Emerging Themes in Integrating Mathematics into Agricultural Education: A Qualitative Study of Star Teachers in Virginia

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ABSTRACT

The purpose of this study was to analyze outstanding agricultural education teachers' attitudes towards mathematics integration. An investigation into the collaboration efforts being made between the agricultural education and mathematics departments was also included. The objective of this study was to identify the primary themes to integration of mathematics that emerged through interviews with the five agricultural education instructors who were identified as having high self-reported levels of mathematics integration in their courses. This study used qualitative methods were used to collect, interpret and analyze the data. Interviews were used by the researcher to collect in-depth information regarding mathematics integration into the agricultural education curriculum. Based on the interviews of the five outstanding agricultural education teachers, four major themes emerged from each of the interviews. Those themes include mathematics as a component of agricultural education, teacher collaboration, role of STATE Standards of Learning, and perceived needs of the teachers.

Introduction

Formal agricultural education started in the United States in 1917 when congress passed the Smith-Hughes Act. This piece of legislation put agriculture in the classroom to prepare students for the workforce. From that point agricultural education has had its role in the formal education system. Agricultural education in the public school system has grown tremendously since its inception at the turn of the last century. Agricultural education courses teach way beyond the boundaries of production agriculture. Agricultural educators are now preparing their students for future careers as biologists, business and industry leaders, political officials, and many other advanced careers. These careers and other vocational occupations require post-secondary degrees. Thus, it is more important than ever to examine academic integration in career and technical education (CTE).

Agricultural education gives students opportunities to make science and mathematics connections that are both real and relevant. However, science and mathematics in agriculture is not a new development. Hillison (1996) stated that the scientific revolution in American agriculture occurred in the late 1800s because farmers demanded more scientific research, which led to the passage of the Hatch Act in 1887. This legislation paved the way for agricultural experimentation, scientific research, and the cooperative extension service. Agriculture is an applied science and applied mathematics, why are we just now concerned with integrating science and math into career and technical education?

There have been many steps that have led up to the integration of academics and CTE. The 1990 amendment to the Carl D. Perkins Vocational Education Act of 1984 provided funds to integrate academic and vocational education (Powell, Agnew, & McJunklin, 2005/2006). This amendment gave more money to schools which were integrating science and mathematics into the curriculum. Infusing academic learning standards into CTE will help strengthen the entire academic curriculum. "All students need an understanding of basic science concepts. Teaching science through agriculture would incorporate more agriculture into the curricula, while more effectively teaching science" (National Research Council, 1988).

39% of high school seniors are not performing at a basic level in mathematics (National Council of Teachers of Mathematics, 2000). We as educators want all students to have an understanding of basic academic skills. The reason we teach the basic skills is students can transfer that knowledge to new situations (Powell, Agnew, & McJunklin, 2005/2006). A successful student will be able to transfer that knowledge to a new situation, thus this successful student becomes a productive member of society.

With the No Child Left Behind legislation (NCLB), current CTE programs are at risk. Students must achieve a level of proficiency in nine subgroups (Daggert, 2003). If CTE cannot adapt to the standards of NCLB, there may be no viable option. If CTE starts to decrease in numbers, due to the need for students to take additional academic coursework, school administrators may not see the importance of vocational education and cut programs. Thus, CTE must adapt to the changes in our education system in order to survive.

According to the Nation's Report Card issued by the National Assessment of Educational Progress (Grigg, Donahue, & Dion, 2007), 39% of 12th grade students are not performing at a basic level in mathematics and less than one quarter of the students are placing at or above a proficient level. These statistics raise many concerns about why high school seniors are not performing well in mathematics. It is plausible that students complete their required mathematics courses early in their high school careers, thus not receiving instruction in mathematics the last two years of school before entering college or the workforce (Stone, Alfeld, Pearson, Lewis, & Jensen, 2005). This gap in instruction can be a cause in the low performance on standardized tests. It can be closed by integrating mathematics into career and technical education. This would give 11th and 12th grade students who have already completed the required math courses the opportunity to continue to receive math instruction.

The National Council of Teachers of Mathematics (NCTM) developed six principles for school mathematics; equity, curriculum, teaching, learning, and assessment (2000). Looking further into two of the principles, equity and learning we can see a role for contextual learning. The principle of equity states that all students are capable of learning mathematics when they have the access to high-quality mathematics instruction. Also, NCTMs research has shown the importance of contextual knowledge in understanding mathematics (2000). This leads us to teaching mathematics in a contextual environment, using real-life applications.

Gutiérrez examined the importance of teaching mathematics in context, she states that all good teachers focus on context. Students need to be able to see themselves as part of the curriculum as well as the curriculum being part of a larger picture (Gutiérrez, 2007). Contextual

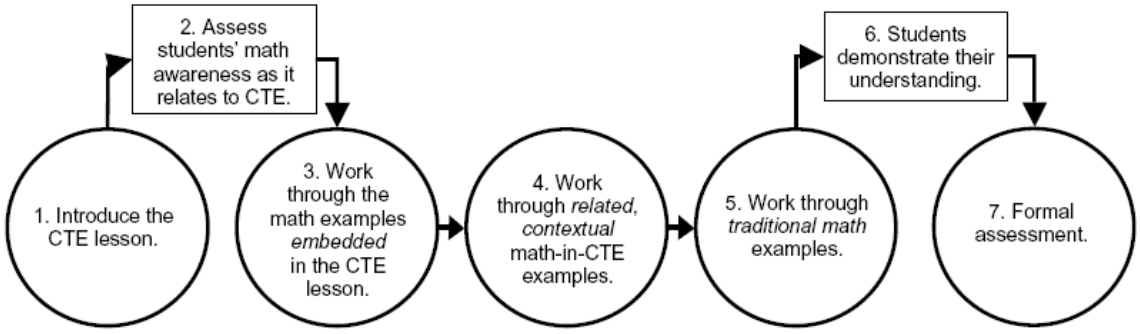
learning methods give students a perspective on how math works in the "real world." These real world applications have many benefits; students know how to execute a mathematical theory, students know why the theory works, and they know where the theory works (Shinn, et al., 2003).

"Contextual relationships have the potential to strengthen links among learning environments of school, home, and informal settings and add meaning to mathematical knowledge for students" (Shinn, et al., 2003, p. 22). In the pilot study conducted by the National Research Center on Career and Technical Education on math-enhanced CTE, students who received the mathematics enhanced CTE curriculum outperformed their counterparts that did not receive the contextual style model on mathematics standardized tests (Stone, Alfeld, Pearson, Lewis, & Jensen, 2005). Additional studies have shown that generalizable mathematical skills instruction in CTE leads to gains in mathematics academic achievement (Wu, 2003). Thus, this study can begin to assume that contextual teaching methods will lead to gains in student success.

Nearly every high school student enrolls in at least one CTE course during their high school career, 43% of all students enroll in at least three specific labor market preparation (SLMP) courses (Silverberg, Warner, Fong, & Goodwin, 2004). SLMP courses are the specialized courses within each career cluster. CTE is a viable option for learning mathematics within a specific context. Stone, et al. (2005) purpose CTE can use the mathematics which is already naturally embedded in the curriculum to provide a context for learning mathematical theory.

Research conducted by Stone, et al. (2005) at the National Research Center for Career and Technical Education (NRCCTE) proposed a model for mathematics infusion in CTE, shown in Figure 1. This model is a guideline for CTE teachers to use the implicit mathematics already present in the curriculum in an explicit manner. This model has the capability to demonstrate to the learner how mathematics is used in the "real world." The research conducted by Stone and his colleagues (2005), partnered of mathematics teachers and CTE instructors with the mission to develop math enhanced CTE curriculum.

Figure 1. The Math-In-CTE Model



Often teachers think that they are integrating mathematics skills into their curriculum and that these skills are essential and provide benefit for the students involved. However, Hunnicutt (1994) found that teachers are not integrating mathematics as much as they believe. Hunnicutt

(1994) also found that slightly less than half of the sample of agricultural education teachers in Alabama coordinated efforts with mathematics teachers. It is essential to look at how the teachers integrate mathematics into their curriculum as states begin utilizing agricultural classes to meet graduation credits for mathematics.

Theoretical Framework

The theoretical perspective that guided the review of literature and the current study was the Diffusion of Innovations Theory developed by Rogers (1995). Rogers' diffusion theory has been used for many years to describe innovation diffusion and the adoption or rejection of innovations. Rogers described the five stages of the innovation-decision process as knowledge, persuasion, decision, implementation, and re-invention.

The five stages are all relevant to this study as well as adopter categories. Adult learners, as Russell (1995) proposed, pass through the six stages of adoption. He suggested that learners could begin at any stage and progress at their own rates. The stages included awareness, learning the proess, understanding the application of the process, familiarity and confidence, adoption to other context, and creative applications to new contexts.

Rogers (1995) categorized adopters based on the 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%). Typically, opinion leaders are most often found in the early adopter category.

Purpose and objectives

The purpose of this study was to analyze outstanding agricultural education teachers' attitudes towards mathematics integration. An investigation into the collaboration efforts being made between the agricultural education and mathematics departments was also included. The study will result in proposed actions to increase mathematics integration into agricultural education curriculums. The objective of this study was to identify the primary themes to integration of mathematics that emerged through interviews with the five agricultural education instructors who were identified as having high self-reported levels of mathematics integration in their courses.

Procedures

This study used qualitative methods used to collect, interpret and analyze the data. Interviews were used by the researcher to collect in-depth information regarding mathematics integration into the agricultural education curriculum. The researcher developed an interview guide based on the results of a survey that analyzed outstanding agricultural education teachers' attitudes toward mathematics integration and self-reported level of mathematics integration into each course. An interview guide is a list of questions or general topics that the researcher wants to explore during each interview. Although it is prepared to collect similar information from each participant, there are no predetermined responses. The following questions were used as a guide for the interviews:

1. Why do you think that mathematics is an important component of agricultural education?
2. Considering some of the current issues in education, why is it important to integrate mathematics into the agricultural education curriculum?
3. What are some of the ways that you intentionally emphasize mathematical concepts in your lessons?
4. What resources are needed to help you increase you integration of mathematics?
5. What sessions at conferences or other-in-service education programs might help you integrate mathematics?
6. How often an in what ways do you indicate specific Standards of Learning that relate to the concepts you are teaching?
7. Do you collaborate with any teachers in your school regarding mathematics? Why or why not? If yes, Please give me a few examples of lessons or topics on which you have worked with another teacher.
8. Please describe a few topics in which you integrate mathematics.
9. Briefly explain a Career Development Event in which your students needed to use math skills.
10. To what extent do you think you efforts to integrate mathematics have helped your students understand math concepts better? Please share any examples related to how your students have done on standardized tests or in their math classes.

The participants of this study were selected by a panel of experts who frequently visit agricultural education teachers and observe them teaching. The panel was composed of two agricultural education teachers at Virginia Tech the Director of Agricultural Education in the Virginia Department of Education, and two Virginia agricultural education curriculum specialists. An email was sent to the panel of experts requesting nominations of ten outstanding agricultural education classroom teachers. From the nominations twenty-six teachers were chosen by the panel to receive a survey about mathematics integration. Five teachers were selected for interviews based on who integrated mathematics at the highest level.

All interviews were audio-taped and transcribed by the researcher. Interview transcripts were coded by two separate researchers, to increase the trustworthiness of the study. Also, the second researcher was unaware of the participants' identities to aid in reducing researcher bias. The researchers made no attempt to generalize the results to other populations, transferability of this study may be determined by others who are able to take the descriptive analysis and apply it to other situations.

Findings and Conclusions

Four out of the five agriculture teachers that reported the highest level of integration were between the ages of 28 and 35; while three of the five were male. Based on the interviews of the five outstanding agricultural education teachers, four major themes emerged from each of the interviews. Those themes include mathematics as a component of agricultural education, teacher collaboration, role of the Virginia Standards of Learning, and perceived needs of the teachers. The subthemes emerging from the data in each area are reported in table 1. Several excerpts from the interviews are supportive of each theme and subtheme. Pseudonyms have been used to conceal the identities of the agricultural education teachers.

The mathematics as a component of agricultural education theme is comprised of five subthemes expressed in all interviews. Those subthemes are: (1) agriculture as a real-world setting for mathematics, (2) issues regarding integration, (3) agricultural education lessons integrated with mathematics, (4) Career Development Events that utilize mathematics, and (5) teacher's cognitive effort to emphasize mathematics.

Table 1
Major Emerging Themes and Sub Emerging-Themes

Major Theme	Sub-Theme
Mathematics as a component of agricultural education	Agriculture as a real-world setting for mathematics
	Issues regarding integration
	Agricultural education lessons integrated with mathematics
	Career Development Events that utilize mathematics
	Teacher's cognitive effort to emphasize mathematics
Teacher Collaboration	Ag teachers efforts to collaborate
Role of *STATE* Standards of Learning	Linking to the *STATE* Standards of Learning
	Teacher's cognitive effort to emphasize the *STATE* Standards of Learning.
Teacher's perceived needs	Perceived needs increase integration
	Perceived in-service needs

Mathematics as a component of agricultural education

All five agricultural education teachers indicated that agricultural education is mathematically-rich and that agricultural education provides a real-world setting for learning mathematics. Carrie Jo stated: "There's a lot of mathematics involved in agriculture. It's already embedded in there, and therefore kids should have to know the basics, and I am finding out that they don't." Jim added: "You deal with math with every single thing you do in agriculture." Dave added:

> The US as a whole is lacking in mathematical skills and I think agricultural education can help students in understanding mathematics in a practical setting, in a real setting and more than just out of a book, but in practical situations. And I think we can help students learn a little more to better understand those mathematics.

It is evident that students are lacking in their mathematical skills. These skills that students are not gaining in school are demanded in workplace. Marcy noted:

> It's almost like any career. There's so much integration. There's math in everything you do. If you're out on the farm he has to figure these chemicals, he has to figure his fertilizer volumes; he has to keep track of his money. If he's running his own business

> it's the same thing. You deal with math in every single thing you do in ag, so you need that back ground there to be competent in what you're doing.

All of the teachers also indicated that there were still some issues regarding the integration of mathematics into agricultural education. Three of the teachers indicated the accountability associated with No Child Left Behind Act and the Virginia Standards of learning. They all indicated that their students lack many of the basic skills needed in order to enter into the workforce. Jim noted that "It's important to integrate in the ag program because we've always kinda been on the forefront among the CTE areas in being there."

Even with the issues regarding integration, these teachers are at the forefront of the innovation process. The five agricultural education teachers were asked how they were already integrating mathematics into their curriculum despite the issues; each of the respondents provided several agricultural topics that utilized mathematic principles. All of the teachers indicated that agricultural business was a good topic for integrating mathematics, and three of the teachers listed agricultural mechanics. Dave indicated: "I have ag business in my school. So basically everything we do in ag business bases itself on math. We talk about everything from just simple elementary math, you know, counting out change and stuff like that, to getting into profit loss margins." Tom added: "In Horticulture, it is very easy to integrate math when determining cost per plant, profit margin, expected and unexpected costs, etc… In the Ag. Mechanics courses, math is used for measurement (both small and large): woodworking, welding, micrometers, etc…" These statements indicate that the teachers have provided several topics in which they have already integrated mathematics in their curricula and identified agricultural topics that they can integrate mathematics.

Another component of an agricultural education curriculum is the FFA. The agricultural education teachers also identified many Career Development Events (CDEs) that utilized mathematics. The teachers provided a wide array of CDEs that utilized mathematics, some teachers provided specific CDEs, and while others pointed out that they all use mathematical skills. Jim also indicated: "Most all these contest have some type of problem solving or team problem and they usually incorporate something mathematical in there like they, whether it's something basic like figuring square footage of volume of something to a lot of things, could be more advanced too." Dave acknowledged:

> The forestry contest, there's another one where we do angles, need to figure out the height of the tree, figure out how far up you can actually get a log out of it. They've got to do pacing and figure out what that actually means as to the angle they are looking at on the tree to figure out how tall is really is and use the measurements that way too."

When asked about placing an intentional emphasis on mathematical concepts in their lessons, the agricultural education teachers indicated that there were several content areas in which they regularly integrate mathematics including agricultural mechanics and horticulture. However, the agricultural education teachers state that do not make the mathematical connection with the students until after the fact. Jim stated: "I try not to tell the students I'm going to do math." Their reasoning included that mentioning mathematics turned the students off of the lessons at hand.

Teacher Collaboration

The agricultural education teachers indicated that they do not intentionally collaborate with the mathematics department at the level that they should. However, Jim stated:

> But I do invite teachers down to show them what we do. Like I do adult work just for teachers in the building. I have them come down and make projects and they see what the students do and then they, it naturally leads them in to say 'well I teach this in class' and that's an easier way to do it than the traditional collaboration, 'well, I'm doing this, what are you going to do and when am I going to teach it.' It's more natural the way I kinda do it like that.

While the teachers mentioned that it was difficult to completely collaborate with the mathematics teachers they tried to cover the same content to reinforce the students' understanding of the mathematics. Carrie Jo described her role as: "So my job is to kind of team effort is to back them up. So if I can take a concept that they've taught or teach, or review or add something extra that's like one of those questions that they can't quite get to." Marcy noted that there were difficulties getting the mathematics department to collaborate with the agriculture department: ' "But sometimes it's hard to wedge your way into that math program. I mean, they're so structured under that time basis that they have to cover this in order to get everything done for that SOL." The teachers also noted the importance of the collaboration; Dave described the situation that he has observed: "I think sometimes if a do a lesson at a different time than what the teacher does, the students don't necessarily make the correct correlation."

Role of STATE Standards of Learning

When talking about the role Standards of Learning (SOLs), the theme can be broken down into two subthemes; (1) Linking to the Virginia Standards of Learning, and (2) Teacher's cognitive effort to emphasize the Virginia Standards of Learning. There was a wide range of responses from the agricultural education teachers about linking SOLs to their curriculum. Two teachers noted that their administration required that every lesson be tied to a SOL, whereas one teacher did not have the pressure to include SOLs in their lesson plans. Marcy stated her frequency of linking SOLs and her reasoning: "Everyday. With us, it's required. When you put your competencies on the board, you have to put which SOL it matches on the board for the students to see." Whereas Dave mentioned that he was not adequately linking his lessons to SOLs, but understood its importance: "Not as much as I should. I mean I'm trying to find more ways that I can do that. I've done a little bit where I can correlate them back and forth. I need to do more of that and find some specific ways to do that."

The five teachers all indicated that when they teach one of the topics addressed in the Virginia Standards of Learning, they teach the skill or principle first and then make the link to the SOL after the student has mastered the task. When asked about emphasizing the SOLs to the students Tom noted: "I very rarely say anything about SOLs because that's more of a negative thing as I see it. If I tell them we're going to do this SOL and they've already done it in math, they probably think that they already know what I am going to teach them." Carrie Jo added to that by stating:

> Students who have already mastered the SOL, they're thinking 'I've already done that; I don't need to learn about it.' If I come back to the SOL after the fact, it gives them an opportunity to understand what an SOL is, other than something they just check off in an academic class. They can see why we have them."

Teachers' Perceived Needs

The final theme that emerged from the data was the perceived needs of the teachers. This theme comprised of two subthemes, which include: (1) perceived needs to increase integration and (2) perceived in-service needs.

When asked what resources they need in order to help them increase their integration of mathematics, they all indicated that they could use more agricultural examples that utilize a variety of mathematical theories and principles. Marcy stated: 'One of the companies has a book, mathematics in agriculture. I think sometimes, if we had more, I don't need to use the word worksheets, because I don't ever see ag becoming a worksheet class where you go in and just hand out worksheets." The agricultural education teachers had a desire had a desire to use practical problem solving exercises and scenarios. Tom stated: "The resources that I need are different types of exercises, like scenarios and those kinds of things where you can give it to the students and let them try to figure it out.

The agricultural education teachers also indicated that it would be helpful to go through the current curriculum and point out the mathematical concepts that correlate to each lesson. Dave added: I think correlations would help, showing specific lessons from the math setting; this is what they're going to learn as a ninth grader in algebra 1 or geometry and this is how we can integrate it into what we're doing in agriculture"

The agricultural education instructors also all indicated that in-service education programs would be helpful in aiding their integration efforts. The teachers expressed a desire to go over the curriculum and point out how you could correlate mathematics and the *STATE* Standards of Learning to the agricultural education curriculum. Marcy noted that other states were also doing similar mathematics integration and that *STATE* needs more work to get to a similar level:

> I know I went to a meeting in Indianapolis and one of the workshops I went to was one of the states was actually getting math credit for one of the ag class, but the ag class then has to turn around and prove that they're teaching enough math to justify. Well I mean there are possibilities there in *STATE*, you know, if we can show if we're doing enough of the math, well then the conference would be the perfect time to bring that in.

Discussion, Implications and Recommendations

These agricultural education teachers who integrate the highest percentage of mathematics indicated that they try to reinforce academic principles and theories through agricultural applications. These teachers believe that agricultural education provides students with the real-life applications needed to apply those theories and principles. The agricultural teachers have indicated that all of the Career Developments to some degree utilize mathematics. The respondents believe that they are helping their students learn the academic concepts, but have little evidence.

The results of this study also suggest that there is an interest in academic integration within the agricultural education curriculum by these outstanding agricultural education teachers. State agricultural education leaders should continue to make an effort to promote agricultural education courses for academic credit. Developing team-teaching courses that utilize both the academic and agricultural teachers to provide students with academic theories and principles and agricultural applications may provide the contextualized learning promoted by Parr (2004) and Thompson, Jansen, and Enochs (2005).

The researchers recommend that agricultural education practitioners should continue to emphasize the importance of academic integration into the agricultural education curriculum to improve student learning. Practitioners should continue to link academic standards of learning to each agricultural education competency. Secondly, agricultural educators should take it upon themselves to reinforce the State Standards of Learning or similar standards in other states to help students connect the principles to real-life applications. Curriculum specialists should continue to develop integrated learning activities that reinforce the academic theories and principles with agricultural applications.

It is encouraged that researchers conduct an in-depth study that investigates the lessons plans of in-service teachers to determine to what extent they are integrating mathematics, where they are emphasizing mathematics, and where they could be integrating mathematics. Secondly researchers are encouraged to investigate mathematics teachers' attitudes toward mathematics integration into the agricultural education curriculum and their attitudes toward collaboration with the agricultural education teachers.

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