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Mathematics Integration in Agricultural Mechanics Courses by Outstanding Agricultural Educators

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Abstract

This study investigated the outstanding agricultural teachers' level of mathematics integration in each agricultural mechanics course taught. The participants of this study were selected by a panel of experts who frequently visited agricultural education teachers and observed them teaching. The panel reached a consensus on 26 outstanding agricultural education teachers and an electronic survey instrument was developed by the researcher. The teachers reported integrating mathematics in a range of 10 to 50% in individual agricultural mechanics courses. The mean indicated the typical agricultural education teacher in this study integrated mathematics into 23% percent of their lessons. The younger agricultural education teachers tended to integrate mathematics at a higher percentage than older agricultural education teachers.

***Keywords*:** Mathematics Integration, Agricultural Education, Agricultural Mechanics

Introduction

Agricultural education has been present in public schools since the development of public schools in America. Minnesota was the first state to offer secondary agricultural education with the first school organized in 1888. By 1910, Virginia promoted agricultural education through Congressional district agricultural schools. A total of 30 states had agricultural education courses established in the public schools systems prior to the Smith-Hughes Act, which was passed in 1917 (Phipps, Osborne, Dyer, & Ball, 2008). The Smith-Hughes Act provided funding to promote and establish agricultural education courses and is often credited for the birth of agricultural education in public schools.

Phipps et al. (2008) noted agricultural education has developed deep philosophical roots, placing a great deal of emphasis on pragmatism. “The practical application and successful transfer of knowledge, skills, and attitudes into real-world settings is the goal of instruction” (p. 19). Phipps et al. (2008) further acknowledged “agricultural education has been cited as an innovative program model for education, in order to maintain an innovative program, efforts have been made to reshape agricultural education programs to ensure their continued value, relevance, vitality, and quality” (p. 14).

At the same time, traditional mathematics instruction has experienced a great deal of scrutiny. One of the reoccurring themes suggests that in academic programs, students are lectured to about theories and principles, but are never shown how these theories and principles can be applied to real situations (Bottoms & Sharpe, 1996). Researchers have suggested that mathematics as it is being taught in American schools lacks the real-world “connection” and “context” needed to be learned and applied effectively (Britton, Huntley, Jacobs, & Weinberg, 1999; Hoachlander, 1999; Parnell, 1995; Resnick & Hall, 1998; Von Secker & Lissitz, 1999). Mathematics educators have expressed a need to reform mathematics education; one of the themes which emerged was contextual-based learning (Briner, 1999). Anderson (2012) indicated that agricultural education was a content area that was rich in mathematics concepts. Furthermore, Parr (2004) suggested that agricultural education teachers and mathematics teachers should work together to help bridge the gap that exists between content and context.

The need for educational reform surfaced from the National Commission on Excellence in Education’s (1983) report suggesting American students are falling behind those in other nations. As a result of the report, titled *A Nation at Risk*, high school graduation requirements for academic subjects increased since 1983 (Barrick, 1992; Campbell, Hombo, & Mazzeo, 2000). The increased academic requirements have come at the expense of career and technical education courses (Cetron & Gayle, 1991). Studies have indicated that the increase in academic coursework has not led to an increase in academic achievement (Clune & White, 1992; Hoffer, 1997). National Assessment of Educational Progress scores for mathematics have been relatively flat for the past 30 years (Castellano, Stringfield, & Stone, 2002).

Career and technical education courses have also come under scrutiny. Some researchers have expressed concern that skills are taught simply by showing a student how to perform an operation without properly training the student in the theory behind the operation (Parnell, 1996). Warmbrod (1974) stated “if vocational education assumed its proper role in American education that vocational education must be concerned with the student’s intellectual, social, and cultural development as well as their vocational development” (p. 5). Phipps et al. (2008) praised agricultural education; however, they pointed out one of the image problems associated with agricultural education programs is the emphasis placed on the technical skills.

Warmbrod (1974) indicated career and technical education should be held accountable for students' achievement in both academic and technical skills. Phipps et al. (2008) stated agricultural education should promote meaningful and practical applications of subject matters, such as mathematics. The National Research Council (1988) argued programs must provide a strong emphasis on traditional academic skills in order for agricultural education programs to remain effective.

The lack of application of the theories and principles taught in the academic classroom and the lack of theories and principles associated with the skills taught in the career and technical education courses have left a gap (Parr, 2004). The lack of connection between subject matter in secondary schools has been widely recognized for a number of years (Glasgow, 1997; NASSP, 1996). This gap between practice and theory must be bridged (Parr, 2004; Schmidt, 1924). Warmbrod (1974) indicated that theories and principles must be linked with the application and practice. According to a guide for implementing curriculum integration published by The Ohio State University (Center on Education and Training for Employment, 1998), this bridge could come in the form of contextualized learning.

Agricultural education has great potential to deliver relevant curriculum which engages students with hands-on and minds-on learning environments, rich with real world applications of mathematics (Shinn et al., 2003). Agricultural education, by the very nature of its structure and content, can be used to teach information which may be difficult to teach in other settings (Drawbaugh & Hull, 1971). Phipps et al. (2008) linked academic and career and technical education, specifically agricultural education stating:

> Vocational education in agriculture (i.e., agricultural education) is an integral part of public school education and contributes to the general objectives of education. It contributes to the development in students of the ability to think and study and in the ability to solve problems efficiently, which require skill in collecting and interpreting data. (p. 9)

Agricultural education provides an authentic context in which students can apply the concepts and skills-grounded mathematic theory (Conroy, Trumbull, & Johnson, 1999). Parr (2004) found math-enhanced agricultural curriculum had a positive effect on student math performance, while maintaining the technical skills associated with the curriculum. According to Bottoms and Sharp (1996), integration of both academic and technical skills into content areas such as agricultural education holds great potential for enhancing student learning in critical academic, technical, and personal areas.

Drosjack (2003) reported fewer than one in every three students nationally are able to do math at a proficient level. Bayer Corporation (2003) found 9 out of 10 U.S. citizens are concerned today's students may not have the mathematical skills to produce the excellence required for homeland security and economic leadership in the 21st century. Students today require strong mathematical knowledge and skills in order to pursue a higher education, compete in the technology driven workforce, and are informed citizens (VDOE, 2005). Agricultural education instructors are required by the standards set forth in the Carl D. Perkins Act (1998) to integrate academics into the agricultural education curriculum.

Miller and Gliem (1993 as cited in Hunnicutt, 1994) found nearly half of the agricultural education teachers studied in Ohio did not coordinate their efforts to integrate mathematics into the agricultural education curriculum with mathematics teachers. Gliem and Warmbrod (1986, as cited in Shinn, 2003) encouraged agricultural education departments to attempt to integrate practical mathematics applicable to agriculture into the curriculum. Alabama agricultural education instructors reported they integrated mathematics into 26-50% of the agricultural education curriculum (Hunnicutt, 1994). Parr (2004) found mathematically enhanced agricultural power and technology courses in Oklahoma had a positive effect on student math performance.

Anderson (2012) found that agricultural education teachers in Virginia had positive attitudes toward the integration of mathematics. The teachers in that study had indicated that agricultural education provided an excellent avenue to teach math concepts. These positive attitudes indicate that those teachers were early-adopters that had entered into the decision stage. The teachers also indicated that they could integrate more mathematics into their curriculum indicating that they had not moved into the re-invention stage. Determining the level of mathematics being integrated into each of the agricultural mechanics courses will help experts in agricultural mechanics identify content areas that are rich in mathematics concepts that can translate into real-life applications. Providing additional concepts, applications and problem solving activities that align to the course content in agricultural mechanics would assist the agricultural education teacher's efforts to integrate mathematics.

Theoretical Framework

The theoretical perspective utilized to frame this study was Rogers' (1995) Diffusion of Innovations Theory. Diffusion theory has been used to describe innovation diffusion and the process in which the adoption or rejection of innovations occur. Phipps et al. (2008) acknowledged "agricultural education has been cited as an innovative program model for education, efforts have been made to reshape agricultural education programs to ensure their continued relevance, and quality" (p. 14). Rogers described the five stages of the innovation-decision process as knowledge, persuasion, decision, implementation, and confirmation. The stages of innovation listed below are linked to previous studies regarding mathematics integration in agricultural education and in some cases agricultural mechanics.

- The innovation-decision process begins with the *knowledge stage* in which the potential adopter is exposed to the innovation and begins to understand how it functions. Parr (2004, p. 116) found that in-service education for teachers concerning contextualized teaching and learning did help instructors recognize opportunities, as well as the knowledge and skills needed, to increase the math performance of their students.
- The *persuasion stage* includes the individual liking the innovation, discussion about the innovation with others, acceptance of the message about the innovation, formation of a positive image of the message and innovation, and support for innovative behavior from the social system. Miller and Vogelzang (1983) found that agricultural instructors in Iowa supported the inclusion of mathematics concepts in agricultural education. Miller and Gliem (1993 as cited in Hunnicutt, 1994) found that all teachers in their Ohio study had positive attitudes toward the integration of mathematics in their curriculum.
- After knowledge is gained and an attitude is formed toward the innovation, the potential adopters enter the *decision stage* in which they are ready to make the decision to adopt or reject the innovation. Innovations that are perceived by individuals as having greater relative advantage, compatibility, trialability, observability, and less complexity will be adopted more rapidly than other innovations. Miller and Gliem (1993 as cited in Hunnicutt, 1994) reported that 47% of all the Ohio agriculture teachers stated they integrated mathematics into their curriculum.
- The *implementation stage* includes the acquisition of additional information about the innovation, as well as regular and continued use of the innovation. An important phase of the implementation stage, when the innovation is applied to uses other than its

original intended purpose, is re-invention. Parr (2004) found mathematically enhanced agricultural power and technology courses in Oklahoma had a positive effect on student math performance.

- The *confirmation stage* consists of recognition of the benefits of using the innovation, integration of the innovation's use into routine, and promotion of the innovation to others. The increase in mathematics achievement among student enrolled in the agricultural power and technology courses in Oklahoma may empower mathematics teachers who have been searching for a way to make their subject matter more meaningful to students (Parr, 2004; Romberg & Kaput, 1999; Parnell, 1996).

Rogers (1995) categorized adopters based on their innovativeness and reported that over time the distribution of adopters will approach normality. Adopter categories include: innovators (2.5%), early adopters (13.5%), early majority (34%), late majority (34%) and laggards (16%). Adopter category ideal types characterized the innovators as venturesome, early adopters as having respect within the social system, early majority as deliberate, late majority as skeptical, and laggards as traditional. Typically, opinion leaders are most often found in the early adopter category.

Purpose

The purpose of this study was to determine the outstanding agricultural teachers' level of mathematics integration into each agricultural mechanics course taught and provide baseline data as the agricultural education instructor's increase their integration of mathematics. The following research questions guided the study:

1. What are the characteristics of outstanding agricultural education instructors who were nominated by Virginia state agricultural education leaders and the programs in which these instructors teach?
2. What is the self-reported level of integration of mathematics for each agricultural mechanics course taught?
3. What are the relationships among selected characteristics of outstanding agricultural education instructors, their programs, and level of integration?

The study will identify proposed actions to increase mathematics integration into agricultural education curriculums. The results of this study will provide insight on how to prepare agricultural education instructors to integrate academics into the agricultural curriculum, specifically mathematics. Parr (2004) recognized agricultural education as a valuable educational resource which already exists in our public schools, but which remains untapped in regard to its potential to increase the academic achievement of our students.

Methods

The participants of this study were selected by a panel of experts who frequently visited agricultural education teachers and observe them teaching. The panel was composed of two Agricultural education teacher educators, the Director of Agricultural Education in the Virginia Department of Education, and two Virginia agricultural education curriculum specialists. An email message was sent to each of the "experts" on the panel requesting nominations of 10 outstanding agricultural education classroom teachers using the following criteria: knowledgeable of the agricultural education curriculum in Virginia; recognized for excellence in the classroom by the "expert", willing to accept change; provide an in-depth analysis of the questions; willing to complete the study thoroughly; and able to communicate effectively through email. After compiling the responses from the panel of experts, a list of nominees was created based on those who were identified by the expert panel. The nomination list was then submitted to the panel of experts for final approval. The panel reached a consensus on 26 outstanding agricultural education teachers. An email was then sent to all prospective participants to inform them of their nomination. The researchers identified “outstanding” teachers as the intended participants of this study because they are typically considered opinion leaders, which are typically found to be early adopters.

With the lack of existing instruments that address all of the goals of the study and with consideration of the advantages associated with the utilization of Internet-based survey instruments, an electronic survey instrument was developed by the researcher. The survey instrument was created based on the review of the literature regarding academic integration into the career and technical education and agricultural education curricula. Principles of electronic survey design from Dillman’s (2000) tailored design method were consulted when constructing the instrument. The survey instrument was composed of seven major parts, Parts I and II were used to answer research question #1, Part III was used to answer research question #2, and the data collected from the survey contained additional parts that were not used in this study. A more detailed description of the instrument is listed below:

I. Teacher characteristics (questions 1-10): This section of the questionnaire was developed to align with research question one to investigate general teacher characteristics associated with outstanding teachers. This section included age, level of education, gender, years teaching, areas of endorsement, grade level taught, mathematics courses completed, licensure, and ethnicity.
II. Program characteristics (questions 11-15): This section of the questionnaire was developed to align with research question one, which investigates general program characteristics associated with teachers who integrate mathematics. This section included the number of teachers in the agricultural education department, student enrollment in agricultural education, type of school schedule, size of community and academic credits offered in agricultural education.
III. Mathematics integration (question 16): This section assesses research question two by asking teachers to self-report the courses taught, the number of students enrolled in each course, and the level of mathematics integration in each course. The researchers did not define the type or level of mathematics being integrated.

A group of 10 Agricultural and Extension Education pre-service teachers completed the instrument while they were student teaching in order to field test the instrument. Upon completion of the field-tested instrument, the pre-service teachers were given the opportunity to provide additional suggestions for improvement of the instrument and report any technical problems to establish face validity. A review of responses indicated only minor revisions were needed and these changes were made prior to data collection. The data collected from the field test allowed the researcher to analyze the reliability of the instrument which yielded a Cronbach’s alpha coefficient of $\alpha = 0.868$ and a Spearman-Brown coefficient of $\alpha = 0.874$. However the results from the study yielded a lower reliability score for both Cronbach’s alpha and Spearman-Brown (0.64 and 0.66 respectively). The change in reliability scores may be due to the fact that all the student teachers in the field study previously received instruction on mathematics integration.

The responses from the online survey were automatically downloaded into a Microsoft Excel worksheet. The time allotted for data collection was three weeks as recommended by Dillman (2000) and Truell, Bartlett, and Alexander (2002). The survey data were analyzed using the Statistical Package for the Social Sciences (SPSS). Data associated with the research questions were analyzed using descriptive statistics. Frequencies, percentages, means, and ranges were calculated for each outstanding agricultural education instructors' overall integration of mathematics and for each agricultural mechanics course taught. The number of instruments which were completed by the participants was 25, resulting in a 96% return rate.

Results

The selected characteristics of the outstanding agricultural education teachers that participated in this study were summarized in Table 1. The outstanding agricultural education teachers had a range of 5 to 34 years of teaching experience, with a mean of 17 years. However, 44% of the respondents had 5 to 10 years of teaching experience and 44% of the respondents had 20 or more years of experience. The mean age of the 25 outstanding agricultural education teachers was 40 (*SD* = 9.08) with a range of 29 to 59. Caucasians accounted for 96% of the respondents, while there was only one African American. Fifty-six percent of the respondents were males and 44% were females.

A bachelor's degree and master's degree were the only two levels of education indicated by the outstanding agricultural education teachers. The findings indicated 52% had master's degrees, while 48% had bachelor's degrees. All 25 outstanding agricultural teachers had an endorsement in agricultural education, while three had an endorsement in science and one had an endorsement in both mathematics and business. Seventeen (68%) of the respondents indicated holding a Collegiate Professional License while respondents with a Postgraduate Professional License accounted for the other eight (32%). The majority of the respondents (76%) taught at the high school level and 24% taught at the middle school level. Ninety-two percent of respondents indicated membership in the Virginia Association of Agricultural Educators (VAAE), the state professional association for agricultural education teachers.

A majority (68%) of the respondents completed 4-5 mathematics courses in high school. A majority (56%) of the respondents did not complete a mathematics course at a two-year college and/or community college, but a range of 1-4 courses at this level was reported by 34% of the agricultural education teachers. Forty-eight percent of the respondents completed 2 to 3 mathematics courses at a four-year college or university.

Table 1. Summary of Selected Teacher Characteristics (n=25)

		f	%
Level of Education	Bachelor's Degree	12	48
	Master's Degree	13	52
Gender	Male	14	56
	Female	11	44
Ethnicity	African American	1	4
	Caucasian	24	96
Grade Level Taught	Middle School	6	24
	High School	19	76
Member of VAAE	Yes	23	92
	No	2	8

Sixty percent of the respondents taught in an urban school, while 40% of the respondents taught in a rural school. The largest number of departments (*n*=10, 40%) had two teachers as indicated by the respondents. Departments with only one agricultural education teacher made up 28% and three teacher departments were reported by 24%. The respondents (*n*=25) reported a range of 62 to 440 students enrolled in their agricultural education programs with a mean of 188 students (SD= 76.67). Only three agricultural education teachers indicated that students receive academic credit outside of agricultural education for courses completed in the department. Two teachers said students received a science elective credit for completing an agricultural education course while one indicated students receive a forestry credit. A majority (22) indicated students did not receive any academic credit for courses taught in their department. Forty percent of the respondents' schools utilized the A/B block scheduling system. Schools which used the 4x4 block system made up 28%, and the seven-period system was reported by 24% of the respondents in Table 2.

Table 2. Summary of Selected Program Characteristics (n=25)

		f	%
Location of School	Urban	15	60
	Rural	10	40
Agricultural Education Teachers on Campus	1	7	28
	2	10	40
	3	6	24
	4	2	8
Type of School Schedule	7 Period	6	24
	8 Period	2	8
	A/B Block	10	40
	4x4 Block	7	28

The agricultural education teachers (*n*=25) reported a mean of 23.63% of course content that utilizes mathematics in their curriculum, with a standard deviation of 11.34. The respondents indicated a range of 10 to 50% of mathematics integrated per teacher. The teachers reported integrating mathematics in a range of 10 to 50% in individual agricultural mechanics courses. The 25 teachers reported teaching 5 different agricultural mechanics courses. There were three courses that were taught by at least seven teachers, with agricultural mechanics and basic plant science I being taught by the most teachers (10). The three courses taught by at least five different teachers had a range of 22.90 to 26.43 mean percentage of mathematics integration. Information for each course taught is presented in Table 3.

Table 3. Percentage of Mathematics Integrated per Agricultural Mechanics Course (n=25)

Course Title	*n*	Minimum	Maximum	Mean	*SD*
Agricultural mechanics & basic animal science II	7	10	50	26.43	12.33
Small engine repair	3	25	25	25.00	0.00
Introduction to power, structural, & tech systems	7	20	35	23.57	5.56
Agricultural mechanics & basic plant science I	10	10	50	22.90	12.33
Agricultural power systems	3	10	35	18.33	14.43

Data were analyzed using correlation analysis with selected teacher and program characteristics and their level of integration. There were two teacher characteristics (age and years teaching) which had a relationship with the percentage of mathematics integration reported by the teachers. Years teaching and age both had significant negative relationships at the .05 level (r= -.45). The negative correlation would indicate that the younger teachers were more receptive to integrating mathematics into the agricultural education curriculum. The results of the data analysis yielded no relationships between percentage of mathematics integration and program variables. It should be noted that with the small sample size the correlations from this study cannot be generalized.

Conclusions

The results of this study may be helpful for leaders in agricultural mechanics by providing information regarding the level of mathematics integration among the selected outstanding agricultural education teachers in Virginia. The mean score indicated the typical agricultural education teacher in this study integrated mathematics into 23% percent of their agricultural mechanics lessons. It should be noted that the percentage of integration of mathematics is lower in this study than the percentage of integration among agricultural education teachers in Alabama as reported by Hunnicutt (1994). Hunnicutt gave the agricultural education teachers the option to select a range 0 to 25, 26 to 50, 51 to 75, and 76 to 100 in their total curriculum. The current study had the teachers report the level of integration as a value rather than selecting from a range for each course they taught in agricultural mechanics. Therefore the researchers assume that had both instruments collected data similarly the results would be relatively consistent. Therefore the researchers believe that they can confirm the findings of Hunnicutt.

The low levels of mathematics integration leaves the researchers wondering if the outstanding teachers are in the persuasion stage or if they have entered the decision stage and have begun to reject the innovation. However, Anderson (2012) indicated that the Virginia agricultural education teachers had favorable attitudes toward academic integration. Therefore, this leads the researchers to think that the issue may be even more critical than initially anticipated. The researchers are concerned that the teachers are struggling with delivering the agricultural mechanics curriculum enough as it is and that they struggle to link the academic standards to the technical skills and need help bridging the gap. This would indicate that the gap between the practice and theory still exists. While Parr (2004) found mathematically enhanced agricultural power and technology courses in Oklahoma had a positive effect on student math performance it will not help the teachers in others state enhance mathematics integration if they do not share their curriculum.

The results of this study indicated there was a negative relationship between percentage of mathematics integration and years of teaching and age. The younger agricultural education teachers tended to integrate mathematics at a higher percentage than older agricultural education teachers. This could help teacher education program leaders recognize their efforts to help pre-service teachers to integrate mathematics may have helped thus far. This also provides teacher education programs with the benchmark data to understand the additional efforts that need to be made in order to integrate academics into the agricultural mechanics curriculum. There was no correlation between the amount of mathematics being integrated into the agricultural mechanics curriculum and the program demographics; this indicates that it really is up to each individual teacher to determine if they are going to integrate mathematics and to what level. This data also provides insight to curriculum specialists to identify the needs among agricultural education teachers regarding mathematics integration.

Recommendations for Implementation

The following recommendations are based upon the findings and conclusions of this study.

- Agricultural education practitioners should continue to emphasize the importance of mathematics integration into the agricultural mechanics curriculum to improve student learning.
- Agricultural education practitioners should continue to link mathematics standards of learning to each agricultural education competency. Agricultural educators should take it upon themselves to reinforce the Virginia Standards of Learning or similar standards in other states to help students connect the principles to real-life applications.
- Agricultural education curriculum specialists should continue to develop integrated learning activities that reinforce the mathematics theories and principles with agricultural mechanization applications.
- Virginia agricultural education leaders should develop workshops that utilize hands-on activities that integrate mathematics. The workshops should place the teachers in the student role. The workshops should be practical, allowing the teachers to take what they learned in the workshop and implement it into their lessons.
- Virginia educational leaders should develop a standardized curriculum that includes generic lesson plans that includes all of the Virginia Standards of Learning and workplace readiness skills associated with each lesson. These lessons will help in-service teachers who need help integrating academics into their lessons.

Recommendations for Further Research

The following recommendations are based upon the findings and conclusions of the study.

- Conduct an in-depth qualitative study that investigates the lessons plans of in-service agricultural education teachers to determine to what extent they are integrating mathematics, where they are emphasizing mathematics, where they could be integrating mathematics and at what levels of mathematics is being utilized.
- Investigate the mathematics achievement levels (standardized test scores) of students who receive mathematics credit for an agricultural course vs. traditional mathematics instruction.
- Conduct a study that investigates the pre-service teachers' attitudes and academic problem-solving abilities before and after completing an agricultural education course that integrates academics.
- Conduct a study that investigates the level of academic integration by teachers after they participate in workshops that emphasize academic integration.
- Conduct a study to investigate students' attitudes toward receiving mathematics credit for completing an agricultural education course that integrate mathematics.

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