The Relationship of Agricultural Mechanics Teachers' Confidence in their Mathematic Skills and Confidence in their Ability to Teach Mathematic Skills

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Abstract

This study assessed Idaho agricultural science and technology teachers that taught at least one agricultural mechanics course during the 2006-2007 school year in terms of their confidence level in their own mathematics skills and their ability to teach mathematics skills. Data were collected using Dillman's Tailored Design Method (2000) resulting in a response rate of 56.84% (N=95, n=54). Data were used to identify relationships between the level of confidence in mathematic abilities and confidence in ability to teach mathematics. A strong relationship was found between the confidence agricultural mechanics teachers had in their ability to perform mathematic tasks and their confidence to teach mathematic skills. The respondents were completely confident in their mathematics skills and their ability to teach mathematics skills. Respondents who were confident in their ability to teach mathematics skills are poised to implement mathematics instruction within the agricultural mechanics courses they teach.

Introduction/Theoretical Framework

High school students in the United States are consistently outperformed by those from Asian and some European countries on international assessments of mathematics and science, according to *The Condition of Education 2006* report released by the U.S. Department of Education's National Center for Education Statistics (National Center for Educational Statistics, 2006). Previous research (Gliem & Elliot, 1988; Gliem, Lichtensteiger, & Hard, 1987; Hague & Phua, 1990; Miller & Gliem, 1994) has suggested that student scores on proficiency tests are not reflective of the number and level of mathematics courses completed by the students. To improve student performance in mathematics, Shinn, et al. (2003) shared that students will learn mathematics best when they can apply the concepts to real life. The context of agriculture can act as a unifying theme for mathematics and can add meaning to what students learn (Shinn, et al., 2003).

Researchers (Melodia & Small, 2002; National Research Council, 1988; Shinn et al., 2003) agree that agricultural education provides opportunities for teaching mathematics. In 1988, the National Research Council recommended that all students needed a basic understanding of mathematics and science concepts and that teaching mathematics and science through agriculture was an effective approach to student learning. Melodia and Small (2002) believed that:

> It is important that a quality agriculture teacher recognize he/she already integrates science and mathematics in many ways. The next step is to be intentional about

> integration. Teachers must understand the core competencies and standards to which the school and state are being held accountable. p. 19

Because 46% of the secondary agriculture courses taught in Idaho are agricultural mechanics courses (Idaho Division of Professional-Technical Education, Agriculture & Natural Resources, 2007a) it is important to ensure that mathematics is integrated in agricultural mechanics courses. There are numerous opportunities to integrate mathematics into agricultural mechanics courses. Basic mathematics such as concepts of measurement can be applied within Idaho's agricultural mechanics courses. For example, basic measuring as it applies to measuring a piece of material to cut in agricultural structures or agricultural fabrication. More complex forms of measurement can also be applied such as measuring bore diameter, horsepower, and torque in agricultural power technology or small gasoline engines. Additional mathematics such as concepts and principals of geometry can be applied in agricultural structures as it relates to cutting truss components or in agricultural fabrication in relation to calculating stress loads.

The state curriculum for Idaho agricultural mechanics courses provides agriculture teachers the opportunity to integrate mathematic standards into each of the ten agricultural mechanics courses. Generalized mathematic standards include: (1) Number and Operation, (2) Concepts and Principals of Measurement, (3) Concepts & Language of Algebra and Functions, (4) Concepts and Principals of Geometry, and (5) Data Analysis, Probability, and Statistics. The Idaho state achievement standards have been linked to the state curriculum for each of the ten agricultural mechanics courses. Specific achievement standards that are repeatedly highlighted throughout Idaho's agricultural mechanics curriculums include (Idaho Division of Professional-Technical Education, Agriculture Science &Technology, 2003):

- Apply dimensional analysis.
- Apply appropriate technology and models to find solutions to problems.
- Understand and use U.S. customary and metric measurements.
- Understand and use a variety of problem-solving skills.
- Apply the geometry of right triangles.
- Apply concepts of size, shape, and spatial relationships.
- Solve simple linear systems of equations or inequalities.
- Evaluate algebraic expressions.
- Use algebraic symbolism as a tool to represent mathematical relationships.
- Perform error analysis.
- Understand and use numbers.
- Use reasoning skills to recognize problems and express them mathematically.

Some professional technical education classes similar to agricultural mechanics have positively aided in increased mathematic assessment scores by incorporating mathematics. A mathematic integration reform at New Castle County Vocational Technical School District consisted of professional collaboration between shop and mathematics teachers. Mathematic teachers visited professional technical learning laboratories to teach mathematics lessons that corresponded to the units within the learning labs. Mathematic teachers also observed how mathematics was applied and then used learning lab references to teach mathematics in their own classrooms. The mathematics integration reform resulted in a 13% increase of student scores on the Delaware Mathematic Assessment from the previous year (Ancess, 2001). Within agricultural education, researchers (Parr, Edwards, & Leising, 2006) found that integrating mathematics into agricultural mathematics instruction had a significant and positive influence on student performance.

Idaho secondary agricultural mechanics courses provide the opportunity for agricultural teachers to reach a large percentage of students. During the 2006-2007 school year, secondary agricultural science and technology instructors offered 1219 sections of Agricultural courses. Agricultural mechanics courses accounted for 46% of the secondary agriculture courses taught in Idaho (Idaho Department of Education, Agriculture & Natural Resources, 2007a). Enrollment in Idaho agricultural mechanics courses during the 2006-2007 school year accounted for 8,128 students of the 20,527 students enrolled (40%) in secondary agricultural education courses (Idaho Department of Education, Agriculture & Natural Resources, 2007b).

Several studies (Gliem & Elliot, 1988; Gliem, Lichtensteiger, & Hard, 1987; Gliem & Warmbrod, 1986; Miller & Gliem, 1993; Persinger & Gliem, 1987) have been conducted to determine whether secondary students, undergraduates in agricultural education, and teachers of agricultural education were proficient in applying mathematics concepts to agriculturally-related problems. Findings have consistently indicated that secondary and undergraduate students as well as teachers were not proficient in solving agriculturally-related mathematics problems. In their study involving agriculture teachers, Miller and Gliem (1994) stated:

> In order for agriculture students to become better mathematical problem-solvers, teachers must become better mathematical problem-solvers. Simply improving teachers' ability to apply mathematics to agricultural related problems will not fully address the issue. It is recommended that high quality instructional materials involving the application of mathematics to agriculture be developed cooperatively by teacher educators in mathematics and agriculture as well as secondary agriculture and mathematics teachers. Inservice education should be provided to agriculture teachers regarding ways to utilize these instructional materials in their agriculture programs. p. 2

Mathematics initiatives may place additional emphasis on mathematics courses and less on elective courses such as agricultural mechanics. If additional emphasis was placed solely on mathematics by requiring more traditional mathematics courses, a reduction in possible elective courses, including agriculture courses could result. Such reductions in electives may threaten Idaho agriculture programs with reduction or even loss of programs as policymakers search for ways to improve the mathematic ability of students and school administrators search for financial means to employ more mathematics teachers. Melodia and Small (2002) declared:

> Agriculture programs are being closed across the country in face of increasing demand of accountability and standards regarding student achievement in math, science and other core competencies. Additional "seat time" is not the answer to student academic achievement. Instead, agriculture educators must promote the strength of the integrated model of agricultural education. Simply, agricultural education provides not only the context, but the content for students to be successful in math and science. p. 18

Despite such assertions, teaching mathematics within agricultural mechanics courses has not been stressed in teacher preparation or from the state department of education in Idaho. A need may develop to demonstrate that agricultural mechanics courses provide a context for mathematics instruction in order to justify funding for the courses.

The theoretical framework for this study was Bandura's (1986, 1997) social cognitive theory. An individual's belief about his or her own abilities on a specific task is called self-efficacy or confidence. Betz and Hackett (1993) reported that mathematics confidence is a major predictor of mathematic performance. Hackett and Betz (1989) found a moderate relationship between mathematics self-efficacy and mathematics performance. Bandura's (1986, 1997) triadic reciprocity, suggests that when an individual is confident in a specific skill they are identified as being efficacious, meaning that their performance of that specific skill is reflective of their confidence. Bandura (1986, 1997) demonstrated that low confidence in regard to a behavior leads to avoidance of the behavior and high confidence should increase the frequency of the behavior. The more confidence one has in their mathematic ability, the better they should be at performing mathematics. In other words, if a teacher has more mathematics confidence, they should have higher confidence as a mathematics teacher, meaning that they can teach mathematics well since they have confidence in their own ability to performance mathematic tasks. Therefore, if mathematics is considered a behavior, the frequency and ability of agricultural mechanics teachers to teach mathematics in the context of agricultural mechanics should be reflective of their confidence to perform mathematics tasks. The confidence of teachers to perform mathematic tasks in relation to the confidence of teachers to teach mathematics has been researched very little both inside and outside of agricultural education.

Bandura (1986, 1997) shared that one's belief in their ability was related to their perception of their performance. Therefore, if agricultural mechanics teachers believe in their own mathematic abilities they should have similar belief in their ability to teach mathematics. It is unknown if agricultural mechanics teachers are confident in their own mathematics skills or if they are confident to teach mathematics skills.

Purpose/Objectives

The purpose of this study, conducted as part of a larger study, was to examine agricultural mechanics teachers' confidence level in their own mathematic skills and their confidence to teach mathematic skills. Specific objectives of the study were to:

1. Determine the level of Idaho's agricultural mechanics Teachers' confidence in their own mathematic skills.

2. Determine the level of Idaho's agricultural mechanics teachers' confidence in their own ability to teach mathematic skills.

3. Describe the relationship between agricultural mechanics teachers' confidence in their own mathematic skills and confidence in their own ability to teach mathematic skills.

Methods/Procedures

Population and Sample

This one shot case study [**X O design**] (Campbell & Stanley, 1963) examined the perceptions of Idaho's secondary agricultural mechanics teachers' toward their perceptions of their own mathematical ability and their ability to teach mathematical skills. This was a census study reflective of all of Idaho's agricultural science and technology teachers that taught at least one agricultural mechanics course during the 2006-2007 school year (*N=95*). The Idaho Division of Professional-Technical Education annually collects approved course lists and enrollment numbers from agricultural and natural resource programs statewide. These state compiled statistics were used to identify the target population for this study. The response rate was 56.84% (*N=95, n=54*). Statistics were used to enhance details within the data.

Instrumentation

The instrument used to collect data from this study had three portions. The first portion was composed of highest mathematics course completed at the college level. The second portion was composed of the Mathematics Self-Efficacy Scale (MSES) by Betz & Hackett (1993). The MSES is copyrighted which prevents the researcher from showing the instrument in its entirety. The MSES consists of two subsections. The first subsection is entitled Mathematics Courses (16 items) and the second subsection is entitled Everyday Mathematic Tasks (18 items). The third portion was composed of the researcher developed Mathematics Sense of Teacher-Efficacy Scale (MSTES).

Betz and Hackett released the latest version of the MSES in 1993. The MSES is one of few instruments available that has been proven over time to be reliable and valid. The MSES is copyrighted and available through www.mindgarden.com. Therefore, the instrument cannot be fully displayed. The MSES has two sections that include Mathematics Courses (16 items) and Everyday Mathematic Tasks (18 items).

The Mathematics Courses section identified the participant's level of confidence in passing a mathematic-based college course with an A or B. The courses included 8 mathematics courses, 4 science-based courses, 3 prerequisite mathematics courses, and one other course. The scale for this section is 0 to 9, as follows: 0=no confidence, 1-3=very little confidence, 4-5=some confidence, 6-7=much confidence, and 8-9=complete confidence. The reliability of this section has produced a Cronbach's Alpha Coefficient (Cronbach, 1951) of 0.92 (Betz & Hackett, 1993).

The Everyday Mathematic Tasks section was divided between arithmetic, algebra, and geometry. Further, the instrument was equivalently divided across three types of operations: comprehension, computational skills, and ability to apply mathematic principles and levels of abstraction (real vs. abstract). The same 0-9 scale from part 1 was used for this section. The reliability of this section also produced a Cronbach's Alpha Coefficient (Cronbach, 1951) of 0.92 (Betz & Hackett, 1993).

The MSES represented an individual's confidence in their ability to accurately complete mathematics tasks. The MSTES was a mirror image of the MSES instrument, except the leading question was changed from MSES "How much confidence do you have that you could successfully" to "How much confidence do you have that you could successfully teach how to…" The MSTES was reviewed by a panel of experts to establish face and content validity. The MSTES was then pilot tested by 15 (*N=25*) preservice agricultural education students at the University of Idaho with a 60.00% response rate. None of the participants in the pilot study were part of the population of the study. The scale for this section was 0 to 9, as follows: 0=no confidence, 1-3=very little confidence, 4-5=some confidence, 6-7=much confidence, & 8-9=complete confidence. The reliability of this section produced a Cronbach's Alpha Coefficient (Cronbach, 1951) of 0.91.

Data Collection and Analysis

Dillman's (2000) methods for collecting mail and internet survey's was followed. Data collection was eight weeks. Both internet and hard copy surveys were used with intent of improving the response. First, a notice was mailed out to the sample to bring their attention to future mailings and emails. A few days later, the instructions for the online version of the instrument were mailed to participants followed by a similar email several days later to remind individuals to participate. The regular mail was sent three days prior to the email to allow for delivery time with the intent of both forms arriving on the same day. One week after the instructions were mailed out, a thank you/reminder post card was sent out. Three days later email thank you/reminder messages were also sent. Three weeks after the instructions were initially mailed a hard copy of the instrument was mailed regular mail with the intent of gaining participation of those that chose not to respond via the internet. A final email was sent a few days later to encourage participation. Finally, after five weeks, the researcher made phone calls to non-respondents to encourage participation.

The return date indicated the respondent's completed instrument was either submitted online via email or postmarked through the US Mail. Both email and physical addresses were obtained from the *2006-2007 Idaho Secondary Agricultural Science and Technology Instructor Directory* (Agricultural & Extension Education Department, 2006). Completed instruments were considered early if they were received with an online date stamp by Survey Monkey between February 5th and February 25th. Completed instruments were considered late if they were received with an online date stamp or postmarked by the US Mail between February 26th and March 27th. Because there were no statistical differences between early and late respondents (*Table 1*) on the measures of MSTES, non-respondents were assumed to be similar to the two groups (Miller & Smith, 1983).

Table 1

Agricultural Mechanics Teacher Return Date and Corresponding Frequency

Group	Return Date	*F*
Early Respondents	February 5th - February 25th	35
Late Respondents	February 26th - March 27th	19
	Total Respondents	54

At the end of the data collection, the data set was analyzed using SPSS 15.0 (2006). Data were nominal, ordinal, or ratio in nature and correlated, producing Pearson product moment coefficients representing the linear relationships between the constructs of Mathematics Self Efficacy and Mathematics Sense of Teacher Efficacy. Specific items on each instrument produced frequencies, means, and standard deviations.

Results/Findings

Objective 1: Determine the level of Idaho's agricultural mechanics teachers' confidence in their own mathematic skills.

Idaho agricultural mechanics teachers *(n=53)* indicated they had much confidence in their own ability to complete mathematic related courses. The respondents mean score on part one of the MSES was 6.37 with average standard deviation of 1.37 as found in *Table 2*. Basic College Mathematics was the only course in which respondents indicated they had complete confidence to pass with an A or B. Respondents had much confidence to pass 11 of the courses listed, some confidence to pass 3 of the courses, and very little confidence to pass Advanced Calculus with a grade of A or B.

Table 2

Mathematics Self-Efficacy Part 1(n=53)

			Range	
	M	*SD*	*Min*	*Max*
Basic College Mathematics	8.00	1.39	5	9
	7.60	1.15	5	9
	7.47	1.58	3	9
	7.42	1.69	1	9
	6.98	1.91	1	9
	6.81	1.68	1	9
	6.68	1.83	2	9
	6.58	1.79	2	9
	6.57	1.95	2	9
	6.40	1.89	2	9
	6.38	2.14	1	9
	6.36	2.24	1	9
	5.40	2.45	0	9
	5.11	1.63	1	8
	4.57	2.15	0	9
Advanced Calculus	3.66	2.27	0	8
Average	6.37	1.37		

Note. Scale values are 0=no confidence, 1-3=very little confidence, 4-5=some confidence, 6-7=much confidence, 8-9=complete confidence.

Idaho agricultural mechanics teachers (*n=52*) indicated they had complete confidence in their own ability to complete mathematic related tasks. The mean score on part two was 8.21 with average standard deviation of 0.82 as found in *Table 3*. Respondents indicated they had complete confidence to complete twelve of the eighteen tasks. Respondents had much confidence to complete the other six tasks. The task to “Compute a car’s gas mileage” was the task respondents had the most confidence to complete followed by “Multiply and divide using a calculator”. “Add two large numbers (eg. 5379 + 62543) in your head” was the task that respondents had the least confidence to complete.

Table 3

Mathematics Self-Efficacy Part 2 (n=52)

			Range	
	M	*SD*	*Min*	*Max*
6. Compute your car's gas mileage. [a]	8.86	0.72	4	9
5. Multiply and divide using a calculator. [a]	8.82	0.74	4	9
7.	8.71	0.70	5	9
11.	8.65	0.89	4	9
16.	8.53	0.64	7	9
8.	8.49	0.99	4	9
18.	8.49	0.86	6	9
17.	8.43	0.88	6	9
14.	8.37	1.11	4	9
10.	8.33	1.16	4	9
3.	8.29	1.03	4	9
15.	8.16	1.01	5	9
2.	7.98	1.68	0	9
13.	7.98	1.42	4	9
9.	7.90	1.57	0	9
12.	7.45	1.84	2	9
4.	7.25	1.85	0	9
1. Add two large numbers (eg. 5379 + 62543) in your head. [a]	7.10	2.08	2	9
Average	8.21	0.82		

Note. Scale values are 0=no confidence, 1-3=very little confidence, 4-5=some confidence, 6-7=much confidence, 8-9=complete confidence.
[a]*n=51*, [b]*n=52*

The mean score of the total MSES with parts 1 and 2 combined was 7.33 with average standard deviation of 1.15 as found in *Table 4*. The mean score of 7.33 indicates that Idaho's AST teachers have much confidence in their own mathematic skills.

Table 4

Average Combined Mean Score of MSES (n=53)

	M	*SD*
MSES Part 1 Average *M*[a]	6.37	1.37
MSES Part 2 Average *M*[b]	8.21	0.82
Combined Average *M*	7.33	1.15

Note. Scale values are 0=no confidence, 1-3=very little confidence, 4-5=some confidence, 6-7=much confidence, 8-9=complete confidence.
[a]*n=53,* [b]*n=51*

Objective 2: Determine the level of Idaho's agricultural mechanics teachers' confidence in their own ability to teach mathematic skills.

The mean score for teachers' (*n=45*) confidence level in their ability to teach mathematics in agricultural mechanics was 8.09 on a scale of 0 to 9 with average standard deviation of 0.64 (*Table 5).* Respondents indicated they had complete confidence to teach twelve of the eighteen tasks and much confidence to teach the other six tasks. "Multiply and divide using a calculator" was the task that respondents had the most confidence to teach followed by "Compute your car's gas mileage". "Compute your income taxes for the year" was the task that respondents had the least confidence to teach.

Table 5

Mathematics Teaching Self-Efficacy (n=45)

	M	*SD*	*Range* *Min*	*Max*
5. Multiply and divide using a calculator [a]	8.87	0.34	8	9
6. Compute your car's gas mileage [a]	8.80	0.46	7	9
7.	8.53	0.79	6	9
8.	8.42	0.87	5	9
11.	8.36	0.88	6	9
10.	8.27	1.10	5	9
17.	8.25	0.89	6	9
3.	8.24	1.05	4	9
14.	8.21	1.06	5	9
18.	8.20	1.05	6	9
2.	8.11	1.32	4	9
16.	8.11	1.02	4	9
13.	7.78	1.41	4	9
15.	7.74	1.42	3	9
9.	7.64	1.26	4	9
4.	7.60	1.37	4	9
1.	7.24	1.90	0	9
12. Compute your income taxes for the year [a]	6.91	1.81	3	9
Average	8.09	0.64		

Note. Scale values are 0=no confidence, 1-3=very little confidence, 4-5=some confidence, 6-7=much confidence, 8-9=complete confidence.
[a]n=45, [b]n=44, [c]n=43

Objective 3: Describe the relationship between agricultural mechanics teachers' confidence in their own mathematic skills and confidence in their own ability to teach mathematic skills.

Calculations of the relationship between teacher's confidence in their own mathematic skills and their confidence to teach mathematic skills resulted in an r value of 0.72 and was statistically significant (*p<.05 two-tailed)*. Utilizing Bartz's (1999) adjectives describing strength of relationships an r value of 0.72 is interpreted as a strong relationship. This shows that if a teacher is confident in their own mathematic ability then they are also confident in their ability to teach mathematics.

Conclusions/Implications/Recommendations

Bandura (1986, 1997) shared that one's belief in their ability was related to their perception of their performance. Hackett and Betz (1989) concluded there is a moderate relationship between mathematics self-efficacy and performance. Idaho agricultural mechanics teachers showed a very strong relationship between their confidence in their own mathematic ability and their confidence in their ability to teach mathematic skills. The respondents of this study confirmed Bandura's self-efficacy theory.

For part I of the MSES, Idaho's agricultural mechanics teachers indicated they had much confidence in their own ability to complete mathematics related courses with a grade of A or B. For part II of the MSES they indicated they had complete confidence in their own ability to complete mathematic tasks. The combined MSES scores indicated that Idaho's agricultural mechanics teachers had much confidence in their mathematic abilities.

One reason for the difference between mean scores in the two parts of the MSES could be because some of the college courses listed were not courses related to agricultural education majors. Therefore, the title alone may not have provided enough information for participants to be familiar with the course.

The agricultural mechanics teachers in this study are completely confident in their mathematical abilities. With Bandura's (1986, 1997) triadic reciprocity, when an individual is confident in a specific skill they are identified as being efficacious, meaning that their performance of that specific skill is reflective of their confidence. Bandura also stated that frequency of a behavior increases as confidence in the behavior increased. However, previous research (Persinger & Gliem, 1987; Gliem & Elliot, 1988; Gliem, Lichtensteiger, & Hard, 1987; Gliem & Warmbrod, 1986; Miller & Gliem, 1993) has consistently indicated that teachers performed poorly in solving agriculture-related mathematics problems. The previous research would suggest that Idaho's agricultural mechanics teachers may not be as proficient in their mathematic ability as they have indicated, despite their complete confidence. While looking at actual mathematic problem-solving ability was outside the scope of the present study, future research should be conducted to establish a relationship self-reported confidence data such as that collected in this study with actual performance measures.

Further research should be performed to determine if Idaho's agricultural mechanics teachers are confident in their mathematic skills and abilities to teach mathematics in general as measured by the MSES or to teach mathematics as it applies specifically to agricultural mechanics. Part I of the MSES should be revised and piloted to focus specifically on agricultural science related courses. Performance evaluations should be conducted to demonstrate a relationship between the teachers' MSES score and their mathematics performance.

Idaho's agricultural mechanics teachers indicated they had complete confidence in their ability to teach mathematic skills. The mean score of the MSTES which was used to determine this confidence level was very close to the mean score for part II of the MSES which determined the confidence level of Idaho's agricultural mechanics teachers' in their own mathematic skills.

Because "secondary agricultural education…has high potential for engaging students in active, hands-on/minds-on learning environments rich with opportunities for learning mathematics" (Shinn et al., 2003, p. 16) and Idaho's agricultural mechanics teachers indicated they have complete confidence in their ability to teach mathematics, then Idaho's secondary agricultural mechanics courses should enhance mathematics instruction if Idaho's agricultural mechanics teachers do incorporate mathematics into such courses.

References

Agricultural & Extension Education Department (2006). *2006-2007 Idaho secondary agricultural science and technology instructor directory.* Moscow, ID: University of Idaho.

Ancess, J. (2001). Teacher learning at the intersection of school learning and student outcomes. *In A. Lieberman & L. Miller (Eds.), Teachers caught in the action: Professional development that matters* (pp. 61-78). NY: Teachers College Press.

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

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W.H. Freeman and Co.

Bartz, A. E. (1999). *Basic statistical concepts*. Upper Saddle River, NJ: Prentice-Hall.

Betz, N. E., & Hackett, G. (1993). *Mathematics self-efficiency scale: Sampler set manual, test booklet and scoring guide*. Mindgarden, Inc., www.mindgarden.com.

Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental designs for research.* Chicago: McNally.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16:297-334

Dillman, D. A. (2000). *Mail and internet surveys: The tailored design method (2nd ed.)*. John Wiley & Sons, Inc.: New York.

Gliem, J. A., & Elliot, J. (1988). Problem-solving skills of agricultural education undergraduates when completing mathematical word problems in agricultural mechanics. *Proceedings of the 15th annual National Agricultural Education Research Meeting, St. Louis, MO.*

Gliem, J. A., Lichtensteiger, M. J., & Hard, D. L. (1987). Mathematical problem-solving skills in agricultural mechanics of undergraduate students in agriculture. *Proceedings of the 15th annual National Agricultural Education Research Meeting, Las Vegas,* 191-198.

Gliem, J. A., & Warmbrod, J. R. (1986).*Students problem-solving abilities in agricultural mechanics*. Paper No. 86-5057, American Society of American Engineers. St. Joseph, MI.

Hackett, G., & Betz, N. E. (1989). Mathematics performance, mathematics self-efficacy, and the prediction of mathematics-related college majors. *Journal for Research in Mathematics Education,* 20, 261-273.

Hague, S. K., & Phua, M. S. (1990). *Reactions to word problems: Perceptions and performance.* Washington: University of the District of Columbia.

Idaho Division of Professional-Technical Education (2003). *Agriculture and natural resources: Approved courses, curriculum and competency profiles,* Retrieved March 28, 2007, http://www.pte.state.id.us/ast/astdocs/linked/AG%20230%20Linked%20Report.doc

Idaho Division of Professional-Technical Education (2007a). *Agricultural science and technology: Courses/sections offered 2006-2007* [Data file]. Boise, ID: Idaho Professional Technical Education Department.

Idaho Division of Professional-Technical Education (2007b). *Agriculture and natural resources: 10-D enrollment form 2006-2007* [Data file]. Boise, ID: Idaho Professional Technical Education Department.

Melodia, A., & Small, T. (2002 November-December) Integrating math and science into agriculture. *Agricultural Education Magazine*, 75(3) 18-19.

Miller, G., & Gliem, J. A. (1993). Mathematical problem-solving ability of secondary agriculture teachers. *Proceedings of the 20th National Agricultural Education Research Meeting*, Nashville, TN.

Miller, G., & Gliem, J. (1994). Agricultural education teachers' ability to solve agriculturally related mathematics problems. *Journal of Agricultural Education*, 35(4) 25-30.

Miller, L. E., & Smith, K. L. (1983). Handling nonresponse issues. *Journal of Extension, 41*(1) 79-87.

National Center for Educational Statistics (2006). *The condition of education 2006 report.* Retrieved December 1, 2006, from http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2006073

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

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.

Persinger, K. M., & Gliem, J.A. (1987). Mathematical problem-solving skills of high school vocational agriculture teachers and students. *Proceedings of the 14th Annual National Agricultural Education Research Meeting*, Las Vegas, NV.

Shinn, G. C., Briers, G. E., Christiansen, J. E., Harlin, J. F., Lindner, J. R., Murphy, T. H., et al (2003). *Improving student achievement in mathematics: An important role for secondary agricultural education in the 21st Century.* Unpublished Manuscript. Texas A&M University.