An Evaluation of the Alabama FFA Agricultural Mechanics Career Development Event to Determine Represented Mathematical Competencies - An Analysis of Curriculum Alignment

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Abstract

This study sought to discover what specific math skills from the Alabama mathematics curriculum have been previously embedded within selected activities from the Alabama State FFA Agricultural Mechanics Career Development Event (CDE). Leedy and Ormrod's (2005) content analysis method was used to evaluate both the 2009 Alabama Course of Study: Mathematics and selected activities from the Alabama State FFA Agricultural Mechanics CDE. It was discovered by the researchers and verified by an Alabama mathematics specialist that a total of twenty-seven mathematics curriculum standards were indeed represented by the contest activity requirements. Upon these findings, the conclusion reached within this study was the determination of an assortment of various mathematics skills that should be learned, understood, and retained by student participants and their agriculture teachers in preparation for participation in the Alabama State FFA Agricultural Mechanics CDE. Agriculture teachers are encouraged to work with mathematics teachers in their schools to develop a math-enhanced agricultural mechanics curriculum. Instruction through a math-enhanced agricultural mechanics curriculum could possibly result in increasing both agriculture teachers' and students' understanding of mathematical applications in agriculture. Enhanced understanding of various mathematical applications could potentially result in higher contest scores.

Introduction & Conceptual Framework

Criticism of the public education system has been documented (National Center for Education Statistics, 2010; Norton, Barlow, Prout, & Bidwell, 1998). Many critics believe that students often lack preparation to perform many workplace tasks that require skills in problem-solving and critical thinking (Norton et al., 1998). Moreover, studies have shown that students in many traditional secondary classrooms often lack opportunities in which to apply knowledge gained within an academic classroom to real-world situations (Grubb, Davis, Lum, Philhal, & Morgaine, 1991). However, a potential solution to these persistent issues may exist within the education reform technique of contextualized learning (Parnell, 1996; Parr, 2004; Young, 2006). Previous research (Parr, 2004; Parr, Edwards, & Leising, 2006; Parr, Edwards, & Leising, 2008; Parr, Edwards, & Leising, 2009; Young, 2006; Stone III, Alfeld, Pearson, Lewis, & Jensen, 2005; Stone III, Alfeld, Pearson, Lewis, & Jensen, 2006) has indicated that positive gains in student achievement have resulted from career and technical (CTE) educators' efforts in academic integration. Additionally, CTE students have reported that there are indeed tangible benefits to academic integration within CTE classrooms (Conroy & Walker, 2000).

The significance of contextualized learning and teaching has been an important topic in the field of agricultural education for several years. As evidence of this importance, the National Research Council (NRC) (1988) published the book *Understanding Agriculture: New Directions for Education* in order to bring greater transparency and recognition to the topic which ultimately has served as a guide to bring agricultural education into a more relevant state for the 21st century. A portion of what the report called for was the integration of scientific concepts into the secondary agricultural education curriculum in a way that provided basic fundamental education in the sciences while providing a practical, hands-on application in the context of agriculture. Furthermore, the book called for and described the necessary changes to be made to the vocational agriculture [now agricultural education] curriculum to reflect a greater emphasis on scientific concepts within agriculture. The authors called for a move from instruction in traditional production agriculture and into a much more in-depth look at agriculture from a scientific perspective. What was recommended and ultimately resulted from this perspective was the integration of more academic concepts into the agricultural education curriculum at large. Additionally, a new term was created to describe and reflect this integration - agriscience. Although this term is now used to represent multiple applications within the field, it is generally accepted that it reflects the notion that agricultural education has made a shift from a vocational training ground to a more scientific application of concepts in the context of agriculture, natural resources, and the fiber industry (Peasley & Henderson, 1992). Consequently, subsequent years brought about other name changes that removed the vocational emphasis from agricultural education, such as the FFA's name change in 1988 "from Future Farmers of America to the National FFA Organization" (FFA, n. d., ¶ 12).

As decades have passed, the educational process has become better understood and utilized in secondary classrooms throughout America. This was summarized by Yager (n. d.) as the author stated that "Since the mid - 1980s, we have learned more about learning. We now know that most students do not learn what teachers teach. Instead they retain explanations personally constructed to account for phenomena in the rational universe" (¶ 7). Further, in 1994, Romberg stated that the retention of academic material by students is increased whenever the subject material is given within a recognized context. In 1998, Bailey ascertained that familiar concepts, such as agricultural education, can serve as an opportunity for contextualized learning and teaching:

> Agriculturally based activities, such as 4H and Future Farmers of America [, now FFA,] have for many years used the farm setting and students' interests in farming to teach a variety of skills. It only takes a little imagination to think of how to use the social, economic, and scientific bases of agriculture to motivate and illustrate skills and knowledge from all of the academic disciplines. (p. 27).

In addition, utilizing agricultural education as a context for academic integration has resulted in enhanced student understanding of academic material, as documented by previous research (Parr, 2004; Young, 2006; Parr, Edwards, & Leising, 2009; Young, Edwards, & Leising, 2009). Concomitantly, research has indicated that the integration of academic material into CTE classrooms has had no negative effects on students' grasp of CTE coursework (Parr, 2004; Parr, Edwards, & Leising, 2006; Young, 2006; Young, Edwards, & Leising, 2009).

Agricultural mechanics has been cited as a prime curriculum within which to implement contextualized mathematics instruction in a real-world setting (Parr, 2004; Young, 2006). Edney and Murphy (2010) discovered that the implementation of math-enhanced "enrichment activities" (p. 5) in preparing students for participation in the Texas State FFA Agricultural

Mechanics CDE resulted in "improved CDE scores and mathematics achievement" (p. 1). The potential for increased mathematics concept education and integration could lie within the Alabama State FFA Agricultural Mechanics CDE as well. Participation in the Alabama Agricultural Mechanics CDE requires enrollment in grades ranging from seven through twelve. The CDE is designed to complement agricultural mechanics classroom and laboratory instruction and is arranged in the following format: five individual skill development/problem solving activities, one team activity, and one written examination (Alabama FFA Association, 2009). This type of format coupled with the inherent mathematics basis of its adjoining agricultural curriculum could provide an ability to maximize the potential integration of mathematics concepts within a competitive, practical context.

In addition to the recognition of the need to more fully implement an integrated approach to teaching and learning agriculture to include core content areas such as science and math, other factors began to develop within the mathematics education community to provide momentum for this movement. The National Council of Teachers of Mathematics (NCTM) voiced its support for the contextualized learning and teaching of mathematics that very possibly could be taught through the context of agricultural education. According to Kahle (1998), the council has concluded that a successful mathematics education ought to sow into students a deeper-embedded perception of the value of math as a result of their teaching. In 2011, the NCTM stated that "The opportunity to experience mathematics in context is important. Students should connect mathematical concepts to their daily lives,…" (Connections section, ¶ 3). Recent secondary mathematics education literature also proposes that a movement toward the reformation of mathematics education in the form of contextualized learning and teaching may be in progress (NCTM, 2011; Romberg & Kaput, 1999; Kahle, 1998; Bailey, 1998; Bickmore-Brand, 1993; Yager, n.d.).

The need for increased student achievement in secondary mathematics in the United States is well established. The National Assessment of Educational Progress (NAEP) reported that in the year 2009, 36% of 12th grade students performed at a "Below Basic" level on the math portion of their assessment. What is more, 71% of students performed at a level lower than "Proficient" (National Center for Education Statistics, 2010, p. 26). The need for improved student performance in mathematics is acutely apparent in the state of Alabama. The National Center for Education Statistics (2009) reported that 42% of the eighth graders in the state scored at a "Below Basic" level in mathematics in 2009. Further, 80% of the eighth graders in the state scored at a level lower than "Proficient" (p. 1). These results possibly indicate that traditional mathematics education methods may not be providing students with an appropriate level of cognitive development that can be utilized beyond the classroom (Stone III et al., 2006). Also, data such as this indicate that in order to improve student achievement in mathematics, changes must take place in the methodology for mathematics instruction and application at the secondary level. Perhaps agriculture classrooms can help to provide the necessary changes in context, methodology, and results in student mathematics achievement (Parr, 2004; Young, 2006; Conroy & Walker, 2000).

Objectives & Research Question

Agricultural mechanics curricula have been demonstrated to provide a variety of opportunities for both hands-on and minds-on learning (Parr, 2004). What is more, as demands for increased academic proficiency and concept application have increased, secondary agricultural mechanics coursework has been deemed an appropriate vehicle for mathematics concept integration and application (Young, 2006). With possible changes in context for mathematics education, as well as the lack of performance on the parts of students, the researchers' posit was this: To what extent has the FFA Agricultural Mechanics CDE served as a practical, real-world context for mathematics education and application in Alabama? To help address this question, the following objectives for this study were established::

1. Locate, list, and confirm the 2009 Alabama Course of Study: Mathematics content standards embedded within selected FFA Agricultural Mechanics CDE contest activities.

2. Provide a practical and specific list of mathematics concepts that should be integrated within secondary agricultural mechanics technical subject matter.

Procedures

This study utilized an approach consisting of an analysis of both the 2009 Alabama Course of Study: Mathematics and selected activities within the Alabama State FFA Agricultural Mechanics CDE from the years of 2008, 2009, and 2010. Furthermore, Leedy and Ormrod (2005) have classified the procedure as a content analysis, which is defined as "a detailed and systematic examination of the contents of a particular body of material for the purpose of identifying patterns, themes, or biases" (p. 108). In keeping with the content analysis procedure, the first step (p. 142) was to recognize the works to be evaluated, which in this case were the aforementioned mathematics course of study and the appropriate Agricultural Mechanics CDE materials. Next, the traits of each document to be examined were distinctly selected and supporting examples were located (p. 142).

To initiate the second step, the researchers contacted the Alabama State FFA Agricultural Mechanics CDE superintendent and requested documentation of all contest activities from the years of 2008, 2009, and 2010. These activities represented the contest's composite portions of participants applying practical knowledge to complete hands-on skill sets, a written examination, and a team activity consisting of various problem-solving situations. After receipt of these materials, both researchers conducted a thorough examination of both the mathematics course of study and the selected contest activities to determine the various mathematics skills that students needed to accurately complete each selected activity. Each activity was selected based on the researchers' posit that mathematics competency is required to solve these selected problems. Due to student participant grade requirements, only mathematics standards from grades seven through twelve were evaluated for possible inclusion (Alabama FFA Association, 2009). These efforts resulted in an initial list of example activities and the twenty-four mathematics concepts represented within the selected contest activities.

To follow the third step of the content analysis procedure (p. 142), the researchers compiled the subsequent composition of the materials into sections to be examined individually by a(n) Alabama mathematics specialist. Additionally, the researchers compiled the initial data set into the following format: mathematics class title, grade level(s), mathematics curriculum standard, and example problem(s).

After the compilation of the data, the researchers followed the final portion of Leedy and Ormrod's procedure set, in which dissection of the data for examples of each occurring trait found in the second step took place (p. 142). To accomplish this final step, the data set was presented to a mathematics education specialist within the state of Alabama, who evaluated the discovered mathematics curriculum standards and the corresponding sample problems to determine whether there was indeed curriculum alignment. Additionally, the mathematics education specialist was asked to notify the researchers of any ambiguity within the data set as well as determine if any portions of the contest activity material did not align with the mathematics curriculum standards.

The mathematics education specialist was recognized as an expert in secondary mathematics education by a faculty member at [University] University and was thus an ideal medium through which to verify, correct, and critique the researchers' methods and findings. The selected mathematics education specialist had previous experience teaching mathematics courses ranging from grades seven to twelve. The mathematics education specialist was asked to carefully screen each selected contest activity and the aligned mathematics competencies reported by the researchers. To accomplish this, the mathematics education specialist was provided the first draft data set composed by the researchers. To evaluate the data set and ensure its validity, the education specialist compared the representations of each selected contest activity to the 2009 [State] Course of Study: Mathematics. During the evaluation process, the education specialist noted where definitive curriculum alignment between agricultural mechanics activities and mathematics competencies did and did not occur (D. Peppers, Personal communication, December 30, 2010) As a result, validity to the researchers' methods and findings were established through a third-party mathematics curriculum expert.

Results

Upon further review by the mathematics education specialist, it was noted that twenty-three out of the discovered twenty-four mathematics standards were found to be consistent with the selected Alabama State FFA Agricultural Mechanics CDE activity requirements (D. Peppers, personal communication, December 30, 2010). The math specialist noted that one standard did not fit the appropriate criteria but did suggest that four additional standards should be included within the data set, bringing the total represented math standards to twenty-seven. The researchers complied with the mathematics education specialist's findings and deleted the non-compliant mathematics standard and added the suggested standards.

The final data set given in the table below, which consisted of twenty-seven aligned mathematics standards, indicates a positive link between both the mathematics curriculum and the agricultural mechanics curriculum. Also, it is illustrated here that the Alabama State FFA

Agricultural Mechanics CDE has shown the capacity to serve as a practical and effective vehicle for embedded mathematics education and application in Alabama. In order to provide for more opportunities for academic integration within agriculture classrooms, these mathematics concepts should be further analyzed, utilized, and understood by student participants and their agriculture teachers. Increasing students' and teachers' knowledge of mathematics concepts and applications could result in enhanced performance within the Agricultural Mechanics CDE (Edney & Murphy, 2010).

Table 1. *Mathematics Standards Verified To Be Linked With Agricultural Mechanics CDE Requirements And Competencies.*

Contest Activity	Alabama Mathematics Standards Addressed within Contest Activity
1. The following activity was given as a three-part question and was taken from the 2008 State FFA Agricultural Mechanics CDE Team Activity: When laying out a building, determine its square footage, cubic yards of concrete needed for the given slab depth, and the diagonal length of the building in inches.	1. Solve problems requiring the use of addition, subtraction, multiplication, and division on rational numbers. Grade 7 Mathematics 2. Demonstrate computational fluency with addition, subtraction, multiplication, and division of integers. Grade 7 Mathematics

2. The following activity was given as two separate questions and was taken from the 2010 State FFA Agricultural Mechanics CDE Individual Problem Solving - Concrete Calculation Skill section: The first question asked for a determination of the cubic yards of concrete needed to construct a slab for a building, while the second question asked for a determination of the cubic yards of concrete needed to construct a pier for a building support.	3. Use order of operations to evaluate numerical expressions. Grade 7 Mathematics 4. Solve problems involving circumference and area of circles. Grade 7 Mathematics 5. Determine surface area and volume of rectangular prisms, cylinders, and pyramids. Grade 8 Mathematics 6. Determine the perimeter and area of regular and irregular plane shapes. Grade 8 Mathematics 7. Solve problems algebraically involving area and perimeter of a polygon, area and circumference of a circle, and volume and surface area of right circular cylinders or right rectangular prisms. Grades 9-12 Algebra I
3. The following activity was given as a six-part question and was taken from the 2009 State FFA Agricultural Mechanics CDE Team Activity section: Determine how much of each ingredient is needed to blend a one ton mix of 5-10-15 fertilizer.	8. Solve problems involving rates or ratios, using proportional reasoning. Grade 7 Mathematics 9. Use various strategies and operations to solve problems involving real numbers. Grade 8 Mathematics 10. Applying proportional reasoning to application-based solutions. Grade 8 Mathematics
4. The following activity was given as a three-part question and was taken from the 2010 State FFA Agricultural Mechanics CDE Individual Problem Solving - Rafter Construction Skill section: Given the dimensions of span and slope, determine rise of the roof, rafter length to the nearest 1/16", and draw the appropriate angles and dimensions for the ridge cut.	11. Solve problems using the Pythagorean Theorem. Grade 8 Mathematics 12. Determine measures of special angle pairs, including adjacent, vertical, supplementary, complementary angles, and angles formed by parallel lines cut by a transversal. Grade 8 Mathematics 13. Determine missing information in an application-based situation

	using properties of right triangles, including trigonometric ratios and the Pythagorean Theorem. Grades 9-12 Algebraic Connections 14. Apply proportional reasoning to determine missing lengths of sides, measures of angles, and ratios of perimeters and areas of similar polygons. Grades 9-12 Geometry 15. Apply the Pythagorean Theorem and its converse to solve application problems, including expressing answers in simplified radical form or as decimal approximations and using Pythagorean triples where applicable. Grades 9-12 Geometry 16. Apply properties of special right triangles, including 30-60-90 and 45- 45-90 triangles, to find missing side lengths. Grades 9-12 Geometry 17. Utilizing the Pythagorean Theorem to solve application-based problems. Grades 9- 12 Algebra I
5. The following activity was given as a five-part question and was taken from the 2010 State FFA Agricultural Mechanics CDE Team Activity section: Provide an analysis to answer questions concerning the use of integrated pest management in sweet corn. These questions concerned data such as percentage of yield, value of net returns, comparisons of values of net returns, determining which chemical(s) provided the most value to producers, and the value of integrated pest management. To determine the answers, competencies in data analysis and comprehension were necessary.	18. Use given and collected data from samples or populations to construct graphs and interpret data. Grade 8 Mathematics 19. Calculate probabilities given data in lists or graphs. Grades 9-12 Algebra I 20. Compare various methods of data reporting, including scatterplots, stem- and-leaf plots, histograms, box-and- whisker plots, and line graphs, to make inferences or predictions. Grades 9-12 Algebra I 21. Use analytical, numerical, and graphical methods to make financial and economic decisions, including those involving banking and invest-

	ments, insurance, personal budgets, credit purchases, recreation, and deceptive and fraudulent pricing and advertising. Grades 9-12 Algebraic Connections 22. Determine approximate rates of change of nonlinear relationships from graphical and numerical data. Grades 9-12 Algebraic Connections 23. Create a model of a set of data by estimating the equation of a curve of best fit from tables of values or scatterplots. Grades 9-12 Algebraic Connections 24. Using multiple representations, including graphical, numerical, analytical, and verbal, to compare characteristics of data gathered from two populations. Grades 9-12 Algebra II with Trigonometry 25. Analyze data to determine if a linear, quadratic, or exponential relationship exists. Grades 9-12 Algebra II with Trigonometry 26. Use multiple representations to, including graphical, numerical, analytical, and verbal, to compare characteristics of data gathered from two populations. Grades 9-12 Algebra II 27. Analyze data to determine if a linear or quadratic relationship exists. Grades 9-12 Algebra II

Conclusions

Upon review of the data, the logical conclusion was that there indeed exists substantial curriculum alignment between the fields of mathematics and agricultural mechanics. What is more, these mathematics skills are often inherently embedded within the secondary agricultural mechanics curriculum. It is interesting to note that fifteen of the twenty-seven math standards come from grades nine through twelve, which implies that higher levels of mathematics education and understanding are required for optimal success in the competition. However, this finding is appropriate, as a majority of the student participants are enrolled in grades nine through twelve. The researchers recommend that each of the activities listed in the above table be implemented into the agricultural mechanics curriculum so that the most opportunities for teaching embedded mathematics may be achieved (Stone III et al., 2006).

Discussion & Implications

This study could serve as a guide to demonstrate yet another area where curriculum integration naturally occurs – the FFA Career Development Event. The information obtained here is supported by previous research (Young, 2006; Young, 2009; Parr, Edwards, & Leising, 2006; Parr, 2004; Conroy & Walker, 2000) that has indicated that not only is curriculum integration between agriculture and mathematics possible, but that such cooperation between the two disciplines can result in potentially higher mathematics achievement and understanding for both students and teachers. However, while many of these mathematics concepts are often inherently present within agricultural mechanics curricula, this fact can be easily overlooked by program stakeholders (Warnick & Thompson, 2007). Therefore, increased communication with education program stakeholders about the applications and effects of mathematics integration within secondary agricultural curricula is desirable (Warnick & Thompson, 2007).

The [State] FFA Agricultural Mechanics CDE and the mathematical competencies that align with selected activities taken from it do provide a practical example of mathematics concept integration. However, while this body of research provides a glimpse of the current and potential levels for mathematics integration within the CDE and its corresponding agricultural curricula, the researchers stress that a relatively small percentage of secondary agricultural education students in [State] do participate in the Agricultural Mechanics CDE. As a result, the possibility exists that not all agricultural education students have the opportunity to experience this variety of practical mathematical applications within in a real-world context. Thus, to provide this level of real-world mathematics application, agriculture teachers are encouraged to implement mathematics concepts within secondary agricultural mechanics coursework.

For those individuals who organize and conduct the Alabama FFA Agricultural Mechanics CDE, perhaps the increased integration of mathematics concepts within the Agricultural Mechanics CDE could provide a meaningful context for mathematics education and application (Edney & Murphy, 2010). Agricultural mechanics curricula have demonstrated excellent potential to serve as an effective vehicle for mathematics education (Parr, 2004; Young, 2006). What is more, as preparation for participation in the Alabama Agricultural Mechanics CDE, perhaps contest organizers could conduct preparation activities that align with both this list of embedded mathematics concepts and Edney and Murphy’s methodology (2010).

Further research on the current state of curriculum integration between mathematics and agriculture can help to lead the call for additional education reform within both secondary classrooms and the teacher education program environments. The National Research Council (1988) determined that in order to graduate highly-qualified individuals, secondary agricultural education must remain relevant as well as effective through the teaching of advancements in agriculture as well as a heavier emphasis on academics. In 1995, Newcomb gave his support of this recommendation, as he stated that “The need to have students graduate with the demonstrated capacity to think at the higher levels of Bloom’s taxonomy is more urgent than ever. The nature of the world we live in demands it” (p. 4). Furthermore, in order to remain competitive globally, program graduates must be capable of demonstrating increased academic and technical competence (Parr, 2004).

For classroom practice, it is suggested that agriculture teachers as well as their students gain better understanding of mathematics and its applications, procedures, and functions. To help accomplish this, agriculture teachers should be encouraged to establish a practical working relationship with mathematics educators within their schools (Parr, 2004; Stone III et al., 2006). Also, agriculture teachers are advised to implement mathematics education tools and methodologies [e.g., the Math-in-CTE model (Stone III et al., 2006)] into agriculture classes in order to possibly improve students’ grasping of mathematics concepts and applications. By increasing competence in mathematics, students could develop a deeper understanding of math applications within agricultural mechanics; therefore, they could possibly be better prepared to participate in the Alabama State FFA Agricultural Mechanics CDE. Ideally, increased agricultural mechanics concept development and contest preparation will yield increased contest scores (Edney & Murphy, 2010).

For professional development, agriculture teachers are advised to participate in development sessions that emphasize academic integration within agriculture classrooms. Moreover, these sessions should be of significant duration, as Garet, Porter, Desimone, Birman, and Yoon (2001) indicated “that sustained and intensive professional development is more likely to have an impact, as reported by teachers, than is shorter professional development” (p. 935). In accordance with their findings, suggestions for teacher professional development include educational workshops in utilizing agriculture as the context for mathematics education to possibly enhance understanding and cooperation between the two disciplines. Also, according to Bickmore-Brand (1993), communication issues have risen in the utilization of differing mathematics terminology between teachers of different disciplines. These issues have often previously resulted in both students and teachers being confused on the proper names of mathematical concepts (Bickmore-Brand, 1993). As a result, there is often a lack of both students’ and teachers’ understanding of mathematics concepts within agricultural curricula (Parr, 2004). Therefore, professional development workshops should be designed to address terminology differences and issues as well (Bickmore-Brand, 1993; Parr, 2004; Parr, Edwards, & Leising, 2006).

References

Alabama FFA Association. (2009, September). Agricultural mechanics career development event rules and regulations handbook. Retrieved from http://www.Alabamaffa.org/Forms_Applications/Agricultural%20Mechanics%20CDE.pdf

Alabama State Department of Education. (2009, May). *Alabama Course of Study: Mathematics*. Retrieved from http://alex.state.Alabama.us/standardAll.php?subject=MA1&summary=1

Bailey, T. (1998). Integrating vocational and academic education. In National Research Council, *High school mathematics at work: Essays and examples for the education of all students*. Washington DC: National Academy Press.

Bickmore-Brand, J. (1993). Implications from recent research in language arts for mathematical teaching. In J. Bickmore-Brand (Ed.), *Language in mathematics.* (pp. 1-9). Portsmouth, NH: Heinemann.

Conroy, C. A., & Walker, N. J. (2000). An examination of integration of academic and vocational subject matter in the aquaculture classroom. *Journal of Agricultural Education, 41*(2), 54-64. doi: 10.5032/jae.2000.02054

Edney, K. C., & Murphy, T. H. (2010). Evaluating the mathematics achievement levels of selected groups of students participating in the state FFA agricultural mechanics career development event. *Proceedings from the Association for Career and Technical Education Research 2010 CTE Research and Professional Development Conference*. Las Vegas, NV: 1-14.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001, Winter). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915-945.

Grubb, W., Davis, G., Lum, J., Plihal, J., & Morgaine, C. (1991). The cunning hand, the cultured mind: Models for integrating vocational and academic education (ED 334 421). Berkeley: National Center for Research in Vocational Education.

Kahle, J. B. (1998). Science and mathematics education: Finding common ground. In National Research Council, *High school mathematics at work: Essays and examples for the education of all students*. Washington DC: National Academy Press.

Leedy, P. D., & Ormrod, J. E. (2005). *Practical research: Planning and design* (8^{th} ed.). Upper Saddle River, NJ: Pearson Education, Inc.

National Center for Education Statistics. (2010, November). *The nation's report card: Grade 12 reading and mathematics 2009 national and pilot state results* [Data file]. Retrieved from http://nces.ed.gov/nationsreportcard/pdf/main2009/2011455.pdf

National Center for Education Statistics. (2009, October). *The nation's report card: Mathematics 2009 snapshot state report –Alabama grade 8 public schools* [Date file]. Retrieved from http://nces.ed.gov/nationsreportcard/pdf/stt2009/2010454AL8.pdf

National Council of Teachers of Mathematics. (2011). *Principles & standards for school* *mathematics*. Retrieved from http://standards.nctm.org/

National FFA Organization. (n. d.). *A brief history of the National FFA Organization*. Retrieved from https://www.ffa.org/documents/about_ffahistory.pdf

National Research Council. (1988). *Understanding agriculture: New directions for education.* Danville, IL: The Interstate Printers and Publishers, Inc.

Newcomb, L. H. (1995, December). The genius of the agricultural education model for nurturing higher order thinking. *The Agricultural Education Magazine. 68*(6), 4, 6.

Norton, R. E., Barlow, M., Prout, R., & Bidwell, S. E. (1998). *Implement an integrated academic & vocational education curriculum*. Winterville, GA: American Association for Vocational Instructional Materials.

Parnell, D. (1996). Cerebral context. *Vocational Education Journal, 71*(3), 18-21.

Parr, B. A. (2004). Effects of a math-enhanced curriculum and instructional approach on the performance of secondary education students enrolled in an agricultural power and technology course: An experimental study. Unpublished doctoral dissertation, Oklahoma State University, Stillwater.

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. doi: 10.5032/jae.2006.03081

Parr, B. A., Edwards, M. C., & Leising, J. G. (2008). Does a curriculum integration intervention to improve the mathematics achievement of students diminish their acquisition of technical competence? An experimental study in agricultural mechanics. *Journal of Agricultural Education, 49*(1), 61-71. doi: 10.5032/jae.2008.01061

Parr, B. A., Edwards, M. C., & Leising, J. G. (2009). Selected effects of a curriculum integration intervention on the mathematics performance of secondary students enrolled in an agricultural power and technology course: An experimental study. *Journal of Agricultural Education, 50*(1), 57-69. doi: 10.5032/jae.2009.01057

Peasley, D. D., & Henderson, J. L. (1992). Agriscience curriculum in Ohio agricultural education: Teacher utilization, attitudes, and knowledge. *Journal of Agricultural Education, 33*(1), 37-45. doi: 10.5032/jae.1992.01037

Romberg, T. A. (1994). Classroom instruction that fosters mathematical thinking and problem solving. In A. H. Schoenfeld (Ed.), *Mathematical thinking and problem solving* (287-304). Hillsdale, NJ: Lawrence Erlbaum.

Romberg, T. A., & Kaput, J. J. (1999). Mathematics worth teaching, mathematics worth understanding. In E. Fennema & T. Romberg (Eds.), *Mathematics classrooms that promote understanding*. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Stone III, J. R., Alfeld, C., Pearson, D., Lewis, M. V., & Jensen, S. (2005). Building academic skills in context: Testing the value of enhanced math learning in career and technical education (Pilot Study). St. Paul, MN: National Research Center for Career and Technical Education, University of Minnesota.

Stone III, J. R., Alfeld, C., Pearson, D., Lewis, M. V., & Jensen, S. (2006). Building academic skills in context: Testing the value of enhanced math learning in career and technical education. St. Paul, MN: National Research Center for Career and Technical Education, University of Minnesota.

Warnick, B. K. & Thompson, G. W. (2007). Barriers, support, and collaboration: A comparison of science and agriculture teachers' perceptions regarding integration of science into the agricultural education curriculum. *Journal of Agricultural Education, 48*(1), 75-85. doi: 10.5032/jae.2007.01075

Yager, R. E. (n.d.). Real-world learning: A necessity for the success of current reform efforts. Retrieved from http://people.umass.edu/educ512f/Sept19Materials/yagerinquiry.html

Young, R. B. (2006). Effects of a math-enhanced curriculum and instructional approach on the performance of secondary education students enrolled in year-long agricultural power and technology course: An experimental study. Unpublished doctoral dissertation, Oklahoma State University, Stillwater.

Young, R. B., Edwards, M. C., & Leising, J. G. (2009). Does a math-enhanced curriculum and instructional approach diminish students' attainment of technical skills? A year-long experimental study in agricultural power and technology. *Journal of Agricultural Education, 50*(1), 116-126. doi: 10.5032/jae.2009.01116