of success, or delaying completing required mathematics courses as a result of a lack of expected success? This information will be helpful to teacher educators in developing mathematics self–efficacy of preservice agricultural education teachers.
- Research is needed to determine the most appropriate courses for developing the personal mathematics efficacy, mathematics teaching efficacy, and mathematics ability of

Florida preservice teachers in regard to national mathematics standards. Mixed results were obtained in regard to the level and number of mathematics courses completed.

The research areas outlined above are important in developing the mathematics ability and self–efficacy of Florida preservice teachers. By producing preservice agricultural education teachers that are proficient in mathematics and mathematics teaching, the agricultural education profession will contribute to the National Research Council's goals for U.S. K–12 STEM education by increasing the supply of secondary students who are prepared to pursue STEM careers and thereby strengthen the U.S. economy.

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