EFFECTS OF A MATH-ENHANCED CURRICULUM AND INSTRUCTIONAL APPROACH ON THE PERFORMANCE OF SECONDARY EDUCATION STUDENTS ENROLLED IN A YEAR-LONG AGRICULTURAL POWER AND TECHNOLOGY COURSE: AN EXPERIMENTAL STUDY

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Dare Mighty Things

"In the battle of life, it is not the critic who counts; nor the one who points out how the strong person stumbled, or where the doer of a deed could have done better.

The credit belongs to the person who is actually in the arena; whose face is marred by dust and sweat and blood, who strives valiantly; who errs and comes short again and again, because there is no effort without error and shortcoming; who does actually strive to do deeds; who knows the great enthusiasms, the great devotion, spends oneself in a worthy cause; who at the best knows in the end the triumph of high achievement; and who at worst, if he or she fails, at least fails while daring greatly.

Far better it is to dare mighty things, to win glorious triumphs even though checkered by failure, than to rank with those timid spirits who neither enjoy nor suffer much because they live in the gray twilight that knows neither victory nor defeat."

-Theodore Roosevelt

It is doubtful that Theodore Roosevelt would have considered starting a doctorial program at age 43 a “mighty thing”. There may have been those who considered it a “foolish thing”, giving up a comfortable job and life to expose a middle aged mind and body to the rigors of three more years of graduate school. For those of you that have supported me during the past three years, I would like to thank you for allowing me to pursue “mighty things”.

I would like to thank the members of my graduate committee, Dr. James Leising, Dr. James Key, Dr. Janice Miller, and Dr. Craig Edwards. I wish to thank Dr. Leising for giving me the opportunity to pursue a dream and obtain a goal these past three years. I thank Dr. Key for his continued assistance and guidance in the area of research methodology. I reserve a special “Thank You” to Dr. Miller for her practical approach to statistics both in and out of the classroom and for her patience in working with a certain doctorial student who’s last experience with math was “cowboy math” some 25 years ago. Finally, I thank Dr. Edwards for the assistance he has provided toward the completion of this document and being an excellent mentor.

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Finally, I thank the many friends that I have made at Oklahoma State University. I will always look back at the past three years and the time spent with each of you as some of the best years of my life.

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CHAPTER I

INTRODUCTION

January 8, 2002 will be remembered as one of the most significant days in the history of public education in the United States. On that date, President George W. Bush signed into law the Elementary and Secondary Education Act of 2001 (widely known as the No Child Left Behind Act). A major focus of the No Child Left Behind Act (NCLB) is the assessment of student learning. "NCLB requires that an assessment in reading and math must be given in at least one of the grades in high school (10^{th}, 11^{th}, or 12^{th} grade) by the 2005-2006 school year. Also, an assessment in science must be given in high school in either the 10^{th}, 11^{th}, or 12^{th} grade" (Phelps, 2002, p. 5).

As a result of this renewed emphasis on assessment of student learning and school accountability, 18 states have instituted mandatory graduation examinations. In the 18 states where these tests are given, students must pass the examination before they can graduate. In addition, 25 states have the right to distribute financial rewards to successful or improved schools, and 25 states have the power to close, reconstitute, or take over low performing schools (Amrein & Berliner, 2002).

In a climate of increasing pressure to achieve coupled with competition for scarce resources, it is imperative that every content area be seen as contributing to the common goal of producing students who are ready to succeed in the 21^{st} century. "Accountability is certainly not new in the area of career and technical education. In the

1998 reauthorization of Perkins, there were strong accountability measures, so this notion of accountability and assessment is not a new concept for career and technical education at all" ("Interview with," 2002, p. 35). As a member of the career and technical education family and a vital component of many educational institutions across the United States, secondary agricultural education must contribute to the overall success of the students it serves, including the academic performance of those pupils.

The need for increased achievement in mathematics in the United States is well documented. A report commissioned by the Committee for Economic Development (2003) found that most national measures of student achievement in math were generally disappointing. This study also found that student interest in math has declined, especially among high school seniors. In addition, the 2000 National Assessment of Educational Progress (NAEP) (National Center for Educational Statistics, 2004b) revealed that less than 20% of 12^{th} graders were proficient in math. Moreover, in 2003 the mathematics performance of U.S. students aged 15 was assessed by the Program for International Student Assessment (PISA) and compared to math achievement of students from 39 other nations. Results of the PISA indicated that the mathematics scores of U.S. students ranked 9^{th} behind such countries as Latvia, Hungary, and Russia (National Center for Educational Statistics, 2004a).

The current level of student achievement in mathematics in the state of Oklahoma is also of concern. Oklahoma ranked 41^{st} in the nation on the 2005 NAEP scores for mathematics (National Center for Educational Statistics, 2005). In 2005, the Oklahoma state board of education reported that only 32% of students scored at the "satisfactory" or "advanced" performance levels for the algebra I end-of-instruction examination

(Oklahoma State Board of Education, 2005). "Improving the math and science skills of our young people is an important step towards maintaining innovation-led economic growth in the coming decades" (Committee for Economic Development, 2003).

Over the past 30 years math scores reported by the National Assessment of Educational Progress (NAEP) for 17 year-olds in the United States have remained relatively flat (Figure 1). However, from 1982 to 2000 the number of academic credits taken by high school students had increased (Figure 2). What is more, embedded in the overall increase in academic credits from 1990 to 2000 was a 15% increase in math credits (National Center for Educational Statistics, 2004c).

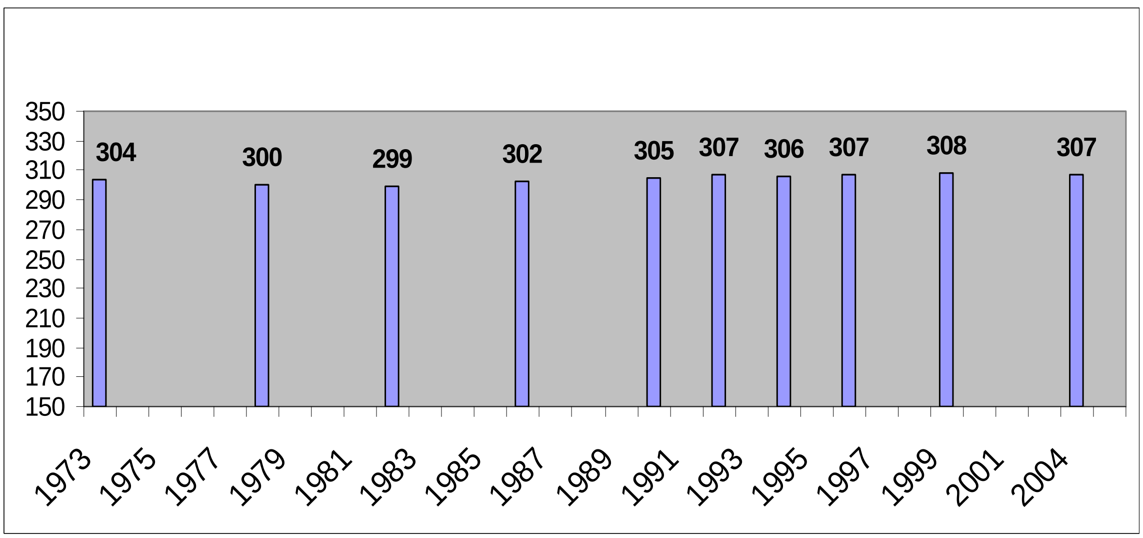

Figure 1. Math Scores for 17 year-olds. (Taken from National Center for Educational Statistics, 2004b)

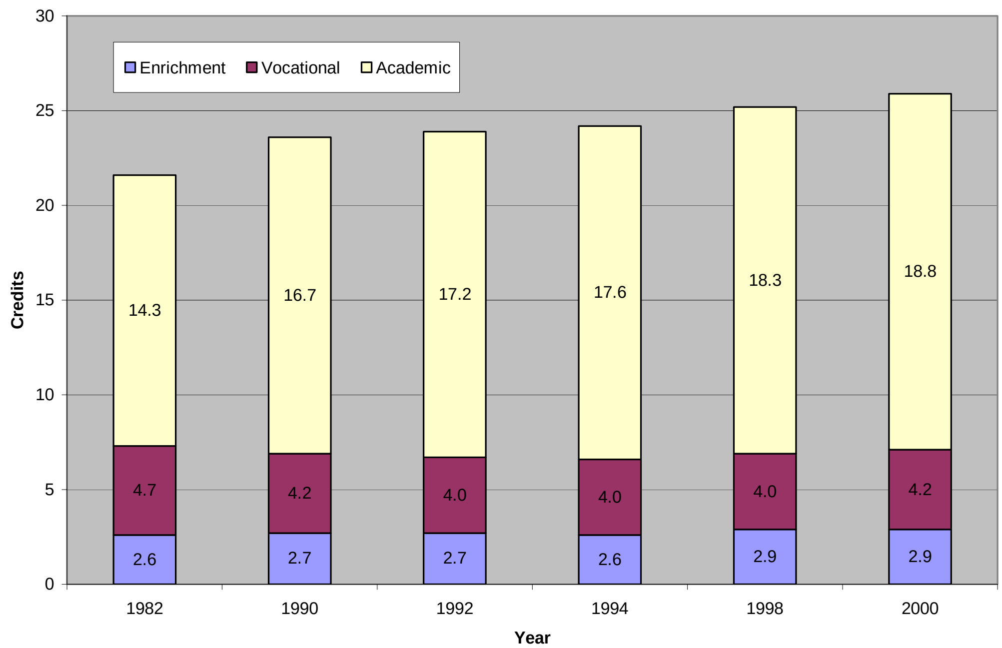

Figure 2. Average Credits Earned by High School Students, by Type of Course Work: 1982-2000. (Taken from Levesque, 2003; National Center for Educational Statistics, 2004c)

Statement of the Problem

It appears that previous attempts to increase math achievement by increasing the number math credits taken by high school students have not worked. Therefore, the concept of doing more of the same must be replaced by looking at new curriculum and instructional methods to engage students and improve their competence in the area of mathematics.

Purpose

The purpose of this study was to empirically test the hypothesis that students who participated in a contextualized, mathematics-enhanced high school agricultural power and technology curriculum (i.e., an experimental curriculum and instructional approach) would develop a deeper and more sustained understanding of selected mathematical concepts than those students who participated in the traditional agricultural power and technology curriculum. The assumption was that students who received the experimental curriculum and instruction would be able to transfer their math learning to new and novel settings (Stone III, Alfeld, Pearson, Lewis, & Jensen, 2005) in their technical field and more broadly. Mathematics achievement was measured by student performance on three standardized, "paper-and-pencil" tests: Terra Nova CAT™ Basic Battery (CTB/McGraw-Hill) Level 21/22 Form A, WorkKeys, and ACCUPLACER. Student technical competence in agricultural power and technology was measured by the Oklahoma Department of Career and Technology Education's, agricultural mechanics competency examination. In addition, improved performance on these tests could offer a concrete demonstration of skills to potential employers and to higher education institutions resulting in a reduced need for workplace and post-secondary remediation in mathematics (Parr, 2004).

This full-year study was conducted as a result of a pilot study carried out during the spring 2004 semester (Parr, 2004). Accordingly, the investigation's research questions, null hypotheses, assumptions, and limitations echo those of the pilot study (Parr, 2004). Both studies were conducted as one replication of a larger study (Stone III et al., 2005); the pilot being one of six replications and this study one of five replications nationwide. The National Research Center for Career and Technical Education (NRCCTE) funded and facilitated coordination of the larger study.

Research Questions

The following research questions guided the study:

1. What is the effect of a math-enhanced agricultural power and technology curriculum and aligned instructional approach on student performance as measured by (a) a traditional test of student math knowledge and by (b) an "authentic" assessment of student ability to use math to solve workplace problems?

2. Does a math-enhanced agricultural power and technology curriculum and aligned instructional approach affect students' need for post-secondary math remediation?

3. Does a math-enhanced agricultural power and technology curriculum and aligned instructional approach diminish students' acquisition of technical skills?

4. What were selected characteristics of students enrolled in, and instructors teaching, Agricultural Power and Technology in the state of Oklahoma during the 2004-2005 school year?

5. Does teacher adherence to the seven-element instructional model in the context of agricultural power and technology affect student achievement as measured by conventional standardized tests?

Null Hypotheses

The following null hypotheses guided the study's statistical analyses:

H_o 1 There is no difference between the two study groups on math performance as measured by a conventional standardized test of math achievement.

H_o 2 There is no difference between the two study groups on math performance as measured by a "real world" or problem-based test.

H_o 3 There is no difference between the two study groups on technical competence in agricultural power and technology as measured by an examination used to assess students' agricultural power and technology competence.

H_o 4 There is no difference between the two study groups on a math placement test used to determine students' need for math remediation at the post-secondary level.

Scope of the Study

This study included students and instructors from 32 high schools in the state of Oklahoma. Student participants were enrolled in an agricultural power and technology course during the 2004-2005 school year. Instructors were teaching the abovementioned course. The total number of students tested was 417, including 205 experimental group participants and 212 control group participants, respectively. Thirty-two teachers responded to questionnaires related to the study's purpose

Assumptions

The following assumptions were made concerning this study:

1. Control group teachers did not teach more math to students enrolled in the agricultural power and technology classes due to involvement in the study.
2. Control group and experimental group teachers did not discuss the experiment while it was in progress.
3. Experimental group teachers presented lessons as they were developed during the study's professional development meetings.
4. Experimental group teachers presented each lesson utilizing the NRCCTE model including the seven-elements of a math-enhanced lesson.
5. Each student performed to the best of their ability on each assessment measure.

Delimitations of the Study

This study was delimited to 417 students enrolled in Agricultural Power and Technology and to 32 teachers of that course during the 2004-2005 school year in the state of Oklahoma.

Limitations of the Study

The following were limitations of the study:

1. There may have been significant variability between schools offering the same agricultural power and technology course.
2. By selecting teachers and their classrooms as the units of analyses, there may have been bias resulting from different student populations enrolled in those classrooms.

A pretest of students' general math ability, i.e., Terra Nova CAT™ Survey Edition (CTB/McGraw-Hill), was administered to test this possibility.

3. The study was delimited to "volunteers." The volunteer group that was derived may not have been representative of the population of agricultural power and technology teachers in Oklahoma during the 2004-2005 school year. However, by randomly assigning teachers and their classes to treatment and control groups, unmeasured characteristics of teachers that potentially threatened the study's validity were minimized (Tuckman, 1999). This strategy also ensured that there would be a sample of teachers who were inclined toward the kind of intervention the study proposed to test. In addition, this minimized costs of professional development and allowed the study to progress in a timely manner.

Significance of the Study

This full-year study was conducted as a result of a pilot study carried out during the spring 2004 semester (Parr, 2004). Results of the pilot study indicated a significant finding regarding student performance, and a reduced need for math remediation at the post-secondary level for students who received the treatment. A significant difference ($p = .017$) was observed between the experimental and control groups after the treatment was administered, as demonstrated by the ACCUPLACER examination. In addition to reaching statistical significance, the practical significance of the difference ($d = .83$) was considered a "large" effect size as defined by Cohen (as cited in Shavelson, 1996, p. 318). Results of this study could add to the general body of literature regarding student achievement in mathematics and support the findings of the pilot study.

The pilot study was conducted over the spring semester 2004 and as a result of the limited time frame, Parr (2004) recommended that a full-year study be conducted,

> Because the treatment described in this experiment was limited to only one semester, this experiment should and will be extended over a longer time period, i.e., one academic year. . . . Accordingly, a similar study is being conducted over the course of a full school year at the time of this writing. Perhaps extending time of treatment will help demonstrate additional significant increases in student math performance that were not exhibited in one semester. (p. 111)

Results from this study could provide rationale for the development of a full-year curriculum in agricultural power and technology using math-enhanced lessons and aligned instruction that would benefit agricultural education students in Oklahoma and nationally.

The use of a randomized trial to conduct this study adds to the overall body of knowledge in the field of education and supports the concept of "gold standard" research as outlined by the Institute of Educational Sciences (IES). Grover J. Whitehurst (2003), Director, Institute of Educational Sciences, U.S. Department of Education explained the position of the IES regarding randomized trials:

> Questions of efficacy and effectiveness, or what works, are causal, and are addressed most rigorously with randomized field trials. The Institute and I have garnered a fair amount of attention for pushing randomized trials, both in funding programs and in the What Works Clearinghouse. From some quarters the attention has been positive. From others it has been negative. If you have a view on this that is still open, it is important that you understand and form your view

based on the Institute's actual position on randomized trials, not a caricature of that position.

This is a synopsis of our position

1. Randomized trials are the only sure method for determining the effectiveness of educational programs and practices. (p. 6)

Operational Definitions

ACCUPLACER- Test designed to assess the student's math aptitude when determining college placement (College Entrance Examination Board, 2002).

Agricultural Education- ". . . a systematic program of instruction available to students desiring to learn about the science, business, and technology of plant and animal production and/or about the environmental and natural resources systems" (Team Ag Ed, 2004, ¶1).

Agricultural Power and Technology- "Curriculum provides information about the selection, operation, maintenance, and use of agricultural power, electronics, electricity, agricultural machinery and equipment, structures and utilities, soil and water management, and agricultural mechanics, including welding and cutting" (Oklahoma Department of Career and Technology Education, What courses are available in Agricultural Education? p. 4, 2004; Oklahoma Department of Career and Technology Education, 2004b).

Career and Technical Education (CTE)- ". . . a planned program of courses and learning experiences that begins with exploration of career options, supports basic academic and life skills, and enables achievement of high academic standards, leadership, preparation for industry-defined work, and advanced and continuing education" (Washington Office of Superintendent of Public Instruction, Career and Technical Education section, ¶1, 2004).

Communities of Practice- ". . . a set of relationships among persons, activity, and world, over time and in relations with other tangential and overlapping communities of practice. A community of practice is an intrinsic condition of the existence of knowledge, not least because it provides the interpretive support necessary for making sense of its heritage. Thus, participation in the cultural practice in which any knowledge exists is an epistemological principle of learning" (Lave & Wenger, p. 98, 1991).

Contextualized Learning- The use of a specific environment or "context" to provide practical application to abstract principles (Dworkin, 1959).

Curriculum Integration- The process of combining curriculum for the purpose of increased comprehension by students (Bottoms & Sharp, n.d.).

Fidelity of the Treatment- The degree to which a treatment condition is delivered as intended (Moncher & Prinz, 1991).

General Education- Traditional or "academic" centered courses (e.g., math, science, social studies, English, foreign languages).*

Math-Enhanced Curriculum- Agricultural power and technology curriculum that has been revised so that the mathematical principles within the curriculum are made transparent and presented in a contextualized fashion to the student. In addition, attempts are made to extend student understanding of selected math concepts such that it can be transferred to, and applied in, less contextualized settings.*

Math-Enhanced Instruction- Instruction in agricultural power and technology that employs an math-enhanced curriculum and is delivered through the following seven-element teaching procedure:

1. Teacher introduces the CTE lesson.
2. Teacher assesses students' math awareness as it relates to the CTE lesson.
3. Teacher works through the math example embedded in the CTE lesson.
4. Teacher works related, contextual math-in-CTE examples.
5. Teacher works through traditional math examples.
6. Students demonstrate their understanding.
7. Students complete a formal assessment. (Bickmore-Brand, 1993; Stone III et al., 2005)

Math-Enhanced Lesson Plan- A teaching plan that outlines a series of instructional elements involving math and agricultural power and technology curriculum and includes each of the seven steps necessary to carry out the math-enhanced instructional intervention employed in this study (Stone III et al., 2005).

National Council of Teachers of Mathematics (NCTM) Standards- Standards set by the National Council of Teachers of Mathematics to guide math instruction in public schools in the United States (National Council of Teachers of Mathematics, 2004).

Oklahoma Priority Academic Student Skills (PASS) in Mathematics for High School- Curriculum framework prepared by the Oklahoma State Department of Education (August 27, 2002) designed to prepare students for ". . . a society increasingly dominated by technology and quantitative methods" (Oklahoma State Board of Education, 2004, p. 1).

Professional Development of Teachers- the process of improving staff skills and competencies needed to produce outstanding educational results for students (Hassel, 1999).

Student Achievement- Learner behaviors related to the mathematical concepts presented within the curricular content of agricultural power and technology as measured by multiple standardized examinations.*

Student Technical Competence- ". . . competencies for vocational [i.e., career] and technical education are *those tasks, skills, attitudes, values, and appreciations that are deemed critical to successful employment*" (Finch & Crunkilton, 1979, p. 220). For the purpose of this study, student competence was assessed and compared for the technical area of agricultural power and technology as it existed as part of the secondary agricultural education curriculum in Oklahoma during the 2004-2005 school year.

Terra Nova CAT™ Basic Battery (CTB/McGraw-Hill) Level 21/22 Form A- An examination employed to determine students' level of general math achievement following the experimental treatment.*

Terra Nova CAT™ Survey Edition (CTB/McGraw-Hill)- An examination employed to determine students' level of general math achievement prior to the experimental treatment.*

Traditional Mathematics Instruction- Mathematics instruction rooted in cognitive development with little attention to practical application (Parnell, 1998).

Traditional Science Instruction- Science instruction rooted in cognitive development with little attention to practical application (Parnell, 1998).

Transfer of Learning- The ability to obtain knowledge in one setting and apply it in another situation (Phipps & Osborne, 1988).

WorkKeys Applied Mathematics Assessment (ACT)- A job skills assessment system for measuring real-world skills as they relate to students' use of mathematics (ACT, 2006).

**Note.* Definition was developed by the researcher, and it may be unique to the purpose of this study.

CHAPTER II

REVIEW OF LITERATURE

Introduction

This full-year study was conducted as a result of a pilot study carried out during the spring 2004 semester (Parr, 2004). Accordingly, the investigation's research questions, null hypotheses, assumptions, and limitations echo those of the pilot study (Parr, 2004). Both studies were conducted as one replication within a larger study (Stone III et al., 2005); the pilot being one of six replications and this study one of five replications nationwide. The National Research Center for Career and Technical Education (NRCCTE) funded and facilitated coordination of the larger study.

Analysis of qualitative data gathered as a part of the pilot study led researchers to conclude that the positive quantitative results of the pilot study were due to more than just the teaching of the math-enhanced lessons. Researchers began to understand that results from the pilot study were based on a combination of the experimental treatment's pedagogy and the process associated with its development and implementation (e.g., teacher professional development). This understanding led to the emergence of the *Math-in-CTE* model (see Figure 5) developed by the NRCCTE. The model involved both a particular pedagogy and a prescribed process, and it can be expressed by the following mathematical equation:

(Pedagogy)(Process) = Student Math Performance

Further, in mathematical terms, without both a particular pedagogy and a prescribed process that results found would not have emerged.

The purpose of this chapter is to present a review of literature for this study as informed by the pilot study. This review will provide enlightenment as to the effectiveness of contextualized teaching and learning (i.e., the pedagogy), and to the effectiveness of professional development and communities of practice for the experimental group teachers (i.e., the process). This chapter is divided into the following sections: (1) Introduction; (2) Curriculum Integration; (3) Transfer of Learning; (4) Contextualized Teaching and Learning in Mathematics; (5) Teaching Mathematics in the Context of Agriculture; (6) Professional Development for Teachers; (7) Communities of Practice in Education; (8) Theoretical Framework; and (9) Summary.

Curriculum Integration

Curriculum Integration is not a new concept. The 20th Century educational reformer, John Dewey, believed very strongly in the importance of curriculum integration and the consequences of separating knowledge from application. Dewey's position is shown clearly in the following passage:

> 'The divorce between learning and its use is the most serious defect of our existing education. Without the consciousness of application, learning has no motive. . . . [It] is separated from the actual conditions of the child's life, and a fatal split is introduced between school learning and vital experience.' (as cited in Fishman & McCarthy, 1997, p. 180)

The Association for Career and Technical Education (2006), in the recent publication "Reinventing the American High School for the 21st Century," captured the current state of curriculum integration between academic and CTE courses when it stated, "Academic integration has been required in federal CTE legislation for 15 years but has not been implemented as widely as possible" (p. 14). Moreover, the ACTE called for a dramatic improvement in where and how academic content is taught:

> In the new American high school, the entire school must own the mission of academic proficiency, and teachers should be required to collaborate across disciplines to help students reach these proficiencies. CTE teachers will need to explicitly integrate academic standards into their CTE classes, and academic teachers will also need to learn ways of demonstrating real-world context and application from coursework that is more contextual than traditional teaching methods. (Association for Career and Technical Education, 2006, p. 15)

Susan Sclafani, former U.S. Department of Education's acting chief of Career and Technical Education, in a presentation to career and technical education practitioners, asserted that CTE could help students become more engaged in learning because of the contextual learning opportunities which can make learning academics more exciting (Association for Career and Technical Education, 2004).

Although persistent calls for curriculum integration have been heard, the emergence of examples from the field have been sparse. Accordingly, some observers believe that certain barriers must exist preventing teachers from implementing curriculum integration in their classrooms. To that end, Hernandez and Brendefur (2003) analyzed the efforts of mathematics and CTE teachers in eight sites across the United States as they developed integrated mathematics curricula. Their findings are summarized as follows:

> In sum, although the quality of the units varies, our findings suggest that it is possible for interdisciplinary teams of mathematics and VTE [i.e., vocational and technical education] teachers to create high quality integrated curriculum units if certain conditions are met. Team dynamics, teachers' beliefs and school supports, in particular, appeared to be critical to sustain productive collaborative curriculum development work. It appeared that having support from the school's community, meeting regularly with all the team members, focusing conversations toward student understanding and writing tasks that promote conceptual and integrated understandings of the concepts, and writing the unit together with reflective thought, all seemed to be critical complementary conditions in successful integrated unit writing. (p. 17)

So, if curriculum integration is desirable, and it appears that it is possible at the classroom level, does it improve student achievement? In a quasi-experimental research study, Childress (1996) attempted to determine if an integrated technology, science, and mathematics curriculum would improve the problem solving abilities of middle school students. Although the results of the study proved to be statistically non-significant, the researcher did find that the experimental group students were better able to apply the mathematical and scientific principles learned as a result of the integrated curriculum.

Further evidence of the value of integrated curriculum efforts between mathematics and CTE courses can be found in the results of a study conducted by Wu and Greenan (2003). In another quasi-experimental trial, Wu and Greenan administered a treatment consisting of the Generalizable Mathematics Skill Instructional (GMSI) intervention to an experimental group drawn from a population of secondary CTE students in Indiana. The GMSI was a 22 lesson curriculum that integrated mathematics concepts into CTE curricula. As a result of the treatment, the experimental group students had significantly higher mathematics skills achievement than did students in the control group.

Regarding statewide initiatives, the state of Kentucky now offers 10 "interdisciplinary courses" that allow students to receive academic credit by taking courses with a more occupational-oriented focus. Moreover, two courses were developed to address all 23 state standards for geometry (Association for Career and Technical Education, 2006). During 2003-2005, Arizona updated all of its 36 CTE programs to reinforce state academic standards. Arizona high school students who graduated in 2004 and who took two or more Carnegie units of CTE courses, scored higher than the general high school student population on all three of Arizona's high stakes academic tests (Arizona Department of Education, 2005).

Curriculum integration is a pedagogical approach with roots in the educational philosophy of John Dewey that has earned the endorsement of modern scholars and policy-makers (Association for Career and Technical Education, 2006; Childress, 1996; Hernandez, & Brendefur, 2003; Wu, & Greenan, 2003). Although barriers to implementing curriculum integration that involves academic and CTE courses may exist, they are not insurmountable. The potential to increase student achievement through curriculum integration involving the intersection of core academic and career and technical education courses appears to outweigh any imposed barriers, perceived and otherwise (Southern Regional Education Board, 2000).

Transfer of Learning

"A major, but often tacit, assumption in education is that the knowledge that students learn in school will transfer to situations and problems encountered outside school" (p. 4) was a conclusion drawn by Jose Mestre (2002) in a report of a workshop sponsored by the National Science Foundation. Further, Mestre asserted that, "Indeed much of our investment in education is justified in terms of preparing students for future learning so that they may become productive members in a society where workplace needs and demands are in constant flux" (p. 4).

Even though this may be a basic assumption on which our system of education is based, is the transfer of knowledge or the ability of students to apply knowledge in new or novel settings an outcome of education in the 21st century? Some classic studies illustrate barriers to transfer of knowledge that shares a common structure. Moreover, when the context of the application changes the results are less favorable (Gick & Holyoak, 1980; Hayes & Simon, 1977; Reed, Ernst, & Banerji, 1974). It appears, in many instances, so much knowledge is context-bound that teaching students to apply it in other settings provides a daunting task for educational practitioners (Mestre, 2002).

Concomitantly, researchers have concluded that several factors affect transfer of learning: Some initial acquisition of knowledge is required for transfer to occur in the future (Brown, Bransford, Ferrara, & Campione, 1983; Carey & Smith, 1993; Chi, 2000). Learning with understanding promotes transfer; rote learning does not (Barnett & Ceci, 2002). Context is important to transfer of learning; if the knowledge is too tightly bound in context, transfer to new and novel contexts will be limited (Bjork & Richardson-Klavhen, 1989; Carraher, 1986; Lave 1988; Saxe 1989). Mestre (2002) summarized the research about transfer of knowledge when he stated, ". . . research suggests that transfer is enhanced when the learner abstracts the deep principles underlying the knowledge being learned and that abstraction is facilitated by opportunities to experience concepts and principles in multiple contexts" (p. 6).

Although the transfer of learning is recognized as a basic goal of education, research suggests that ensuring students acquire the ability to transfer prior learning may be elusive. Investigators who compared the performance of experts and novices have provided the backdrop to support the second of three key findings of the National Research Council report, *How People Learn* (Bransford, Brown, & Cocking, 1999). Finding number two stated that, "To develop competence in an area of inquiry, students must: (a) have a deep foundation of factual knowledge, (b) understand facts and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application," (p. 12). This finding was expanded further by the report's implication about teaching, i.e., "Teachers must teach some subject matter in depth, providing many examples in which the same concept is at work and providing a firm foundation of factual knowledge," (p. 16).

Contextualized Teaching and Learning in Mathematics

"Mathematics isn't a palm tree, with a single long straight trunk covered with scratchy formulas. It's a banyan tree, with many interconnected trunks and

> branches—a banyan tree that has grown to the size of a forest, inviting us to climb and explore." (Thurston, 1990, p. 7)

Thurston used this metaphor to describe mathematics in terms of a human activity rather than an unrelated set of formulas. Unfortunately, most students are taught mathematics in a traditional approach that isolates mathematics from other disciplines and results in the development of symbol manipulation and a set routine devoid of creation or discovery (Romberg & Kaput, 1999). Romberg and Kaput further stated:

> Previously, students studied number for number's sake, or algebra for algebra's sake, and later applied what they had learned to solve problems and perhaps even engage in serious mathematical modeling. We suggest the reverse: that number, algebra, and most other core school mathematics should arise in the service of making sense of individual experience. (p. 13)

Parnell (1998) echoed this sentiment when he opined that, "In many of today's classrooms . . . teaching is a matter of putting students in classrooms marked English history, or mathematics and then attempting to fill their heads through lectures, textbooks, and the like" (p. 14). He lamented further that contextual learning is, for the most part, absent and little is done to connect the students' learning with the real world in which they must live.

This notion of teaching mathematics in context has not gone unheeded entirely. Many mathematics education researchers and reformers have called for greater emphasis on the use of context to teach mathematics. For example, Carpenter and Lehrer (1999) noted that to teach mathematics for understanding, applications in which contexts were provided was essential to the development of skills linked to their applications. Other researchers have made claims of increased retention due to teaching subject matter through context (Romberg, 1994). What is more, a study conducted in Kentucky, where mathematics was integrated into an environment-based learning program in the context of the local community, provided students with a deeper understanding of math, enabling them to more readily master crucial math skills (Liberman & Hoody, 1998).

In an effort to provide guidance for school administrators and teachers of mathematics, who were working to improve student achievement in mathematics, the National Council of Teachers of Mathematics (NCTM) (2004) released the publication, *Principles and Standards for School Mathematics*. Six principles, five content and five process standards were identified. Two of the process standards dealt directly with the concept of teaching and learning math in context. The process standard identified as “connections” has direct implications for contextual teaching and learning:

> Mathematics is not a collection of separate strands or standards, even though it is often partitioned in this manner. Rather, mathematics is an integrated field of study. When students connect mathematical ideas, their understanding is deeper and more lasting, and they come to view mathematics as a coherent whole. They see mathematical connections in rich interplay among mathematical topics, in contexts that relate mathematics to other subjects, and in their own interest and experience. Through instruction that emphasizes the interrelatedness of mathematical ideas, students learn not only mathematics but also about the utility of mathematics. (p. 4)

A second process standard, “problem solving” also has implications for contextual teaching and learning as well as the future transfer of learning:

> Solving problems is not only a goal of learning mathematics but also a means of doing so. It is an integral part of mathematics, not an isolated piece of the mathematics program. Students require frequent opportunities to formulate, grapple with, and solve complex problems that involve a significant amount of effort. They are to be encouraged to reflect on their thinking during the problem-solving process so that they can apply and adapt the strategies they develop to other problems and in other contexts [i.e., transfer of learning]. By solving mathematical problems, students acquire ways of thinking, habits of persistence and curiosity, and confidence in unfamiliar situations that serve them well outside the mathematics classroom. (National Council of Teachers of Mathematics, 2004, p. 4)

Researchers, Berns and Erickson (2001) made the connection between career and technical education and contextualized teaching and learning when they posited that,

> . . . contextual teaching and learning draws upon the latest research on effective teaching and student learning. As a pedagogical aspect of school reform, it places responsibility on the student with the teacher serving as a significant contributor in the process. Engaging, active learning replaces passive, traditional methods through a variety of hands-on, collaborative, high-level approaches. These approaches result in a motivational, invigorating educational experience for all students as they learn at a higher level. As a result of CTL [contextual teaching and learning], students are better prepared for the new economy. They better retain knowledge and skills, thus raising student academic and career-technical

achievement. Indeed, they are better prepared for post-secondary education, careers, and bright futures in the 21st century. (p. 8)

Scholars (Parnell, 1998; Romberg & Kaput, 1999; Thurston, 1990) have identified the absence of connections to the "real world" as a major problem facing the current methods used to teach mathematics. Some researchers (Carpenter & Lehrer, 1999; Fennema, Sowder, & Carpenter, 1999; Parnell, 1998; Romberg & Kaput, 1999) have recognized the need for a more contextualized approach to the teaching and learning of mathematics that allows students to construct meaning in a situated fashion; an approach that holds potential for deepening their understanding and thus improving their future performance as it relates to mathematics. To that end, the NCTM (2004) has developed principles and standards for teaching mathematics, including process standards relating to contextual learning and problem solving.

Teaching Mathematics in the Context of Agriculture

Agriculture has long been considered a natural context for teaching mathematics. Shepardson (1929) most eloquently expressed the relationship of agriculture to mathematics when he stated, "Agriculture is the meeting-ground to the sciences. Physics and chemistry lie at its base. To these elements biology adds its conception of organism. Mathematics is their common instrument" (p. 69).

Long before the advent of the Smith-Hughes act of 1917, agricultural education was known for its strong scientific basis (Hillison, 1996); a foundation that relied on students' use of mathematics. This emphasis on science has remained and was reiterated in the National Research Council's publication, *Understanding Agriculture: New*

Directions for Education. The council stated, “All students need an understanding of basic science concepts: “Teaching science through agriculture would incorporate more agriculture into curricula, while more effectively teaching agriculture” (National Research Council, 1988, p. 11).

In support Conroy, Trumbull, and Johnson (1999) stated, “Science and mathematics have always been the basic tenets of agricultural instruction in the United States” (¶ 4). They also pointed out that secondary agricultural education could provide an appropriate context for students to explore and use key mathematical skills. Additionally, Conroy et al. asserted that many research studies have concluded students fail to develop deep understandings of mathematics in traditional classroom settings and cannot apply their knowledge outside the classroom.

Teachers of mathematics also support the concept that agriculture is a powerful context for teaching mathematics. To that end, Miller and Vogelzang (1983) found that, among a population of agricultural education teachers, teachers of mathematics, principals and agricultural education students from 36 randomly selected schools in Iowa, the teachers of mathematics supported the inclusion and application of math concepts in agricultural education classes to a greater degree than the other groups studied.

That study identified 13 math concepts that were applicable to problems in agriculture and should be included in the agricultural education curriculum. The researchers also recommended that applied math concepts should be incorporated in new curriculum, and suggested that teachers of mathematics should provide assistance to agricultural education teachers in developing lesson plans which incorporated applied math (Miller & Vogelzang, 1983).

Agricultural education instructors in the state of Louisiana were asked to account for the amount of instructional time devoted to teaching math-related content in their agricultural education curriculum (Moss, 1988). These instructors reported that, on average, approximately 17% of their total instructional time was devoted to math-related concepts. Additionally, this study revealed that the instructional area of agricultural mechanics is where the greatest amount of math-related instruction occurred.

In addition to providing a powerful context in which to teach mathematics, agricultural education could address the second process standard identified by the National Council of Teachers of Mathematics (2004), i.e., the use of problem solving as a method to teach mathematics. The problem-solving method of instruction, as used by agricultural educators for decades, relies on a "problem" derived from a context through which students learn a more general or abstract concept (Boone, 1990; Cano & Martinez, 1989; Conroy et al., 1999; Crunkilton & Krebs, 1982; Dyer & Osborne, 1996; Flowers & Osborne, 1988; Hammonds, 1950; Krebs, 1967; Newcomb, McCracken, & Warmbrod, 1993; Phipps & Osborne, 1988; Torres & Cano, 1995).

The value of the problem-based approach to learning has been a widely held view among several prominent scholars of agricultural education, including textbook authors, e.g., Cook, (1947); Crunkilton and Krebs, (1982); Newcomb, McCracken, and Warmbrod, (1993); Phipps and Osborne, (1988). What is more, Lancelot (1944) suggested that all subjects could be taught effectively through the problem-based approach. Lancelot endorsed the use of the problem-solving method in all subjects and its positive effect on students when he stated, "The truth appears to be that the school subjects generally *can* be taught by means of problems and that pupils can, therefore, be kept thinking while studying them" (p. 144).

Shinn et al. (2003) summarized the value of problem-solving and teaching and learning in mathematics:

> There are indications that student achievement in mathematics will increase when students become more engaged using inquiry-based, problem-solving learning strategies, particularly when coupled with highly qualified, caring teachers who deploy a contextualized curriculum that connects new ideas and skills to students' past knowledge and experience. (p. 23)

Agriculture has been recognized for many years as a viable context for teaching and learning mathematics. Additionally, problem solving has been the method of choice of many agricultural educators for decades (Parr & Edwards, 2004). This combination of teaching through context and reliance on the problem solving method could make secondary agricultural education a natural curriculum venue for the teaching of mathematics, i.e., one in which student performance in mathematics is affected positively.

Professional Development of Teachers

In an era of standards-based reform in education, many believe the best way to raise student academic achievement is through improved teaching (Birman, Desimone, Porter, & Garet, 2000). To that end, Porter and Brophy (1988) maintained that student learning can be improved only if teachers' practices are of high standard; however, they concluded many teachers are not prepared to implement practices that reflect high standards. What is more, professional development for teachers could serve to fill the gap between standards-based reform and pre-service teacher preparation (Birman et al., 2000). Unfortunately, many times the professional development provided to teachers does not adequately prepare them for the rigors of standards-based student achievement (Corcoran, 1995; Darling-Hammond, 1996; Hiebert, 1999; Little 1993; Sparks & Loucks-Horsley, 1989).

In an effort to identify effective professional development for teachers, Birman et al. surveyed a sample of more than 1000 teachers who participated in the Eisenhower Professional Development Program. These researchers identified the following six factors aligned with effective professional development: 1) F*orm*, was the activity planned as a traditional workshop or a reform activity; 2) *Duration,* how many hours were devoted to professional development; 3) *Participation,* were participants from the same or different schools; 4) *Content focus,* to what extent did the professional development activity focus on improving teachers' subject matter knowledge in mathematics or science; 5) *Active learning,* were teachers actively engaged in significant examination of teaching and learning; and, 6) *Coherence,* were teachers encouraged to continue a professional dialog after the professional development session. Results from this study indicated that effective professional development should provide activities that are longer in duration, involve collective participation, afford opportunities for active learning, encourage a deepening of teachers' content knowledge and provide opportunities for continued coherence (Birman et al., 2000).

The issue of professional development that supports school mathematics reform was addressed by Borasi and Fonzi (2002) in a monograph prepared for the National

Science Foundation. The authors identified five factors that must be present in professional development programs in order for those programs to meet the needs of teachers of mathematics. Those factors are:

> (1) be sustained and intensive; (2) be informed by what we know about how people learn best; (3) center around the critical activities of teaching and learning rather than focus primarily on abstractions and generalities; (4) foster collaboration; and (5) offer a rich set of diverse experiences. (p. 114)

Notably, a congruence of opinion exists between those who posited factors necessary for effective professional development of teachers in general (Birman et al., 2000) and those who directed their efforts specifically at teachers of mathematics (Borasi & Fonzi, 2002).

The format used to deliver effective professional development for teachers of mathematics may be as important as the factors necessary; what is more, this conclusion may hold for all teachers who strive to improve student achievement in mathematics. Summer institutes, study group of teachers who meet on a regular basis, a series of workshops held during the school day or after school, and independent work done by the teacher are examples of effective formats for delivering professional development (Borasi & Fonzi, 2002). Moreover, most successful programs use a combination of formats based on the needs of the teachers involved (Borasi & Fonzi, 2002; Loucks-Horsley, Hewson, Love, & Stiles, 1998; Southern Region Educational Board, 2000).

Once the factors necessary for effective professional development are identified and put into practice, the question still remains, "Is professional development of teachers an effective means to improve student achievement?" To that end, Gordan (1999) found that in successful schools, professional development opportunities to improve [student] achievement were prominent; and, Kent (2004) concluded, “Therefore, linking improved teacher quality through effective professional development will ultimately lead to student success” (p. 432).

Harwell, D’Amico, Stein, and Gatti (2000) found similar results in a longitudinal study conducted in school District #2 in New York City. This study, conducted from 1988 to 1998, explored a variety of factors that influenced student achievement, particularly the role of teacher professional development. During the decade of observation, the percentage of District #2 students that were achieving at or above grade level in mathematics rose from 66% to 82%. The researchers concluded that the professional development activities of the teachers may have had some effect.

Further, the use of intensive professional development was found to improve teacher self-efficacy years after the initial professional development session had occurred. For example, Watson (2006) found that teachers’ self-efficacy regarding the use of the Internet remained high many years after the initial series of intense professional development sessions had concluded.

What is more, some researchers (Mitchell, 2002; Wenger, 1998; White, 2002) have called for the use of “communities of practice” as a cost-effective method to deliver quality professional development for teachers. For example, Chalmers and Keown (2006) suggested that the Internet was a cost-effective delivery platform for delivering professional development to secondary teachers in New Zealand who were utilizing communities of practice.

Educational practitioners, researchers, and scholars (Gordan, 1999; Harwell et al., 2000; Kent, 2004) have posited that a significant relationship exists between the quality of professional development received by teachers and their future impact on student learning and achievement. However, in order to be effective, professional development must address the critical factors of form, duration, participation, content focus, active learning, and coherence (Birman et al., 2000). Accordingly, effective professional development can have a long term effect on how teachers view their self-efficacy (Watson, 2006). What is more, the use of communities of practice may be an effective way to provide valuable, sustainable, professional development for teachers, including agricultural educators who may be striving to improve their students' achievement in mathematics. Finally, some researchers (Chalmers and Keown, 2006; Mitchell, 2002; Wenger, 1988; White, 2002) have called for the use of "communities of practice" as a cost-effective method to deliver quality professional development for teachers

Communities of Practice in Education

From the time the term "community of practice" was popularized by Lave and Wenger (1991), many in business and education have embraced the theory and its alignment with organizational, situated, and sociocultural learning theories. Educational researchers have used the concept of community of practice to explain cultural knowledge through the perceptual lens that members of a community view and interpret the world and give order, meaning, and significance to their experiences (Maynard, 2001). The recognition of communities of practice in education has signaled an ideological shift by some, i.e., where researchers have begun to examine learning not only in traditional school settings but also in non-formal, everyday contexts (Brown, Collins, & Duguid, 1989; Lave, 1988; Resnick, 1987; Rogoff, 1990).

Lave and Wenger (1991) explained the concept as follows:

> A community of practice is a set of relationships among persons, activity, and world, over time and in relations with other tangential and overlapping communities of practice. A community of practice is an intrinsic condition of the existence of knowledge, not least because it provides the interpretive support necessary for making sense of its heritage. Thus, participation in the cultural practice in which any knowledge exists is an epistemological principle of learning. (p. 98)

Yamagata-Lynch (2001) reported that communities of practice have been used in education properly as a research tool to describe interindividual interactions and identity formations, and improperly as a tool to design educational communities. Further, Wenger (1998) explained that communities of practice are not new methods of organizing people, and "they are not a design fad, a new kind of organizational unit or pedagogical device to be implemented" (p. 228). Conversely,

> Communities of practice are about content—about learning as a living experience of negotiating meaning—not about form. In this sense, they cannot be legislated into existence or defined by decree. They can be recognized, supported, encouraged, and nurtured, but they are not refined, designable units. (Wenger, p. 229)

Moreover, Yamagata-Lynch (2001) used communities of practice as a conceptual metaphor and theoretical tool to examine and reflect on interactions that took place at a rural Midwestern school district involved in a teacher development program. The concept of communities of practice was used successfully to identify, support, and strengthen practices that already existed in the school district. In addition, using communities of practice as a theoretical lens may be used to assist those who are involved in the professional development of teachers, and to identify barriers and accelerators to introducing new pedagogical practices. The work of Yamagata-Lynch supports Wenger's (1998) view that community of practice could be a useful tool for identifying and supporting efforts to improve the learning of groups and individuals, but not as a blueprint for group organization.

An example of the emergence of a community of practice in education through involvement in intensive professional development activities has been documented by Barab and Duffy (1998). According to the researchers, an intensive professional development program for pre-service teachers at Indiana University-Bloomington, known as the community of teachers (CoT), displayed all of the attributes of a community of practice. Those attributes were (1) a common cultural and historical heritage; (2) an interdependent system where individuals become part of something bigger than themselves; and, (3) a reproduction cycle where "newcomers" can become "old timers."

The Indiana University Community of Teachers (CoT) was a field-based program where pre-service teachers are required to commit to one school for the duration of their field experience. Pre-service teachers are not assigned to a specific teacher but rather to an entire school (i.e., a common culture and an interdependent system). In time, a reproductive cycle was completed when the make-up of the CoT became a mixture of veteran teachers, advanced students with teaching experience, and sophomore-level students entering the program (Barab & Duffy, 1998).

Communities of practice represent a method of describing both formal and informal learning groups (Brown, Collins, & Duguid, 1989; Lave, 1988; Resnick, 1987; Rogoff, 1990). In education, communities of practice have been used without success as a tool to design organizations (Yamagata-Lynch, 2001). The more appropriate use of communities of practice in education has been to recognize when the communities are present and to provide the resources necessary to sustain them (Wenger, 1998); moreover, there is evidence to support the notion that communities of practice can emerge from professional development activities (Barab, & Duffy 1998).

Comprehensive Theoretical Framework for this Study

The underlying theoretical framework for this study relies on the model of teaching and learning developed by Dunkin and Biddle (1974) (Figure 3), that was derived from concepts first espoused by Mitzel (1960).

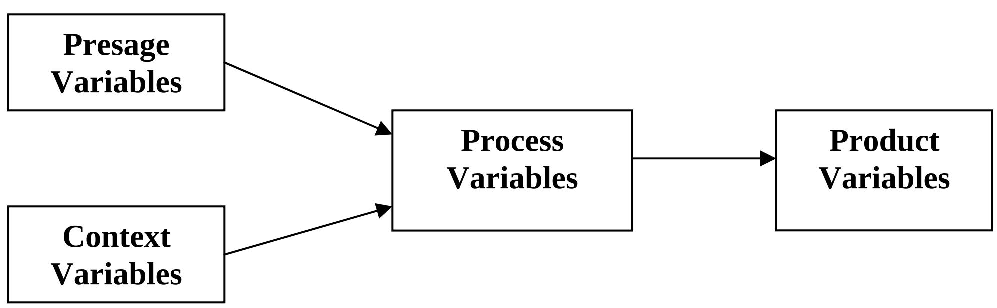

Figure 3. Model for the Study of Classroom Teaching. (Taken from Parr, Edwards, and Leising, in press, p. 4)

Dunkin and Biddle organized the variables that contribute to teaching and learning into four general classes. The characteristics of teachers that may be observed for their effects on the teaching process are called *presage variables*. Teacher formative experiences, teacher properties, teacher-training experiences, and any other variable that may be controlled by teacher educators or school administrators are included as presage variables. *Context variables* are those conditions over which a teacher has little control. Pupil formative experiences, pupil properties, school and community contexts, and classroom contexts were variables identified by Dunkin and Biddle as context variables.

Process variables refer to those activities that take place in the classroom during the act of teaching. These variables include behaviors in the classroom demonstrated by the teacher and students, as well as the observable changes in pupil behavior. Finally, *product variables* describe the actual outcomes of teaching. The product variables of most interest are immediate pupil growth and long-term pupil effects (Dunkin & Biddle, 1974).

Park and Osborne (2004) used the Dunkin and Biddle model as theoretical support from which to explore the variables necessary to improve student reading, comprehension, critical thinking and motivation to read in the context of agriscience. After completing a review of literature, the researchers grouped the related literature into themes related to presage and context variables. This grouping of literature, based on variables described by Dunkin and Biddle, then allowed the researchers to posit a model for the study of reading in secondary agriscience. Park and Osborne made a strong case as to the utility of the Dunkin and Biddle model for examining the integration of academic and CTE courses, including effects that may be related to improving student academic achievement.

The model posited by Dunkin and Biddle is robust, and, therefore, provides a comprehensive and grounded approach for looking at many of the significant variables associated with the teaching and learning process. This model is also valuable as an aid to summarize research-based knowledge about the teaching and learning process, and it provides a transparent lens to view and interpret the results of this study in its entirety.

Summary

This review of literature revealed a concern among many educators and scholars regarding the lack of curriculum integration in public schools (Association for Career and Technical Education, 2006). This finding is especially troubling given the demonstrated benefits to students who are exposed to academic subject matter taught in the context of CTE courses (Childress, 1996; Hernandez, & Brendefur, 2003; Association for Career and Technical Education, 2006; Wu & Greenan, 2003). Barriers inherent to curriculum integration were identified (Hernandez, & Brendefur, 2003). Strategies to overcome the obstacles that may be preventing teachers from integrating curriculum effectively were described as well (Hernandez, & Brendefur, 2003).

Transfer of learning, the ultimate goal of formal education, was found to be an elusive objective. Many scholars are at odds as to the ability of teachers to present material such that students are able to take acquired knowledge and apply it in new and novel settings (Gick & Holyoak, 1980; Hayes & Simon, 1977; Reed, Ernst, & Banerji, 1974). Research involving observing experts and novices has shone some light on the subject (Bransford, Brown, & Cocking, 1999). Promising findings include the value of teaching some subject matter in depth and providing many contextual examples as the act of teaching and learning occurs (Mestre, 2002).

Contextual teaching and learning in mathematics and the opportunity that approach may hold for many students who struggle to make critical connections between their world and the math they study was explored. What is more, several scholars (Carpenter, & Lehrer, 1999; Liberman & Hoody, 1998; Romberg, 1994; Shinn et al., 2003) have made the connection between contextual teaching and learning and student achievement in mathematics. Further, the National Council of Teachers of Mathematics (2002) has developed program standards that call for increasing the use of context and problem solving in the nation's math classrooms.

A review of relevant literature suggested that secondary agricultural education stands ready as a natural curricular context for the teaching of mathematics such that student learning and achievement could be improved (Conroy, Trumbull, & Johnson, 1999; Miller & Vogelzang, 1983; Moss, 1988; National Research Council, 1988; Shepardson, 1929; Shinn et al., 2003). It provides subject matter and student learning experiences rich with opportunities for mathematical applications. Further, many agricultural education teachers employ problem solving as a method of instruction, i.e., a teaching and learning approach that could improve student academic performance, including achievement in mathematics (Edwards, 2004).

This review of literature has provided some insight about factors that help to make the professional development of teachers an effective and valuable experience (Birman et al., 2000; Borasi & Fonzi, 2002). Earlier researchers (Gordan, 1999; Harwell et al., 2000; Kent, 2004) have described positive connections between selected professional development approaches for teachers and the potential for increasing student achievement. An example of a long term effect on teacher self-efficacy due to one's participation in professional development was described (Watson, 2006). Finally, some scholars (Mitchell, 2002; Wenger, 1998; White, 2002) have advocated using communities of practice to provide effective professional development for teachers.

Communities of practice were defined and explored through this review of literature. In addition, using communities of practice as a conceptual prism to identify existing groups of practitioners who share common interests in order to nurture and develop them professionally was examined (Wenger, 1998; Yamagata-Lynch, 2001). What is more, Yamagata-Lynch, (2001) called for additional research to explore methods of using communities of practice as a model when developing working groups in education, including those devoted to improving student achievement.

The theoretical framework espoused by Dunkin and Biddle (1974) and addressed in this review of literature provides a conceptual nexus for assembling, organizing, and interpreting the major components and features of this study, i.e., presage variables, context variables, process variables, and product variables (see Figure 3).

CHAPTER III

METHODOLOGY

Introduction

The purpose of this study was to empirically test the hypothesis that students who participated in a contextualized, mathematics-enhanced high school agricultural power and technology curriculum (i.e., an experimental curriculum and instructional approach) would develop a deeper and more sustained understanding of selected mathematical concepts than those students who participated in the traditional agricultural power and technology curriculum. The assumption was that students who received the experimental curriculum and instruction would be able to transfer their math learning to new and novel settings (Stone III et al., 2005) in their technical field and more broadly. Mathematics achievement was measured by student performance on three standardized, "paper-and-pencil" tests: Terra Nova CAT™ Basic Battery (CTB/McGraw-Hill) Level 21/22 Form A, WorkKeys, and ACCUPLACER. Student technical competence in agricultural power and technology was measured by the Oklahoma Department of Career and Technology Education's, on-line agricultural mechanics competency examination. In addition, improved performance on these tests could offer a concrete demonstration of skills to potential employers and to higher education institutions resulting in a reduced need for workplace and post-secondary remediation in mathematics (Parr, 2004).

This full-year study was conducted as a result of a pilot study carried out during the spring 2004 semester (Parr, 2004). Accordingly, the investigation's research questions, null hypotheses, assumptions, and limitations echo those of the pilot study (Parr, 2004). Both studies were conducted as one replication of a larger study (Stone III et al., 2005); the pilot being one of six replications and this study one of five replications nationwide. The National Research Center for Career and Technical Education (NRCCTE) funded and facilitated coordination of the larger study.

Institutional Review Board

In order to comply with Federal regulations and Oklahoma State University policy, all research studies involving human subjects must be reviewed and approval given before the research can begin. The Office of University Research and Institutional Review Board at Oklahoma State University conducted a review of the proposal for this study, determined that the rights and welfare of the human subjects involved were protected and granted permission for the study to be conducted. A copy of the institutional review board approval form AG0411 is presented in Appendix A.

Population

Teachers

Oklahoma agricultural education teachers who participated in this study were recruited and randomly assigned to either the control or experimental group as part of the pilot study. A total of 38 teachers, 18 in the experimental group and 20 in the control group, participated in the pilot study (Parr, 2004). Participating teachers were contacted via a postal mailed letter (Appendix B) by the researcher in March, 2004 to solicit their participation in the year-long study. A total of 32 teachers, 16 in the experimental group and 16 in the control group, agreed to be involved in the year-long study that was conducted during the 2004-2005 school year.

Group 1. Agricultural education instructors who taught math-enhanced lessons using an aligned instructional approach within an agricultural power and technology curriculum during the 2004-2005 school year (i.e., experimental group teachers, $n = 16$).

Group 2. Agricultural education instructors who taught the traditional agricultural power and technology curriculum during the 2004-2005 school year (i.e., control group teachers, $n = 16$).

Students

Oklahoma high school students ($N = 417$) who were enrolled in 32 schools and received instruction in agricultural power and technology during the 2004-2005 school year participated in this study.

Group 1. Students who received instruction via math-enhanced lessons with an aligned instructional approach in the context of an agricultural power and technology curriculum during the 2004-2005 school year (i.e., experimental group students, $n = 205$).

Group 2. Students who received instruction via a traditional agricultural power and technology curriculum during the 2004-2005 school year (i.e., control group students, $n = 212$).

Design of the Study

This study utilized a posttest only control group experimental design (Campbell & Stanley, 1963). Participating teachers and their classrooms were randomly assigned to either the experimental or control groups. Accordingly, the resulting unit of analysis was intact classrooms. The unit of analysis for this study was predetermined by the National Research Center for Career and Technical Education (NRCCTE). The NRCCTE chose intact classrooms for the unit of analysis for two reasons.

> First, it avoids the well-documented problems of parental opposition to such activities (for extended discussions of random assignment studies, see Cook, 2005; and Stern & Wing, 2004). With classroom-level assignment, all students received or did not receive the treatment, and could only opt out of the testing regime; very few opted out. The second reason is more important: because CTE [agricultural education] classes are often "singletons" in their schools, there would have been no control to which they could have been assigned. (Stone III et al., 2005, p. 21)

The researcher acknowledges that using intact classrooms as the unit of analysis rather than individual students greatly reduced the size of the sample analyzed, and thus reduced the statistical power of the study.

The randomly assigned classrooms were pre-tested to determine level of equivalence regarding basic mathematical skills (Campbell & Stanley, 1963; Tuckman, 1999). Four posttest measures were administered upon completion of the treatment: three tests assessed student performance in mathematics and one test assessed student technical competence in agricultural power and technology. The research design is illustrated in Figure 4.

Group		Time	
Experimental	R	X	O
Control	R	______	O

Figure 4. Research Design

The design of this study was chosen based on its robust nature, and adherence to the U.S. Department of Education's standards for considering funding of educational practices that are supported by research using experimental designs whereby participants are randomly assigned to treatment and control groups (U.S. Department of Education, 2003a). In addition, this study followed the guidelines set forth by the U.S. Department of Education (2003b) for evaluating whether an intervention is supported by rigorous evidence by using outcome measures that are "valid."

The Terra Nova CAT Survey examination (25 items) used to establish equivalence of groups prior to the treatment had a reliability coefficient of 0.84 (Cronbach's alpha) (McGraw-Hill, 2000). The examination used to determine the need for mathematics remediation, the ACCUPLACER (35 items), had an internal consistency reliability coefficient of 0.92 (Cronbach's alpha) (College Entrance Examination Board, 2002). The Terra Nova CAT Basic Battery (46 items) used as a post-treatment measure for evaluation of general math aptitude has a reliability coefficient of 0.91 (Cronbach's alpha) (McGraw-Hill, 2000). The examination that measured a student's ability to use math to solve workplace-related problems, WorkKeys (ACT, 2006) (33 items), has scored a 0.88 (KR-20) reliability estimate (B. Ziomeck, personal communication, December 2, 2004, as reported by Parr, 2004). Student technical competence was measured using the Oklahoma Department of Career and Technology Education's, on-line agricultural mechanics competency examination (42 items)

The content validity of this examination is assured based on the methods employed by the Testing Division of the Oklahoma Department of Career and Technology Education to develop the examination. These methods are outlined in the Testing Handbook (Oklahoma Department of Career and Technology Education, 2004a) and are as follows:

> Using values and information in the skills standards, the Testing Division determines the test specifications and contracts with subject matter experts to develop the test. When writing test items, subject matter experts typically reference materials identified in the curriculum crosswalk that is included in the skills standard, which reinforces the connection between standards, instruction, and assessment.
>
> A committee of subject matter experts reviews the test and carefully scrutinizes individual test items. Specifically, the committee validates the structure and content of each question and verifies the question has been keyed correctly. (p. 6)

Participants

Four groups of individuals were involved in this study. Figure 5 provides a list of the participants and their primary roles.

Participants	Primary Role
Experimental group agricultural education teachers	**Taught the math-enhanced lessons**
Math teachers	**Provided support for the experimental group agricultural education teachers**
Math Captains	**Selected math teachers who provided organizational support for the math cluster meetings**
Control group agricultural education teachers	**Taught their regular curriculum**
Testing liaisons	**Administered questionnaires and tests**

Figure 5. Study participants and their roles

Additional responsibilities of the experimental agricultural education teachers can be found in Appendix C; for the math teachers in Appendix G; for the control agricultural education teachers in Appendix D; and for the testing liaisons in Appendix I.

Recruitment of Study Participants

Agricultural education teacher participants were recruited for participation in this study from the pool of teachers who participated in the pilot study conducted during the spring semester 2004 (Parr, 2004). The 18 experimental group and 20 control group teachers were sent a letter and a questionnaire from the National Center for Career and Technical Education (NRCCTE) requesting their continued participation in the study (Appendix C and D). As a result of this letter, 16 experimental and 16 control teachers opted to continue as participants in the year-long study. These teachers were then required to obtain permission from their building principals to remain in the study (Appendix E and F). All participating teachers complied with this requirement.

Once the recruitment of agricultural education teachers was complete, math teacher partners of the experimental agricultural teachers who had participated in the pilot study were also recruited for the full-year study. A letter was sent from the NRCCTE requesting their participation and permission from their building principals (Appendix G and H). Of the 16 math teachers solicited, 15 opted to continue with the approval of their principals. The loss of one math teacher resulted in one experimental agricultural education teacher without a partner. This problem was solved when one of the math teachers volunteered to work with the agricultural education teacher who had lost his original math teacher partner.

The final group of participants recruited for this study were the testing liaisons. Letters were sent from the NRCCTE to testing liaisons who participated in the pilot study from the 32 schools represented by the experimental and control group agricultural education teachers who had consented to be involved in the full-year study (Appendix I). Due to numerous factors, several of the testing liaisons, who had participated in the pilot study, were unable to continue (e.g., retirement or having moved to a different school). Suitable replacements were found and 32 testing liaisons were identified who carried out the administration of student questionnaires and the study's testing regimen.

Incentives

Agricultural education teachers in the experimental group received a stipend of $1,500.00 payable in two installments of $750.00 at the end of each semester, and an additional $1,000.00 payable as a bonus at the end of the study for their completion of all study-related requirements. In addition, each experimental agricultural education teacher received travel, food, lodging, and the provision of substitute teacher pay to their school for attending professional development workshops and math cluster meetings. Math teacher partners of the agricultural education teachers in the experimental group received a stipend of $1,000.00 payable in two installments of $500.00 at the end of each semester, and an additional $1,000.00 payable as a bonus at the end of the study for their completion of all study-related requirements. Each math teacher also received travel, food, lodging, and the provision of substitute teacher pay to their school for attending professional development workshops and math cluster meetings.

Agricultural education teachers in the control group received a stipend of $500.00 payable in two installments of $250.00 at the end of each semester. These teachers were also provided the opportunity to receive professional development training for enhancing their curriculum with mathematics following completion of the study. Testing liaisons received $375.00 for administering the pre-treatment measure of math equivalence and pre-treatment student questionnaires, and $375.00 for administering the posttests and post-treatment student questionnaires. All students in both the experimental and control groups received a $10.00 gift card for taking the pre-treatment measure and for completing a questionnaire; a second $10.00 gift card was given to students who took the posttests and completed a post-treatment questionnaire.

Curriculum Artifacts

Several techniques were employed in an effort to assure the fidelity of the treatment. The collection of curriculum artifacts was one such technique. Experimental agriculture education teachers were instructed to collect and submit one sample of student work related to Element 7 for each math-enhanced lesson taught, and to submit copies of any math-related supplementary instructional materials they had developed (Appendix C). These artifacts were reviewed by researchers at the NRCCTE to provide documentary evidence confirming that the treatment was indeed administered by the experimental agricultural education teachers (i.e., a form of “triangulation”).

Administration of Teacher Questionnaires

Agricultural education teachers in both the experimental and control groups were sent a questionnaire from the National Research Center for Career and Technical Education (NRCCTE) along with a letter requesting their continued participation in the study (Appendix C and D). The questionnaires were returned to the NRCCTE by the agricultural education teachers who elected to participate in the year-long study. Data derived from these questionnaires was provided to the researcher.

Administration of Examinations and Student Questionnaires

Each school in the control and experimental groups had a testing liaison recommended by the school principal to serve in that capacity. Many of the testing liaisons had been designated prior to this study as the campus-level testing liaison for their particular school, and in that capacity were responsible for administering various, local, state, and federally required examinations. In cases where a campus-level testing liaison was not available, the school principal designated themself or a school guidance counselor as the testing liaison for the study.

On August 13, 2004, testing liaisons were sent, via postal mail from the project coordinator, all of the pre-treatment materials and instructions. During the first week of school, testing liaisons provided the experimental and control teachers a prepared script to read to their students that explained the purpose of the study (Appendix J and K), as well as student consent forms (Appendix L and M) and parental consent forms (Appendix N and O) to be signed and returned prior to the study's start.

A few days later, testing liaisons returned to the classrooms to collect signed consent forms and to administer the student questionnaire. At least three days afterward, and within the first two weeks of the fall 2004 term, testing liaisons returned to the classrooms to administer the study pre-treatment measure, i.e., Terra Nova CAT™ Survey Edition (CTB/McGraw-Hill). Student participants in both the experimental and control groups were given calculators provided by the NRCCTE to be used as needed as they completed of the mathematics examinations. The calculators were limited to the following mathematical functions: addition, subtraction, multiplication, division, square root, and percentage. Students who opted out or whose parents had not granted permission for them to participate in the study were provided an alternative activity, and were not present during administration of the pre-treatment measure and questionnaire. Thirty-one schools tested during the month of August 2004; one school on a trimester schedule tested at the beginning of the second mester in mid November 2004.

Four schools, one in the control group and three in the experimental group were on alternative schedules and conducted their posttesting from December 2004 through March 2005. A testing window of April 25 to May 13, 2005 was designated for posttesting of the remainder of the schools. On April 4, 2005, testing liaisons were sent via postal mail the materials necessary to administer the posttests and post-treatment student questionnaire. Testing liaisons scheduled one class period about two weeks before the end of the course to administer the student questionnaire. Three to five class periods after administration of student questionnaires, the liaisons scheduled a class period to administer posttests. Students were randomly assigned within the intact classrooms to take one of three mathematics examinations.

The decision to require students to take only one of three examinations was made to reduce the expense of posttesting, while protecting the integrity of the test (i.e., random assignment), and to reduce the possibility of test fatigue that may have had a negative effect on student performance (Enderlin & Osborne, 1992; Wolf, Smith, & Birnbaum, 1995). The posttest measures of mathematical ability included the Terra Nova CAT™ Basic Battery (CTB/McGraw-Hill) Level 21/22 Form A, WorkKeys, and ACCUPLACER examinations. The final day of posttesting was reserved for the testing of student technical competence in agricultural power and technology. This test was administered on-line via the Internet in the participating schools' computer laboratories. The examination was a measure of student agricultural mechanics competence; it was developed by the Oklahoma Department of Career and Technology Education.

The unit of analysis for students' mathematical and technical competencies were the intact classrooms; thus, classroom data were aggregated and individual data were not reported. All individual data (student and teacher) were gathered using an ID number unique to the study that was assigned by the testing liaisons and kept anonymous and confidential. Only aggregated data by classroom and by groups were reported.

Treatment

The treatment in this study consisted of the *Math-in-CTE* model developed by the NRCCTE. The model involved both a particular pedagogy and a prescribed process that can be expressed in the following mathematical equation:

$$(\text{Pedagogy})(\text{Process}) = \text{Student Math Performance}$$

Further, in mathematical terms, without both pedagogy and process the results found would not have emerged.

This model is based on the basic assumption that occupations aligned to career and technical programs are rich in math content and thus Career and Technical Education (CTE) programs including secondary agricultural education, should strive to enhance the math embedded in their existing curriculum. This model was developed to assist CTE teachers in identifying math in their curricula and to improve their instruction as it related to those math concepts. The goal of such instruction would be for CTE students to view math as they would any other tool (e.g., a saw, a tractor, a plow) necessary to complete a task in their occupational area (Stone III et al., 2005).

The pedagogical part of the NRCCTE model for this study consisted of 17, math-enhanced, agricultural power and technology lessons developed by the experimental agricultural education teachers and their math teacher partners during the pilot study. These lessons were refined further at additional professional development sessions provided for teachers during the summer of 2004 (Appendix Q and V), prior to the 2004-2005 school year. All lessons were revised and improved to conform to the NRCCTE model for a math-enhanced lesson (Figure 6).

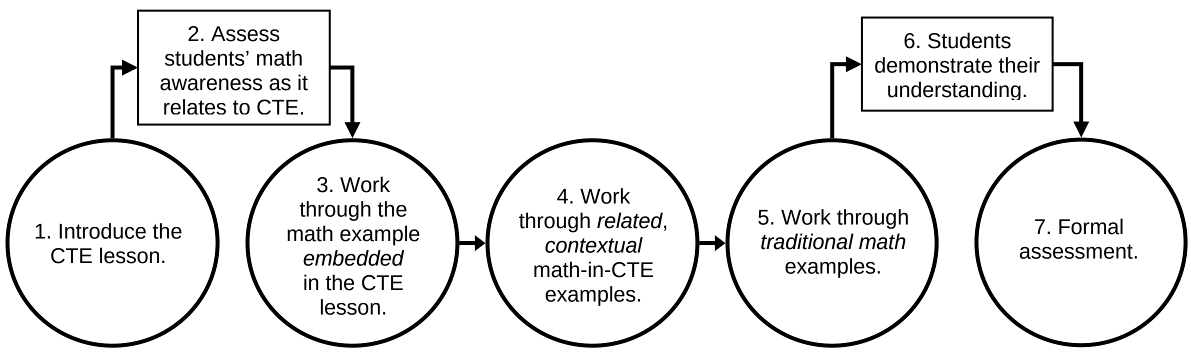

Figure 6. The NRCCTE Model: The Seven-elements of a Math-Enhanced Lesson (Stone III et al., 2005)

The development of math-enhanced agricultural power and technology lessons and the treatment's pedagogy (i.e., aligned instructional approach) was just one aspect of the NRCCTE model. The study's treatment also included the creation of a process by which agricultural education teachers in the experimental group "learned" to develop and teach the math-enhanced agricultural power and technology lessons. This process consisted of sustaining the agriculture-math teacher partnerships (i.e., communities of practice), curriculum mapping, developing a scope and sequence for teaching the lessons, providing professional development, and implementing the math-enhanced lessons.

Curriculum Mapping

Prior to the development of the math-enhanced lessons during the pilot study, a group of experts was convened to develop a curriculum map. The curriculum map would serve to identify the math competencies embedded in the agricultural power and technology curriculum, and provide a “point of intersection” between the embedded competencies and those math concepts identified by the Oklahoma Department of Educations’ Priority Academic Student Skills (PASS) (Parr, 2004). Additionally, the PASS objectives were aligned with the National Council of Teachers of Mathematics’ (NCTM) standards for high school mathematics. The curriculum map developed during the pilot study was subsequently used to develop the 17 agricultural power and technology lessons taught during the pilot study as well as the full-year investigation (Appendix P).

The 17 agricultural power and technology lessons were analyzed by a team of math experts from the NRCCTE who checked their content and compiled a list of mathematical concepts addressed by the math-enhanced lessons. Table 1shows the math concepts and the number of times each concept was addressed by the agricultural power and technology lessons.

Table 1

Math Concepts and the Frequency Addressed by Math-Enhanced Lessons in Agricultural Power and Technology (Adapted from Stone III et al., 2005)

Math Concept	Number of Math-Enhanced Lessons Addressing that Math Concept
Number and Number Relations	1
Computation and Numerical Estimation	7
Measurement	14
Geometry and Spatial Sense	5
Data Analysis, Statistics and Probability	4
Patterns, Functions, Algebra	3
Trigonometry	4
Problem Solving and Reasoning	3
Communication	1

Communities of Practice

Teacher teams comprised of experimental group agricultural education teachers and math teacher partners were developed as part of the treatment in the pilot study. Their purpose and function was well documented by Parr (2004) (pp. 49-50). Early in the full-year study, it became apparent that the value of these teams to the eventual outcome of the study would be more than that originally sought from simple teamwork. The phrase "communities of practice" came to be used when referring to the interaction between the experimental group agricultural education teachers and their math teacher partners.

Communities of practice are described as joint ventures that are continually renegotiated, and bind members together through mutual engagement while producing shared resources (Wenger, 1998). A community of practice takes shared knowledge or technical skills and, through the relationships developed by participants' over time, produces ways of doing things that matter to people (Lave & Wenger, 1991).

Professional Development

The goal and objectives of the professional development component of this study's treatment were outlined at a Math-in-CTE Year 2 Planning Meeting held in Minneapolis, MN June 4-5, 2004 (National Research Center for Career and Technical Education, 2004b):

> The overarching goal of the professional development aspect of the study is to prepare teachers to reinforce students' understanding and mastery of higher-level math concepts and skills by enhancing the math that already exists in the CTE curriculum. The professional development sessions will reinforce and build on the teachers' content and pedagogical knowledge. Math-enhanced lessons developed in year 1 of the study will be critiqued and improved. New lessons, based on the identification of mathematics concepts within specific CTE courses, will be developed in year 2 to further help teachers emphasize and enhance math as part of their CTE classroom instruction.
>
> After completing this training program, teachers will be able to:
>
> - Explain the need for "enhanced" mathematics instruction within their respective CTE Curriculum.
> - Identify "points of intersection" of mathematics and CTE within their respective CTE curriculum.

- Develop skill and confidence in creating and implementing math enhancements within their respective CTE classroom instruction.
- Develop specific lesson plans and instructional strategies that enhance and enrich the math principles/concepts within their respective CTE curricula.
- Assess individual student math awareness, knowledge and skills.
- Reinforce the math enhancement with students and check for understanding.
- Assess individual student learning and mastery of math concept.
- Integrate the newly developed math enhancements within their daily CTE classroom instruction.
- Continue to develop additional higher math enhancement strategies within their CTE curriculum.
- Work effectively as a member of a teacher team (p. 9)

First Professional Development Session

The first professional development session of the full-year study was conducted June 23-25, 2004 (Appendix Q). Three major objectives were addressed during this professional development session: 1) to provide an overview and discuss the purpose of the full-year study; 2) to review the modified seven-element teaching procedure to be used with the math-enhanced lessons; and, 3) to critique and improve the 17 agricultural power and technology lessons developed during the pilot study.

Staff from the NRCCTE provided an overview and purpose of the full-year study. Additional reporting requirements including the pre-and post-teaching reports (Appendix

R and S) were discussed as one of several tools to be employed to insure fidelity of the treatment. Modifications to the lesson plan format used in the pilot study were introduced (Appendix T). Teacher teams reviewed the 17 lessons that were developed for the pilot study.

Using the Rubric for Critiquing Lesson Plans (Appendix U), all teacher participants provided constructive criticism for each lesson developed during the pilot study. With written critiques in hand, teacher teams began improving their lesson plans and making revisions necessary to conform to the revised lesson plan template (Appendix T). Each teacher team provided an electronic copy of their revised lesson plan to the project coordinator before departing from the first professional development session.

Second Professional Development Session

Prior to the official start of the second professional development session, two math teacher participants met to revise two lesson plans that were not modified previously during the first professional development session. These two lesson plans were developed during the pilot study by teacher teams who chose not to participate in the full-year study. The full-year teacher teams reconvened in July, 2004 (Appendix V). During this three-day session, teacher teams presented their revised lessons plans for lesson plans 1 through 8. The lesson plans were critiqued by participating teachers as well as members of the project staff, including the researcher. After each lesson was presented, constructive criticism was provided and changes were made to each lesson plan as needed. Once the first eight lessons were presented, written copies of each lesson plan and all supporting materials were exchanged among teacher teams for additional in-depth critique and feedback. Further revisions were made to each lesson plan as a result of the in-depth critiques, and final copies of each plan were provided to the researcher for distribution to participating experimental group teachers prior to the 2004-2205 school year. The revised lesson plans were distributed to the experimental group teachers as a printed copy and on compact disk (CD) via postal mail.

The concept of "Math Clusters" was also discussed during this session. The total number of teacher teams would be divided into four smaller, regional sub-groups for the purpose of providing more in-depth assistance in teaching the math-enhanced lessons. The math clusters would meet three times during the school year to review lessons already taught and to prepare for upcoming lessons. Four math teachers volunteered to serve as "Math Captains" with their primary duties being planning and facilitating the math cluster meetings. The "Math Captains" were provided an additional stipend of $250.00 for their extra responsibilities.

Also, during the second professional development session, considerable discussion surrounded the topic of the proper sequence in which the 17 math-enhanced lessons should be taught. Based on teachers' perceptions of lesson difficulty and conceptual relationships between lessons regarding the embedded mathematics, a consensus was reached among the teachers and a logical sequence was developed accordingly. Agricultural education teachers were asked to review their school calendar for the 2004-05 school year and to develop an "Estimated Schedule for Teaching the Lessons." Information from these schedules was used to develop the Master Scope and Sequence Chart (Appendix W) for the full-year study.

Third Professional Development Session

Study participants met again on November 7-8, 2004 for the third professional development session (Appendix X). A status report was given regarding the lessons taught-to-date and about the first round of math cluster meetings. During the remainder of this two-day session, teacher teams presented their revised lessons plans for lessons 9 through 17. Similar to lessons 1 through 8, teachers' lesson presentations were critiqued by their peers, and by project staff members. After each lesson was presented, constructive criticism was provided by participating teachers as well as members of the project staff, and changes were made to each lesson as needed. Finally, additional revisions were made to each lesson plan as a result of the peer critiques, and final copies were provided to the researcher for distribution to the teacher teams. The revised lesson plans were distributed to the experimental group teachers as a printed copy and on compact disk (CD) via postal mail.

Similar to professional development session two, discussion emerged regarding the proper sequence in which the last nine math-enhanced lessons should be taught. Again, teachers considered lesson difficulty and the conceptual relationships between lessons, and a consensus was reached about a logical sequence to follow when teaching lessons 9 through 17. Subsequently, the agricultural education teachers were asked to review their school calendars for the 2004-05 school year and to modify their "Estimated Schedule for Teaching the Lessons" as needed. Information from these schedules was used to up-date the study's Master Scope and Sequence Chart (Appendix W). Project staff monitoring and lesson plan completion time expectations were modified accordingly.

Fourth Professional Development Session

Agricultural education teachers began the fourth professional development session, held in January, 2005 (Appendix Y) by providing the researchers samples of student work from element 7 of the math-enhanced lessons, videotapes of selected lessons taught previously, and any changes they had made to the lessons taught. Status reports were given by the teacher teams regarding the lessons taught since the third professional development session, and the math captains briefed the group about the second round of math cluster meetings. The final four lessons in the teaching sequence were again presented by their teacher team authors, and were peer critiqued as was customary from previous professional development sessions. Again, the agricultural education teachers were asked to review their school calendar for the 2004-05 school year and to modify their "Estimated Schedule for Teaching the Lessons" as needed. Subsequently, this information was used to up-date the study's Master Scope and Sequence Chart (Appendix W) per the remainder of the 2004-2005 school year.

Staff from the NRCCTE provided detailed information regarding possible improvements for each lesson plan. Teacher teams worked to make modifications suggested by the NRCCTE and their peers, and to improve the math-enhanced lesson plans for future use by other teachers. Additional effort was directed toward lessons number 1 through 8 to make any changes deemed necessary, and to render these lessons ready for publication on the NRCCTE Web site.

Fifth Professional Development Session

The final professional development session for teacher participants was held June 15-16, 2005 (Appendix Z). The primary objectives of this one-day session were to conduct focus group sessions with the teachers to collect additional qualitative data about their experiences in the study, to discuss future opportunities to disseminate the results of the study, and to celebrate completion of the year-long study.

Several teachers who participated in the study returned for a second day to assist with a debriefing session for control group teachers (Appendix AA). This session was a part of the incentive package offered to control teachers from the pilot study; however, it had to be rescheduled from the summer of 2004 when it was decided that a full-year study would be conducted. This session was open to any interested agricultural education instructor in Oklahoma and provided a general overview of the entire study.

Measures of Student Achievement

A battery of four examinations was administered to students to measure their mathematical ability and to assess their technical competence in agricultural power and technology. A decision was made by the research team at the National Research Center for Career and Technical Education to limit the time allotted for each examination to 40 minutes (Stone III et al., 2005). Several of the examinations were designed to be administered over a 70 minute period and the length of class sessions for most of the experimental and control group schools was approximately 50 minutes. Consequently, students were instructed to complete as many of the test items as they could in 40 minutes. This protocol was enforced by the study's testing liaisons.

Pre-treatment

The Terra Nova CAT™ Survey Edition (CTB/McGraw-Hill) examination that was used to establish equivalence of groups prior to the study's treatment had a reliability coefficient of 0.84 (Cronbach's alpha) (McGraw-Hill, 2000) (25 items).

Post-treatment

The ACCUPLACER examination was used to determine students' need for mathematics remediation at the post-secondary level; this measure had an internal consistency reliability coefficient of 0.92 (Cronbach's alpha) (35 items) (College Entrance Examination Board, 2002). The Terra Nova CAT™ Basic Battery (CTB/McGraw-Hill) Level 21/22 Form A was used as a post-treatment measure for evaluation of students' general math aptitude(46 items); its reliability coefficient was 0.91 (Cronbach's alpha) (McGraw-Hill, 2000). The WorkKeys (ACT, 2006) examination was employed to measure a student's ability to use math to solve workplace-related problems (33 items). This examination has been reported to have a 0.88 (KR-20) reliability estimate (B. Ziomeck, personal communication, December 2, 2004, as reported by Parr, 2004).

Student technical competence was measured by the Oklahoma Department of Career and Technology Education's, on-line agricultural mechanics competency examination (42 items). The content validity of this examination is assured based on methods employed by the Testing Division of the Oklahoma Department of Career and Technology Education to develop individual items. This method is outlined in the department's Testing Handbook (Oklahoma Department of Career and Technology Education, 2004a), and is as follows:

> Using values and information in the skills standards, the Testing Division determines the test specifications and contracts with subject matter experts to develop the test. When writing test items, subject matter experts typically reference materials identified in the curriculum crosswalk that is included in the

> skills standard, which reinforces the connection between standards, instruction, and assessment.
>
> A committee of subject matter experts reviews the test and carefully scrutinizes individual test items. Specifically, the committee validates the structure and content of each question and verifies the question has been keyed correctly. (p. 6)

Data Collection

Data collection began in the fall of 2004 with administration of the pre-treatment measure of equivalence and student questionnaire to both the experimental and control groups. Posttests and additional questionnaires were administered to both groups as was appropriate per the closing of each school's term.

Data were collected by testing liaisons located at each experimental and control school. Detailed pre-treatment instructions were provided to each liaison via a Liaison Handbook (National Research Center for Career and Technical Education, 2004a) produced and distributed by the NRCCTE. On August 13, 2004, testing liaisons were sent via postal mail from the project coordinator all of the pre-treatment test materials including calculators, student questionnaires, and instructions. Posttesting instructions were provided later in the form of a supplement to the original Liaison Handbook (National Research Center for Career and Technical Education, 2004a). The handbook supplement was provided to the testing liaisons via postal mail along with the materials necessary to administer the posttests and student questionnaires. Per the instructions for administering the tests and questionnaires, testing liaisons assigned each student a unique ID number, assured that the answer sheets were properly coded, collected the completed test answer sheets into pre-labeled envelopes, and returned the testing materials to the researcher via postal mail.

Qualitative and descriptive data were collected during and at conclusion of the study to measure fidelity of the treatment. Each experimental teacher pair was required to submit a report prior to and after each math-enhanced lesson was taught. Math teachers completed a Pre-Teaching Report (Appendix R) and agricultural education teachers completed a Post-Teaching Report (Appendix S). The pre-teaching reports provided information regarding the agricultural education teachers' understanding of the mathematical concepts in the math-enhanced lesson to be taught, and the amount of assistance given the agricultural education teacher by his/her math teacher partner. In the post-teaching report agricultural education teachers indicate any difficulties they experienced in teaching the math-enhanced lessons, and if each of the seven-elements had been addressed during their teaching.

One-in-four of the experimental classrooms were visited by a recognized qualitative researcher from the NRCCTE to observe the instructors teach one of the seven-element, math-enhanced lessons. In addition to the on-site lesson observations, agricultural education teachers in the experimental group provided videotapes of one complete math-enhanced lesson taught during the study. These videotapes were reviewed by two recognized qualitative researchers from the NRCCTE to determine if the instructors had implemented the prescribed treatment. Finally, during the last professional development session, in June 2005, agricultural education teachers and math teachers who participated in the study were divided into three focus groups: 1) agricultural education teachers; 2) math teachers; and, 3) a mixed group of agricultural education and math teachers. All but two experimental group agricultural education teachers and one math teacher partner participated in the focus groups. The focus groups were facilitated by three staff members from the NRCCTE. The focus group interviews were designed to gather general information about the study, and to provide additional data regarding the study's fidelity of treatment.

The teaching reports, selected on-site observations, and post-study focus groups were used as a form of "triangulation" (Creswell, 2002) to determine the extent to which the study's treatment was carried out.

Data Analysis

Selected characteristics of participating students and teachers were summarized using frequencies and percentages calculated from the study's questionnaires. The pre-treatment measure used to determine the equivalency of groups regarding students' general mathematical ability and the post-treatment measure of agricultural power and technology competence were analyzed using one-way analysis of variance (ANOVA). Due to finding a significant difference ($p = .047$) between the experimental and control groups based on results of the pre-treatment measure, a comparative analysis of the posttest math measures was conducted using the analysis of covariance (ANCOVA) procedure.

The value of using ANCOVA as a means to analyze data from an experimental study with random assignment of subjects was outlined by Keppel (1991):

> The analysis of covariance reduces experimental error by statistical, rather than by experimental, means. Subjects are first measured on the concomitant variable,

> usually called the **covariate** in the context of the analysis of covariance, which consists of some relevant ability or characteristic. . . . Only at the time of statistical analysis does this information come into play, when it is used to accomplish two important adjustments: (1) to refine estimates of experimental error and (2) to adjust treatment effects for any differences between treatment groups that existed before the experimental treatments were administered. . . . Thus, the analysis of covariance is expected to achieve its greatest benefits by reducing the size of the *error term*; any correction for preexisting differences produced by random assignment will be small by comparison. (pp. 301-302)

Effect size, for the purpose of describing *practical significance*, was calculated using Keppel's (1991) formula for Omega squared for all post-treatment measures of students' mathematical abilities. The *Publication Manual of the American Psychological Association*, 5th edition, (2001) lists failure to report effect sizes as one of seven common errors found in the design and reporting of research. The manual goes on to state:

> For the reader to fully understand the importance of your findings, it is almost always necessary to include some index of effect size or strength of relationship in your Results section. . . . The general principle to be followed, however, is to provide the reader not only with information about statistical significance but also with enough information to assess the magnitude of the observed effect or relationship. (pp. 25-26)

The *Statistical Package for the Social Sciences version 13.0* was utilized to complete all of the study's statistical analysis.

CHAPTER IV

FINDINGS

Introduction

The purpose of this study was to empirically test the hypothesis that students who participated in a contextualized, mathematics-enhanced high school agricultural power and technology curriculum (i.e., an experimental curriculum and instructional approach) would develop a deeper and more sustained understanding of selected mathematical concepts than those students who participated in the traditional agricultural power and technology curriculum. The assumption was that students who received the experimental curriculum and instruction would be able to transfer their math learning to new and novel settings (Stone III et al., 2005) in their technical field and more broadly. Mathematics achievement was measured by student performance on three standardized, "paper-and-pencil" tests: Terra Nova CAT™ Basic Battery (CTB/McGraw-Hill) Level 21/22 Form A, WorkKeys, and ACCUPLACER. Student technical competence was measured by the Oklahoma Department of Career and Technology Education's, on-line agricultural mechanics competency examination. In addition, improved performance on these tests could offer a concrete demonstration of skills to potential employers and to higher education institutions resulting in a reduced need for workplace and post-secondary remediation in mathematics (Parr, 2004).

This full-year study was conducted as a result of a pilot study carried out during the spring 2004 semester (Parr, 2004). Accordingly, the investigation's research questions, null hypotheses, assumptions, and limitations echo those of the pilot study (Parr, 2004). Both studies were conducted as one replication of a larger study (Stone III et al., 2005); the pilot being one of six replications and this study one of five replications nationwide. The National Research Center for Career and Technical Education (NRCCTE) funded and facilitated coordination of the larger study.

Research Questions

The following research questions guided the study:

1. What is the effect of a math-enhanced agricultural power and technology curriculum and aligned instructional approach on student performance as measured by (a) a traditional test of student math knowledge and by (b) an "authentic" assessment of student ability to use math to solve workplace problems?

2. Does a math-enhanced agricultural power and technology curriculum and aligned instructional approach affect students' need for post-secondary math remediation?

3. Does a math-enhanced agricultural power and technology curriculum and aligned instructional approach diminish students' acquisition of technical skills?

4. What were selected characteristics of students enrolled in, and instructors teaching, Agricultural Power and Technology in the state of Oklahoma during the 2004-2005 school year?

5. Does teacher adherence to the seven-element instructional model in the context of agricultural power and technology affect student achievement as measured by conventional standardized tests?

Null Hypotheses

The following null hypotheses guided the study's statistical analyses:

H_o 1 There is no difference between the two study groups on math performance as measured by a conventional standardized test of math achievement.

H_o 2 There is no difference between the two study groups on math performance as measured by a "real world" or problem-based test.

H_o 3 There is no difference between the two study groups on technical competence in agricultural power and technology as measured by an examination used to assess students' agricultural power and technology competence.

H_o 4 There is no difference between the two study groups on a math placement test used to determine students' need for math remediation at the post-secondary level.

The aforementioned research questions and null hypotheses guided the presentation of the study's findings and results. Each question and related hypotheses will be addressed in a separate section in this chapter.

General Description of Participants

Students and teachers from 32 secondary schools in the state of Oklahoma provided the data described in the findings of this study.

Selected Student Personal and Educational Characteristics

Student participants were asked to complete a pre-treatment questionnaire containing questions that described their personal characteristics. A summary of this information provides a description of the students that participated in this study.

A total of 417 students completed the questionnaire (control n = 212; experimental n = 205); 77.5% were male, 17.5% were female, and 5.0% did not specify their gender (see Table 2). The experimental group (n = 205) consisted of 80.5% male, 19.5% female, and 4.9% non-response. The control group (n = 212) consisted of 82.6% male, 17.4% female, and 5.2% non-response (see Table 3).

Table 2

Gender of Student Participants, Overall (N = 417)

Gender	n	%
Male	323	77.5
Female	73	17.5
No response	21	5.0

Table 3

Gender of Student Participants by Group (N = 417)

Gender	Experimental Group n	Experimental Group %	Control Group n	Control Group %
Male	157	76.6	166	78.3
Female	38	18.5	35	16.5
No Response	10	4.9	11	5.2

Regarding ethnicity, 44.4% of students selected “other” from the responses available; 24.5% reported being American Indian, 18.5% reported they were European/Anglo, 5.0% were Hispanic, 2.2% reported being African American, 0.5% reported being of Asian descent, and 5% did not respond to this question (see Table 4). Of students in the experimental group (n = 205), 43.4% selected “other,” 26.3% were American Indian, 16.6% reported being European/Anglo, 3.9% were Hispanic, 3.4% reported African American heritage, 0.5% were Asian, and 5.9% did not respond to this question. Of students in the control group (n = 212), 45.3% selected “other,” 22.6% were American Indian, 20.3% reported being European/Anglo, 6.1% were Hispanic, 0.9% reported African American heritage, 0.5% were Asian, and 4.2% did not respond to that item (see Table 5).

It should be noted that the wording of the question regarding student ethnicity was problematic and resulted in a rather large response in the “other” column. Some students might have misunderstood the selection “European/Anglo” and selected “other” instead. When the overall “other” and “European/Anglo” data were combined the resulting number was within five percentage points of the overall “European/Anglo” results reported in the pilot study (Parr, 2004, p. 66).

Table 4

Ethnicity of Student Participants, Overall (N = 417)

Ethnicity	n	%
Other	185	44.4
American Indian	102	24.5
European/Anglo	77	18.5
Hispanic	21	5.0
African American	9	2.2
Asian	2	0.5
No response	21	5.0

Table 5

Ethnicity of Student Participants by Group (N = 417)

Ethnicity	Experimental Group n	Experimental Group %	Control Group n	Control Group %
Other	89	43.4	96	45.3
American Indian	54	26.3	48	22.6
European/Anglo	34	16.6	43	20.3
Hispanic	8	3.9	13	6.1
African American	7	3.4	2	0.9
Asian	1	0.5	1	0.5
No response	12	5.9	9	4.2

When students were asked to provide information regarding their current grade classification, 28.8% of students reported they were twelfth-graders, 31.9% indicated they were in the eleventh grade, 32.1% said they were tenth graders, 1.7% were ninth graders, and 0.5% identified themselves as eighth graders. Twenty-one students (5.0%) did not report their grade level status (see Table 6). The experimental group (n = 205) consisted of 22.4% twelfth graders, 24.4% eleventh graders, 44.4% tenth graders, 2.4% ninth graders, and 1.0% eighth graders; 5.4% of this group did not respond to this question. The control group (n = 212) consisted of 34.9% twelfth graders, 39.2% eleventh graders, 20.3% tenth graders, 0.9% ninth graders; 4.7% of the control group students did not respond to this question (see Table 7).

Table 6

Grade Classification of Student Participants, Overall (N = 417)

Grade Classification	n	%
Twelfth Graders	120	28.8
Eleventh Graders	133	31.9
Tenth Graders	134	32.1
Ninth Graders	7	1.7
Eighth Graders	2	0.5
No response	21	5.0

Table 7

Grade Classification of Student Participants by Group (N = 417)

Grade Classification	Experimental Group n	Experimental Group %	Control Group n	Control Group %
Twelfth Graders	46	22.4	74	34.9
Eleventh Graders	50	24.4	83	39.2
Tenth Graders	91	44.4	43	20.3
Ninth Graders	5	2.4	2	0.9
Eighth Graders	2	1.0	0	0
No response	11	5.4	10	4.7

When students were asked about their age at the time of the study, 0.5% reported being 19 years of age, 10.3% responded that they were 18 years of age, 31.4% indicated they were 17 years of age, 29.5% responded that they were 16 years of age, 24.0% claimed to be 15 years of age, and 4.3% did not report their age (see Table 8). In the experimental group (n = 205), 0.5% reported being 19 years of age, 9.3% responded that they were 18 years of age, 22.9% indicated they were 17 years of age, 28.8% responded that they were 16 years of age, 34.1% claimed to be 15 years of age, and 4.4% did not report their age. Of the control group students (n = 212), 0.5% reported being 19 years of age, 11.3% responded that they were 18 years of age, 39.6% indicated they were 17 years of age, 30.2% responded that they were 16 years of age, 14.2% claimed to be 15 years of age, and 4.2% did not report their age (see Table 9).

Table 8

Age of Student Participants, Overall (N = 417)

Age	n	%
19	2	0.5
18	43	10.3
17	131	31.4
16	123	29.5
15	100	24.0
No response	18	4.3

Table 9

Age of Student Participants by Group (N = 417)

Age	Experimental Group n	Experimental Group %	Control Group n	Control Group %
19	1	0.5	1	.05
18	19	9.3	24	11.3
17	47	22.9	84	39.6
16	59	28.8	64	30.2
15	70	34.1	30	14.2
No response	9	4.4	9	4.2

Concerning students' average grades as reported on a letter grade scale, participants indicated the following: "mostly A's," 9.1%; "mostly A's and B's," 25.4%;

“mostly B’s,” 10.3%; “mostly B’s and C’s,” 25.7%; “mostly C’s,” 6.0%; “mostly C’s and D’s,” 9.4%; “mostly D’s,” 0.2%; “mostly D’s and F’s,” 0.5%; “mostly F’s,” 0.2%; and, 55 students (13.2%) failed to respond to this question (see Table 10). Participants in the experimental group (n = 205) indicated the following: “mostly A’s,” 9.3%; “mostly A’s and B’s,” 22.9%; “mostly B’s,” 13.2%; “mostly B’s and C’s,” 24.4%; “mostly C’s,” 6.3%; “mostly C’s and D’s,” 8.3%; “mostly D’s,” 0.5%; “mostly D’s and F’s,” 0.5%; and, 28 students (13.7%) failed to respond to this question. Participants in the control group (n = 212) responded as follows: “mostly A’s,” 9.0%; “mostly A’s and B’s,” 26.9%; “mostly B’s,” 7.5%; “mostly B’s and C’s,” 26.9%; “mostly C’s,” 5.7%; “mostly C’s and D’s,” 10.4%; “mostly D’s and F’s,” 0.5%; “mostly F’s,” 0.5%; and 27 students (12.7%) failed to respond to this question (see Table 11).

Table 10

Average Grades[a] of Student Participants on a Letter Grade Scale, Overall (N = 417)

Average Grades	N	%
Mostly A’s	38	9.1
Mostly A’s and B’s	106	25.4
Mostly B’s	43	10.3
Mostly B’s and C’s	107	25.7
Mostly C’s	25	6.0
Mostly C’s and D’s	39	9.4
Mostly D’s	1	0.2
Mostly D’s and F’s	2	0.5
Mostly F’s	1	0.2
No response	55	13.2

Note. [a]Self-reported.

Table 11

Average Grades[a] of Student Participants on a Letter Grade Scale by Group (N = 417)

Average Grades	Experimental Group n	Experimental Group %	Control Group n	Control Group %
Mostly A's	19	9.3	19	9.0
Mostly A's and B's	49	23.9	57	26.9
Mostly B's	27	13.2	16	7.5
Mostly B's and C's	50	24.4	57	26.9
Mostly C's	13	6.3	12	5.7
Mostly C's and D's	17	8.3	22	10.4
Mostly D's	1	0.5	0	0
Mostly D's and F's	1	0.5	1	0.5
Mostly F's	0	0	1	0.5
No response	28	13.7	27	12.7

Note. [a]Self-reported.

Selected Characteristics of Participating Teachers

Teacher participants completed a pre-treatment questionnaire that provided a limited amount of personal information. The following is a summary of the information reported by the teachers who participated in this study.

Of the 32 agricultural education teachers (experimental n = 16; control n = 16), 96.9% were male and 3.1% were female (see Table 12). The experimental group teachers (n = 16) consisted of 93.7% male and 6.3% female. Of the control group teachers (n = 16), 100% were male (see Table 13).

Table 12

Gender of Teacher Participants, Overall (N = 32)

Gender	N	%
Male	31	96.9
Female	1	3.1

Table 13

Gender of Teacher Participants by Group (N = 32)

Gender	Experimental Group n	Experimental Group %	Control Group n	Control Group %
Male	15	93.7	16	100
Female	1	6.3	0	0

Teachers from both groups reported their ethnicity as follows: 78.1% European/Anglo and 18.8% American Indian. One teacher (3.1%) did not indicate his or her ethnicity (see Table 14). Accordingly, the experimental group of teachers were 68.8% European/Anglo, and 25.0% American Indian; one experimental teacher (6.2%) did not respond to this question. The control group teachers were 87.5% European/Anglo and 12.5% American Indian (see Table 15).

Table 14

Ethnicity of Teacher Participants, Overall (N = 32)

Ethnicity	n	%
European/Anglo	25	78.1
American Indian	6	18.8
No Response	1	3.1

Table 15

Ethnicity of Teacher Participants by Group (N=32)

Ethnicity	Experimental Group n	Experimental Group %	Control Group n	Control Group %
European/ Anglo	11	68.8	14	87.5
American Indian	4	25.0	2	12.5
No Response	1	6.2	0	0

Analysis of Pre-treatment Measure

In the fall of 2004, the two groups of student participants were tested using the Terra Nova CAT™ Survey Edition (CTB/McGraw-Hill) examination to determine the equivalence of groups in regard to their general math aptitude. The control group mean score for this exam was 49.2119 with a standard deviation of 8.23297; the experimental group mean score was 43.4399 with a standard deviation of 8.00857 (see Table 16). A comparison of this data using a one-way ANOVA indicated that a significant difference in mean scores existed between the groups on general math aptitude at an *a priori* determined alpha level of 0.5 (p = .047; see Table 17).

Table 16

Descriptive Statistics for Student Math Performance by Group on the Terra Nova Survey Examination (Pre-treatment Measure)

	n	Mean	*SD*	Minimum	Maximum
Control	18	49.2119	8.23297	33.11	67.20
Experimental	16	43.4399	8.00857	28.67	57.25
Total	34	46.4957	8.52191	28.67	67.20

Note. The total number of classes that took the Terra Nova Basic Survey Examination differ when compared to the total number of agricultural education teachers who participated in the study (N = 32) due to the fact that two control group teachers taught two sections of agricultural power and technology. Thus, two sections (classes) were tested for each of those teachers.

Table 17

Comparative Analysis of Student Math Performance by Group Means as Measured by the Terra Nova Survey Examination (Pre-treatment Measure)

	SS	*df*	*MS*	*F*	*p*
Between Groups	282.208	1	282.208	4.271	.047*
Within Groups	2114.349	32	66.073		
Total	2396.557	33			

$^*p < .05$.

The use of a pre-treatment measure to determine equivalency of groups regarding general math aptitude prior to the administration of the treatment is a method of reducing experimental error using statistical means rather than experimental (Keppel, 1991). As a pre-treatment measure, the test becomes a covariate and is useful in further refining experimental error and to adjust treatment effects when differences between the experimental and control groups are determined prior to the treatment (Keppel, 1991). Due to finding a significant difference between the experimental and control groups on the pre-treatment measure, analysis of the posttest math examinations was done using the analysis of covariance (ANCOVA) procedure.

Analysis of Posttests

H_o 1 There is no difference between the two study groups on math performance as measured by conventional standardized tests of math achievement.

To address null hypothesis one, student participants in both the experimental and control groups were tested on their general math aptitude using the Terra Nova CAT™ Basic Battery (CTB/McGraw-Hill) Level 21/22 Form A examination after the treatment was completed. The control group mean score was 44.9718 with a standard deviation of 14.72384, and the experimental group mean score was 46.1749 with a standard deviation of 11.06871 (see Table 18). An ANCOVA comparison of this measure revealed no significant difference in general math aptitude between the groups following the treatment (p = .125) at an *a priori* determined alpha level of .05 (see Table 19). The null hypothesis was not rejected based on this analysis. Equality of variances was assured with a Levene's Test (α = .696). Effect size was calculated using Keppel's (1991) formula for Omega squared ($\acute{\omega}^2$ = .031), which is considered a "small" effect (Cohen, 1977).

Table 18

Descriptive Statistics for Student Math Performance by Group on the Terra Nova Basic Battery Examination

	n	Mean	*SD*	Minimum	Maximum
Control	18	44.9718	14.72384	19.57	76.09
Experimental	14	46.1749	11.06871	21.74	60.14
Total	32	45.4982	13.06259	19.57	76.09

Table 19

Comparative Analysis of Student Math Performance by Group as Measured by the Terra Nova Basic Battery Examination with Pre-treatment Measure as a Covariate

Source	*SS*	*df*	*MS*	*F*	*p*
Pre-treatment Measure	2079.080	1	2079.080	18.847	.000*
Between Groups	275.997	1	275.997	2.502	.125
Within Groups	3199.090	29	110.313		
Total	5289.569	31			

*$p < .05$.

Note. Degrees of freedom differ for the Terra Nova Basic Battery Examination when compared to the pre-treatment measure due to the random assignment of the three mathematics posttests to two classes in the experimental group with small numbers of students, which prevented all three measures being administered in those classrooms.

H_o 2 There is no difference between the two study groups on math performance as measured by a "real world" or problem-based test.

To address null hypothesis two, student participants in both the experimental and control groups were tested on their "real world" math aptitude using the WorkKeys examination (ACT, 2006) after the treatment was completed. The control group mean score was 57.5852 with a standard deviation of 12.99742, and the experimental group mean score was 56.9389 with a standard deviation of 10.20943 (see Table 20). A

ANCOVA comparison of this measure revealed no significant difference in “real world” math aptitude between the groups following the treatment (p = .472) at an *a priori* determined alpha level of .05 (see Table 21). The null hypothesis was not rejected based on this analysis. Equality of variances was assured with a Levene’s Test (α = .660). Effect size was calculated using Keppel’s (1991) formula Omega squared ($\acute{\omega}^2$ = -.015), which is considered a “very small” effect (Cohen, 1977).

Table 20

Descriptive Statistics for Student Math Performance by Group on the WorkKeys Examination

	n	Mean	*SD*	Minimum	Maximum
Control	16	57.5852	12.99742	24.24	72.73
Experimental	15	56.9389	10.20943	38.13	73.33
Total	31	57.2725	11.54193	24.24	73.33

Table 21

Comparative Analysis of Student Math Performance by Group as Measured by the WorkKeys Examination with Pre-treatment Measure as a Covariate

Source	*SS*	*df*	*MS*	*F*	*p*
Pretest	973.949	1	973.949	9.032	.006*
Between Groups	57.373	1	57.373	.532	.472
Within Groups	3019.298	28	107.832		
Total	3996.481	30			

*$p < .05$.

Note. Degrees of freedom differ for the WorkKeys Examination when compared to the pre-treatment measure due to the random assignment of the three mathematics posttest to two classrooms in the control group and one classroom in the experimental group with small numbers of students, which prevented all three measures being administered in those classrooms.

H_o 3 There is no difference between the two study groups on technical competence in agricultural power and technology as measured by an examination used to assess students' agricultural power and technology competence.

To address null hypothesis three, student participants in both the experimental and control groups were tested on their technical competency in agricultural power and technology using the Oklahoma Department of Career and Technology Education's, on-line agricultural mechanics competency examination after the treatment. The control group mean score was 45.5522 with a standard deviation of 5.61946, and the experimental group mean score was 44.3050 with a standard deviation of 4.82438 (see Table 22). A one-way ANOVA comparison of this measure revealed no significant difference in technical competence between the groups following the treatment (p = .495) at an *a priori* determined alpha level of .05 (see Table 23). The null hypothesis was not rejected based on this analysis.

Table 22

Descriptive Statistics of Student Technical Competence by Group as Measured by the Oklahoma Department of Career and Technology Education's, On-line Agricultural Mechanics Competency Examination

	n	Mean	*SD*	Minimum	Maximum
Control	18	45.5522	5.61946	33.20	57.18
Experimental	16	44.3050	4.82438	34.85	57.18
Total	34	44.9653	5.21980	33.2	57.18

Table 23

Comparative Analysis of Student Technical Competence by Group as Measured by the Oklahoma Department of Career and Technology Education's, On-line Agricultural Mechanics Competency Examination

	SS	*df*	*MS*	*F*	*p*
Between Groups	13.177	1	13.177	.476	.495
Within Groups	885.951	32	27.686		
Total	899.128	33			

H_o 4 There is no difference between the two study groups on a math placement test used to determine students' need for math remediation at the post-secondary level.

To address null hypothesis four, student participants in both the experimental and control groups were tested on their need for math remediation at the post-secondary level using the ACCUPLACER examination (College Entrance Examination Board, 2002) after the treatment. The control group mean score was 36.4602 with a standard deviation of 7.62071, and the experimental group mean score was 40.3914 with a standard deviation of 13.39890 (see Table 24). An ANCOVA comparison of this measure revealed no significant difference in the need for math remediation between the groups following the treatment ($p = .081$) at an *a priori* determined alpha level of .05 (see Table 25). The null hypothesis was not rejected based on this analysis. Equality of variances was assured with a Levene's Test ($\alpha = .126$). Effect size was calculated using Keppel's (1991) formula for Omega squared ($\acute{\omega}^2 = .062$), which is considered a "medium" effect (Cohen, 1977).

Table 24

Descriptive Statistics for Student Math Performance by Group on the ACCUPLACER Examination

	n	Mean	*SD*	Minimum	Maximum
Control	18	36.4602	7.62071	24.57	54.29
Experimental	16	40.3914	13.39890	21.43	74.29
Total	34	38.3102	10.74659	21.43	74.29

Table 25

Comparative Analysis of Student Math Performance by Group as Measured by the ACCUPLACER Examination with Pre-treatment Measure as a Covariate

Source	*SS*	*df*	*MS*	*F*	*p*
Pretest	484.625	1	484.625	4.701	.038*
Between Groups	334.934	1	334.934	3.249	.081
Within Groups	3195.611	31	103.084		
Total	3811.147	33			

*$p < .05$.

Qualitative Data Analysis

Experimental group teacher teams were required to submit reports prior to and after the teaching of each math-enhanced lesson. The math teachers completed a Pre-Teaching Report (see Appendix R), and agricultural education teachers completed a Post-Teaching Report (see Appendix S). These reports were sent to the researcher via electronic mail and were used to assess the study's fidelity of treatment, i.e., "Did the teacher administer the prescribed treatment?"

To address the issue of potential compromise to the study's fidelity of the treatment, a comparison was made between the classrooms where all 17 of the math-enhanced lessons were taught and the remaining five experimental classrooms (see Tables 26 and 27). A one-way ANOVA comparison detected no significant difference in performance between groups for all posttests following the treatment at an *a priori* determined alpha level of .05 (see Table 28).

Table 26

Number of Math-Enhanced Lessons Taught by Experimental Group Agricultural Education Teachers, Self Reported

Number of Lessons Taught	Number of Teachers	%
17	11	68.8
16	2	12.5
15	2	12.5
7	1	6.2

Table 27

Descriptive Statistics of Number of Math-Enhanced Lessons Taught by Experimental Agricultural Education Teachers

Examination	Group[a]	n	Mean	*SD*	Minimum	Maximum
ACCU PLACER	0	5	43.9736	8.40279	30.48	52.86
	1	11	38.7631	15.22236	21.43	74.29
	Total	16	40.3914	13.3989	21.43	74.29
Terra Nova Battery	0	4	47.9891	3.38356	43.48	51.09
	1	10	45.4493	13.08068	21.74	60.14
	Total	14	46.1749	11.06871	21.74	60.14
WorkKeys	0	5	59.1715	14.73993	38.18	73.33
	1	10	55.8225	7.83727	40.40	65.80
	Total	15	56.9389	10.20943	38.18	73.33
Ag Mechanics	0	5	42.1340	3.99562	37.71	46.16
	1	11	45.2918	5.00981	34.85	52.40
	Total	16	44.3050	4.82438	34.85	52.40

Note. [a]0 = Teachers who reported teaching fewer than 17 math-enhanced lessons; 1 = Teachers who reported teaching all 17 math-enhanced lessons.

Table 28

Comparative Analysis of Examination Scores by Group Means Depending on the Number of Math-Enhanced Lessons Taught by Experimental Agricultural Education Teacher (n = 16)

Examination		*SS*	*df*	*MS*	*F*	*p*
ACCUPLACER	Between Groups	93.326	1	93.326	.503	.490
	Within Groups	2599.631	14	185.688		
	Total	2692.957	15			
Terra Nova Battery	Between Groups	18.431	1	18.431	.140	.714
	Within Groups	1574.282	12	131.190		
	Total	1592.713	13			
Work Keys	Between Groups	37.387	1	37.387	.342	.569
	Within Groups	1421.867	13	109.374		
	Total	1459.254	14			
Ag Mechanics	Between Groups	34.278	1	34.278	1.524	.237
	Within Groups	314.842	14	22.489		
	Total	349.120	15			

Note. Degrees of freedom differ depending on the number of students in a classroom who were randomly assigned to take one of the three posttests of mathematical ability.

The results of teachers' post-teaching reports were combined with reports from on-site observations as a way to assess the study's fidelity of treatment. The review of videotaped lessons, provided by the experimental agricultural education teachers, and their answers to specific questions during post-study focus group sessions were additional means of triangulating data to determine the study's fidelity of treatment.

Results of four on-site observations of experimental group agricultural education teachers revealed that two complete and two partial lessons were taught by those teachers who were observed. Twenty-two videotapes were submitted by the experimental agricultural education teachers; 19 were deemed usable and of those four depicted complete lessons, i.e., all seven-elements were observed. The remaining 15 videotapes were of partial lessons. (It is important to note that many of the math-enhanced lessons required multiple class periods to be taught properly.) Careful examination of the transcripts from the post-study focus groups provided no evidence to conclude that the prescribed treatment was not carried out.

The triangulation of data collected from instructors' post-teaching reports, on-site observations, expert review of videotaped lessons, and transcripts from focus group sessions found no evidence to support that the prescribed treatment was not administered by the experimental agricultural education teachers (D. Pearson, personal communication, March 27, 2006). Subsequently, the study's fidelity of treatment was confirmed.

CHAPTER V

SUMMARY, CONCLUSIONS, RECOMMENDATIONS, IMPLICATIONS AND DISCUSSION

Summary

The purpose of this study was to empirically test the hypothesis that students who participated in a contextualized, mathematics-enhanced high school agricultural power and technology curriculum (i.e., experimental curriculum and instructional approach) would develop a deeper and more sustained understanding of selected mathematical concepts than those students who participated in the traditional agricultural power and technology curriculum. The assumption was that students who received the experimental curriculum and instruction would be able to transfer their math learning to new and novel settings (Stone III et al., 2005) in their technical field and more broadly. Mathematics achievement was measured by student performance on three standardized, “paper-and-pencil” tests: Terra Nova CAT™ Basic Battery (CTB/McGraw-Hill) Level 21/22 Form A, WorkKeys, and ACCUPLACER. Student technical competence was measured by the Oklahoma Department of Career and Technology Education’s, on-line agricultural mechanics competency examination. In addition, improved performance on these tests could offer a concrete demonstration of skills to potential employers and to higher education institutions resulting in a reduced need for workplace and post-secondary remediation in mathematics (Parr, 2004).

This full-year study was conducted as a result of a pilot study carried out during the spring 2004 semester (Parr, 2004). Accordingly, the investigation's research questions, null hypotheses, assumptions, and limitations echo those of the pilot study (Parr, 2004). Both studies were conducted as one replication of a larger study (Stone III et al., 2005); the pilot being one of six replications and this study one of five replications nationwide. The National Research Center for Career and Technical Education (NRCCTE) funded and facilitated coordination of the larger study.

Research Questions

The following research questions guided the study:

1. What is the effect of a math-enhanced agricultural power and technology curriculum and aligned instructional approach on student performance as measured by (a) a traditional test of student math knowledge and by (b) an "authentic" assessment of student ability to use math to solve workplace problems?

2. Does a math-enhanced agricultural power and technology curriculum and aligned instructional approach affect students' need for post-secondary math remediation?

3. Does a math-enhanced agricultural power and technology curriculum and aligned instructional approach diminish students' acquisition of technical skills?

4. What were selected characteristics of students enrolled in, and instructors teaching, Agricultural Power and Technology in the state of Oklahoma during the 2004-2005 school year?

5. Does teacher adherence to the seven-element instructional model in the context of agricultural power and technology affect student achievement as measured by conventional standardized tests?

Null Hypotheses

The following null hypotheses guided the study's statistical analyses:

H_o 1 There is no difference between the two study groups on math performance as measured by a conventional standardized test of math achievement.

H_o 2 There is no difference between the two study groups on math performance as measured by a "real world" or problem-based test.

H_o 3 There is no difference between the two study groups on technical competence in agricultural power and technology as measured by an examination used to assess students' agricultural power and technology competence.

H_o 4 There is no difference between the two study groups on a math placement test used to determine students' need for math remediation at the post-secondary level.

Population

Teachers

Oklahoma agricultural education teachers who participated in this study were recruited and randomly assigned to either the control or experimental group as part of the pilot study. A total of 38 teachers, 18 in the experimental group and 20 in the control group, participated in the pilot study (Parr, 2004). Participating teachers were contacted via a postal mailed letter (Appendix B) by the researcher in March 2004 to solicit their participation in the year-long study. A total of 32 teachers, 16 in the experimental group and 16 in the control group, agreed to be involved in the year-long study that was conducted during the 2004-2005 school year.

Group 1. Agricultural education instructors who taught math-enhanced lessons using an aligned instructional approach within an agricultural power and technology curriculum during the 2004-2005 school year (i.e., experimental group teachers, n = 16).

Group 2. Agricultural education instructors who taught the traditional agricultural power and technology curriculum during the 2004-2005 school year (i.e., control group teachers, n = 16).

Students

Oklahoma high school students (N = 417) who were enrolled in 32 schools and received instruction in agricultural power and technology during the 2004-2005 school year participated in this study.

Group 1. Students who received instruction via math-enhanced lessons with an aligned instructional approach in the context of an agricultural power and technology curriculum during the 2004-2005 school year (i.e., experimental group students, n = 205).

Group 2. Students who received instruction via a traditional agricultural power and technology curriculum and instructional approach during the 2004-2005 school year (i.e., control group students, n = 212).

Design of the Study

This study utilized a posttest only control group experimental design (Campbell & Stanley, 1963). Participating teachers and their classrooms were randomly assigned to either the experimental or control groups. Accordingly, the resulting unit of analysis was intact classrooms. The randomly assigned classrooms were pre-tested to determine level of equivalence regarding students' basic mathematical skills (Campbell & Stanley, 1963; Tuckman, 1999). Four posttest measures were administered upon completion of the treatment: three tests assessed student performance in mathematics and one test assessed student technical competence in agricultural power and technology. The study's research design is illustrated in Figure 4.

Group		Time	
Experimental	R	X	O
Control	R	______	O

Figure 4. Research Design

Treatment

The treatment in this study consisted of the *Math-in-CTE* model developed by the NRCCTE. The model involved both a particular pedagogy and a prescribed process that can be expressed in the following mathematical equation:

(Pedagogy)(Process) = Student Math Performance

Further, in mathematical terms, without the prescribed pedagogy and related process variables the results found would not have occurred.

This model is based on the basic assumption that occupations aligned to career and technical programs are rich in math content and thus Career and Technical Education (CTE) programs should strive to enhance the math embedded in their existing curricula. This model was developed to assist CTE teachers in identifying math in their curricula, and to improve their instruction as it related to those math concepts. The goal of such instruction would be for CTE students to view math as they would any other tool (e.g., a saw, a tractor, a plow) necessary to complete a task in their occupational area (Stone III et al., 2005).

The pedagogical part of the NRCCTE model for this study consisted of 17, math-enhanced, agricultural power and technology lessons developed by the experimental agricultural education teachers and their math teacher partners during the pilot study. These lessons were refined further at additional professional development sessions provided for teachers during the summer of 2004 (Appendix Q and V), prior to the 2004-2005 school year. All lessons were revised and improved to fit the NRCCTE model for a math-enhanced lesson (Figure 6).

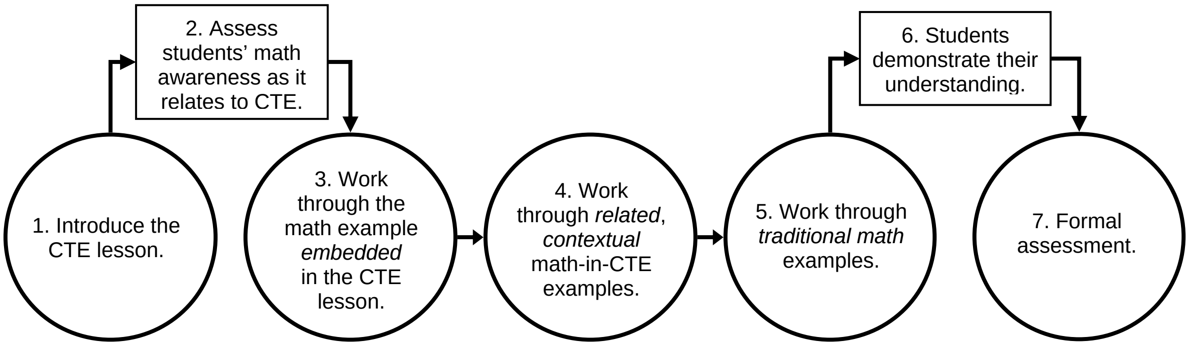

Figure 6. The NRCCTE Model: The Seven-elements of a Math-Enhanced Lesson (Stone III et al., 2005)

The development of math-enhanced agricultural power and technology lessons and the treatment's pedagogy (i.e., aligned instructional approach) was just one aspect of the NRCCTE model. The study's treatment also included the creation of a process by which agricultural education teachers in the experimental group "learned" to develop and teach the math-enhanced agricultural power and technology lessons. This process consisted of sustaining the agriculture-math teacher partnerships (i.e., communities of practice), curriculum mapping, developing a scope and sequence for teaching the lessons, providing professional development, and implementing the math-enhanced lessons.

Measures of Student Achievement

A battery of five examinations was administered prior to (1) and following (4) the treatment to measure the mathematical performance of students and to assess their technical competence in agricultural power and technology.

Quantitative Data

The Terra Nova CAT™ Survey Edition (CTB/McGraw-Hill) examination (25 items) used to establish equivalence of groups prior to the study's treatment had a reliability coefficient of .84 (Cronbach's alpha) (McGraw-Hill, 2000). The examination used to determine a student's need for mathematics remediation at the post-secondary level, the ACCUPLACER (35 items), had an internal consistency reliability coefficient of .92 (Cronbach's alpha) (College Entrance Examination Board, 2002). The Terra Nova CAT™ Basic Battery (CTB/McGraw-Hill) Level 21/22 Form A (46 items) used as a post-treatment measure for evaluation of student general math aptitude has a reliability coefficient of .91 (Cronbach's alpha) (McGraw-Hill, 2000). The examination that measured a student's ability to use math to solve workplace-related problems, i.e., WorkKeys (ACT, 2006) (33 items), has scored a .88 (KR-20) reliability estimate (B. Ziomeck, personal communication, December 2, 2004, as reported by Parr, 2004).

Student technical competence was measured by the Oklahoma Department of Career and Technology Education's, on-line agricultural mechanics competency examination (42 items). The content validity of this examination is assured based on the methods employed by the Testing Division of the Oklahoma Department of Career and Technology Education to develop the examination. These methods are outlined in the department's Testing Handbook (Oklahoma Department of Career and Technology Education, 2004a), and are as follows:

> Using values and information in the skills standards, the Testing Division determines the test specifications and contracts with subject matter experts to develop the test. When writing test items, subject matter experts typically

> reference materials identified in the curriculum crosswalk that is included in the skills standard, which reinforces the connection between standards, instruction, and assessment.
>
> A committee of subject matter experts reviews the test and carefully scrutinizes individual test items. Specifically, the committee validates the structure and content of each question and verifies the question has been keyed correctly. (p. 6)

Data Collection

Data collection began in the fall of 2004 with administration of the pre-treatment measure of equivalence and student questionnaire to both the experimental and control groups. Posttests and additional questionnaires were administered to both groups as was appropriate per the closing of each school's term.

Data were collected by testing liaisons located at each experimental and control school. Detailed pre-treatment instructions were provided to each liaison via a Liaison Handbook produced and distributed by the NRCCTE (National Research Center for Career and Technical Education, 2004a). On August 13, 2004, testing liaisons were sent via postal mail from the project coordinator (researcher) all of the pre-treatment test materials, student questionnaires, and instructions. Posttesting instructions were provided later in the form of a supplement to the original Liaison Handbook. The handbook supplement was provided to the testing liaisons via postal mail, along with the materials necessary to administer the posttests and student questionnaires. Per the instructions for administering the tests and questionnaires, testing liaisons assigned each student a unique ID number, assured that the answer sheets were properly coded, collected the completed test answer sheets into pre-labeled, stamped envelopes, and returned the testing materials to the researcher via postal mail.

Qualitative and descriptive data were collected during and at conclusion of the study to measure the study's fidelity of treatment. Experimental teacher pairs were required to submit a report prior to and after each math-enhanced lesson was taught. Math teachers completed a Pre-Teaching Report (Appendix R) and agricultural education teachers completed a Post-Teaching Report (Appendix S). The pre-teaching reports provided information regarding the agricultural education teacher's understanding of the mathematical concepts in the math-enhanced lesson to be taught, and the amount of assistance given the agricultural education teacher by his or her math teacher partner. In the post-teaching reports, agricultural education teachers reported any difficulties they had experienced in teaching the math-enhanced lessons, and if each of the seven-elements had been addressed during their instruction.

One-in-four of the experimental classrooms were visited by a recognized qualitative researcher from the NRCCTE to observe the instructors teach one of the seven-element, math-enhanced lessons. In addition to the on-site lesson observations, the agricultural education teachers in the experimental group provided videotapes of one math-enhanced lesson that they taught during the study. These videotapes were reviewed by two recognized qualitative researchers from the NRCCTE to determine if instructors had implemented the prescribed treatment. What is more, during the study's final professional development session, in June 2005, experimental group teachers, agricultural education and math, who attended were divided into three focus groups: 1) agricultural education teachers; 2) math teachers; and, 3) a mixed group of agricultural education teachers and math teachers. These focus groups were facilitated by three staff members from the NRCCTE. The group interviews were designed to gather general information about the study, and to provide additional data regarding the study's fidelity of treatment.

Findings from the pre-and post-teaching reports, selected on-site observations, and post-study focus groups were used as a form of "triangulation" (Creswell, 2002) to determine the extent to which the study's treatment was carried out.

Data Analysis

Selected characteristics of participating students and teachers were summarized using frequencies and percentages calculated from the study's questionnaires. The pre-treatment measure used to determine the equivalency of groups regarding students' general mathematical ability and the post-treatment measure of agricultural power and technology competence were analyzed using one-way analysis of variance (ANOVA). Due to finding a significant difference ($p = .047$) between the experimental and control groups based on results of the pre-treatment measure, comparative analyses of the posttest math measures were conducted using the analysis of covariance (ANCOVA) procedure.

The value of using ANCOVA as a means to analyze data from an experimental study with random assignment of subjects was outlined by Keppel (1991):

> The analysis of covariance reduces experimental error by statistical, rather than by experimental, means. Subjects are first measured on the concomitant variable, usually called the **covariate** in the context of the analysis of covariance, which consists of some relevant ability or characteristic. . . . Only at the time of

> statistical analysis does this information come into play, when it is used to accomplish two important adjustments: (1) to refine estimates of experimental error and (2) to adjust treatment effects for any differences between treatment groups that existed before the experimental treatments were administered. . . . Thus, the analysis of covariance is expected to achieve its greatest benefits by reducing the size of the *error term*; any correction for preexisting differences produced by random assignment will be small by comparison. (pp. 301-302)

Effect size, for the purpose of describing *practical significance,* was calculated using Keppel's (1991) formula for Omega squared for all post-treatment measures of students' mathematical abilities. The *Publication Manual of the American Psychological Association* 5th edition (2001) lists failure to report effect sizes as one of seven common errors found in the design and reporting of research. The manual goes on to state:

> For the reader to fully understand the importance of your findings, it is almost always necessary to include some index of effect size or strength of relationship in your Results section. . . . The general principle to be followed, however, is to provide the reader not only with information about statistical significance but also with enough information to assess the magnitude of the observed effect or relationship. (pp. 25-26)

The *Statistical Package for the Social Sciences version 13.0* was utilized to complete all of the study's statistical analysis.

Results

The student pre-treatment questionnaire revealed that the student participants were mostly male (77.5%), and of European/Anglo descent (62.9%). However, one-in four-students reported their race as Native American. Most of the students were either 16 (29.5%) or 17 (31.4%) years of age at the time of the study, and were enrolled almost equally in the 12^{th} (28.8%), 11^{th} (31.9%), and 10th grades (32.1%). Approximately 7-in-10 (70.5%) students reported that their average grades for all courses were mostly B's and C's or higher.

Except for one teacher participant, all were male (96.9%). Nearly 4 of 5 teachers reported they were of European/Anglo descent (78.1%).

A significant difference (p = .047) was found between groups on the math pre-treatment measure (i.e., Terra Nova CAT™ Survey Edition); this finding prompted the researcher to analyze students' math posttest scores using the ANCOVA procedure. None of the study's three null hypotheses related to students' math aptitude were rejected based on the data analysis. No significant differences (p < .05) were found between the two study groups as measured by a conventional standardized test of math achievement (i.e., Terra Nova CAT™ Basic Battery), on math performance as measured by a "real world" or problem-based test (i.e., WorkKeys), or for performance on a math placement test used to determine a student's need for math remediation at the post-secondary level (i.e., ACCUPLACER). Effect size was calculated using Omega squared. Accordingly, a "medium" effect ($\acute{\omega}^2$ = .062) was revealed for the ACCUPLACER examination, and a "small" effect ($\acute{\omega}^2$ = .031) for the TerraNova Basic Battery examination (Cohen, 1977). Effect size for the WorkKeys examination was found to be ($\acute{\omega}^2$ = -.015), which is considered a “very small” effect (Cohen, 1977). Finally, no significant difference (p = .495) was found between the two study groups on technical competence in agricultural power and technology as measured by an examination used to assess a student’s agricultural power and technology competence (i.e., the Oklahoma Department of Career and Technology Education’s, on-line agricultural mechanics competency examination).

Analysis of qualitative data indicated that 11 of 16 experimental agricultural education teachers taught all 17 of the math-enhanced lessons. However, analysis revealed that there was no significant difference ($p < .05$) in the posttest measures between the 11 classrooms where all 17 lessons were taught and the five classrooms where less than 17 math-enhanced lessons were delivered. Moreover, data gathered from on-site observations, review of videotaped lessons, and transcripts derived from the post-study focus groups provided no evidence that the prescribed treatment was not administered by the experimental agricultural teachers, excluding the finding that some teachers (11) were able to teach all of the prescribed, math-enhanced lessons and others (5) were not.

Conclusions

The analysis of data regarding each of the study’s research questions formed the basis for the following conclusions:

1. What is the effect of a math-enhanced agricultural power and technology curriculum and aligned instructional approach on student performance as measured by (a) a traditional test of student math knowledge and by (b) an “authentic” assessment of student ability to use math to solve workplace problems?

Concerning research question one, this study found that within this particular population, a math-enhanced agricultural power and technology curriculum and aligned instructional approach did not result in a significant increase ($p < .05$) in student performance as measured by (a) a traditional test of student math knowledge (i.e., Terra Nova CAT™ Basic Battery) ($p = .125$) or by (b) an "authentic" assessment of student ability to use math to solve workplace problems (i.e., WorkKeys) ($p = .472$).

2. Does a math-enhanced agricultural power and technology curriculum and aligned instructional approach affect students' need for post-secondary math remediation?

Concerning research question two, this study found that within this particular population, a math-enhanced agricultural power and technology curriculum and aligned instructional approach did not significantly affect ($p < .05$) students' need for math remediation at the post-secondary level (i.e., ACCUPLACER) ($p = .081$).

3. Does a math-enhanced agricultural power and technology curriculum and aligned instructional approach diminish students' acquisition of technical skills?

Concerning research question three, this study found that within this particular population, a math-enhanced agricultural power and technology curriculum and aligned instructional approach did not significantly diminish ($p < .05$) students' acquisition of technical skills (i.e., Oklahoma Department of Career and Technology Education's, on-line agricultural mechanics competency examination) ($p = .495$).

4. What were selected characteristics of students enrolled in, and instructors teaching, Agricultural Power and Technology in the state of Oklahoma during the 2004-

2005 school year?

Concerning research question four, this study found that the student participants were mostly male and of European/Anglo descent. However, one-in-four students reported their race as Native American. Most of the students were either 16 or 17 years of age at the time of the study and were enrolled almost equally in the 12th, 11th, and 10th grades. Approximately, 7-in-10 students reported that their average grades for all courses were mostly B's and C's or higher.

Except for one participant all teachers were male. Nearly 4 of 5 teachers reported that they were of European/Anglo descent.

5. Does teacher adherence to the seven-element instructional model in the context of agricultural power and technology affect student achievement as measured by conventional standardized tests?

Concerning research question five, this study found that within this particular population, 11 of the 16 experimental agricultural education teachers taught all of the 17 math-enhanced lessons prescribed as a part of the study's treatment. Subsequent analysis ($p < .05$) revealed no significant differences in any of the posttest measures due to variation in the number of lessons taught by the experimental group agricultural education teachers.

In conclusion, analysis of the data resulted in the decision not to reject any the study's four null hypotheses at the apriori alpha of .05.

Recommendations

Recommendations for Research

Future investigations should be conducted to determine the efficacy of the *Math-in-CTE* model as developed by the NRCCTE, for its usefulness in improving student achievement in other academic areas. For example, could this model, i.e., one that involves both pedagogy and process, be used to improve student achievement in science with the resulting equation?

(Pedagogy)(Process) = Student *Science* Performance

Parr (2004) called for further inquiry concerning the evaluation instruments employed in this study, particularly the ACCUPLACER examination as it provided the only significant ($p < .05$) finding in the pilot study. Albeit not statistically significant at .05, the ACCUPLACER examination also demonstrated the largest effect size and measure of practical significance in this year-long study. This finding warrants additional research into the specific mathematical concepts measured by it, and why the context of agricultural power and technology may be a robust curriculum that assists in improving student learning for the type of mathematics the ACCUPLACER examination assesses.

More than one-fourth of the students who participated in this study reported their ethnicity as Native American. Further analysis of the data collected should be conducted to determine if any significant differences emerge when the performance of Native American students is compared to other ethnic groups. If significant findings were to emerge that supported the experimental treatment, then replications of this study in other states with significant Native American populations may be warranted.

The emergence of professional communities of practice in this study also warrants additional research. The identification of factors inherent to the design of this study that resulted in the transformation of teacher teams as described by Parr (2004) into communities of practice is of interest. The term "community of practice" as used in this study is consistent with the theory espoused by Wenger (1998), and verified in educational practice by Yamagata-Lynch (2001). Although Yamagata-Lynch suggested that the term community of practice be used as a metaphor for analyzing current practices, she also promoted the idea of examining the advantages and disadvantages of using community of practice as a tool for crafting educational environments, including learning contexts that hold promise for improving student achievement.

Using the concept of communities of practice as a tool for designing effective educational environments, research regarding the development of communities of practice among pre-service agricultural education teachers and pre-service academic teachers should be conducted. Would the development of these communities early in teachers' professional careers result in the establishment of communities of practice that, in turn, create vibrant and effective schools where the quality of student learning is exemplary?

In both the pilot and full-year studies, differences of practical significance between the control and experimental groups regarding student mathematics performance were found; however, only the pilot study demonstrated a statistically significant difference ($p < .05$), i.e., for the ACCUPLACER examination. In contrast, students' performance on the pre-treatment measure to determine the equivalence of groups for general math ability was not significantly different in the pilot but was in the full-year study. Comparative analysis of the findings obtained from both investigations regarding differences in student characteristics is warranted in an attempt to determine the possible factors that contributed to differences and similarities between the results of each study.

Additional research should be conducted regarding the mathematical abilities and aptitudes of secondary agricultural education teachers. To date, only a few studies have investigated the mathematical problem-solving abilities of secondary agricultural education teachers. Persinger and Gliem (1987) found that secondary agricultural education teachers scored below an expected level of competence on an examination measuring mathematical problem-solving in the context of agricultural mechanics. Hunnicutt and Newman (1995) discovered similar findings in a study conducted with agricultural education teachers in Alabama. Miller and Gliem (1994) determined that the method by which agricultural education teachers were taught mathematics had a greater influence on their mathematical abilities than the number of college level mathematics classes the instructors had completed.

Finally, this study should be replicated with other student populations and with teachers from comprehensive educational organizations (e.g., entire school districts, regions within states, and/or intact states), so that generalizations across teaching abilities and teacher motivation could be drawn. Teachers who participated in this study were volunteers and as such were self-selected: in addition, they received monetary compensation for their participation. Is it possible that the results would be different for a study conducted with teacher participants representing a wider array of teaching abilities, levels of motivation, and school contexts?

Recommendations for Practice

Teacher educators should consider using the NRCCTE model for developing math-enhanced lessons (Figure 6) as a lesson plan development "template" for pre-service teachers who are developing context–rich learning experiences that could also provide opportunities for improving student learning in other subjects.

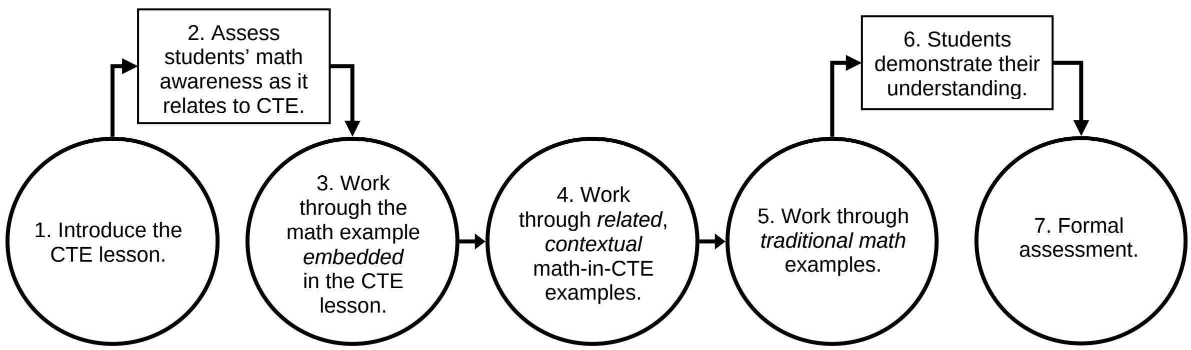

Figure 6. The NRCCTE Model: The Seven-elements of a Math-Enhanced Lesson (Stone III et al., 2005)

This approach to lesson plan development and instructional delivery could hold promise for improving student achievement as it relates to other academic concepts (e.g., science, social studies, and language and communication arts) embedded in existing CTE curriculum. This recommendation supports the findings of Martin, Fritzsche, and Ball (2006) regarding the need for teacher educators to continue to stress the connection between agricultural education and core academics in teacher education programs for pre-service agricultural education teachers.

Although some scholars (Wenger, 1998; Yamagata-Lynch, 2001) assert that communities of practice can not be formed, i.e., they emerge through social interaction, the potential that these learning groups may hold for improving student achievement should not be ignored. Teacher educators should explore methods to foster the emergence of communities of practice among pre-service agricultural education students and their peers from academic curricular areas. This could be accomplished through greater contact with other pre-service teachers from various academic subject areas and/or greater contact with academic teachers during the student teaching internship. For example, requiring CTE student teachers in agricultural education to spend one week of their student teaching internship with an academic subject teacher, and providing an opportunity for lesson planning and development experiences, might be a step toward stimulating the emergence of communities of practice.

Results of this study should be shared with practicing secondary teachers. Concomitantly, professional development opportunities should be provided that would allow other teachers to acquire the pedagogical practices identified in this study, which were found to be effective in improving student achievement in mathematics. However, the researcher cautions those individuals who might be responsible for planning and conducting the professional development to remember that the NRCCTE model involved the intersection of both pedagogy and process: (Pedagogy)(Process) = Student Math Performance.

Finally, the results of this study should be made available to significant stake-holder groups, i.e., school administrators, as well as state and national policy makers. To that end, Stone III (2005) opined:

> [The] literature emphasizes [changes in] *leadership* and *culture* [are necessary to affect effective and lasting reform], however, this [study] was an

> *internal* movement for reform. We made a difference when we enhanced something that already exists in the existing curriculum. When we begin by looking at all the math naturally embedded in our CTE [e.g., agricultural education] content, we began to see our curriculum differently, and then we begin to teach differently. It is do-able and the results are visible. (slide 93)

Implications and Discussion

Although no significant difference were detected for the study's null hypotheses, each of the three post-treatment measures of student math achievement did show a positive effect in favor of the experimental group (see Tables 17, 19, & 23). In addition, two measures (i.e., ACCUPLACER and the Terra Nova CAT™ Basic Battery) did reveal results that held practical significance. These results support the value of curriculum integration as endorsed by other researchers and scholars (Association for Career and Technical Education, 2006; Balschweid & Thompson, 2002; Bottoms & Sharp, n.d.; Childress, 1996; Edwards, 2004; Hernandez & Brendefur, 2003; Roegge & Russell, 1990; Wu & Greenan, 2003).

In addition, this study also supports the findings of Hernandez and Brendefur (2003) in regard to factors necessary to produce high quality, integrated mathematics curriculum. Many of the essential factors outlined by Hernandez and Brendefur were a part of the process in which experimental agricultural education and mathematics teachers participated during the course of the study (i.e., intensive professional development, support from administrators, and meeting regularly in the math cluster sessions). Conversely, this study may negate some of the concerns asserted by some scholars (Bjork & Richardson-Klavhen, 1989; Carraher, 1986; Lave, 1988; Saxe, 1989) regarding knowledge that is bound too tightly in a particular context, thus limiting its transfer to new and novel settings. Apparently, providing instruction using the seven-element, math-enhanced lesson plan allowed the experimental group students to transfer the math skills they learned to new and novel settings, i.e., to the ACCUPLACER and Terra Nova CAT™ Basic Battery examinations, with a level of practical significance.

Further, the results as measured by the ACCUPLACER and the Terra Nova CAT™ Basic Battery examinations supported the assumptions of Carpenter and Lehrer (1999) and Romberg (1994) regarding an improvement in student achievement when mathematics is taught in context. Moreover, the seven-element, math-enhanced lesson plan format addressed both the "connections" and problem-solving process standards outlined by the National Council of Teachers of Mathematics (NCTM) (2002). The focus on agricultural power and technology as a context for teaching mathematics and the use of problems specifically in elements 3, 4, and 5 of the math-enhanced lesson plans provided evidence of congruence with those NCTM standards. In addition to meeting many of the NCTM standards, the agricultural power and technology curriculum provided a point of intersection between existing, embedded competencies and some of the math concepts identified by the Oklahoma Department of Education's Priority Academic Student Skills (PASS) for high school students (Appendix P).

This study reflected the thoughts of many agricultural education scholars (Conroy, Trumbull, & Johnson, 1999; Miller & Vogelzang, 1983; Moss, 1988; National Research Council, 1988; Shepardson, 1929; Shinn et al., 2003), i.e., the positive results as measured by the ACCUPLACER and Terra Nova CAT™ Basic Battery examinations supported the use of agriculture as a context for teaching and learning mathematics. What is more, usefulness of the problem-based approach to learning in agricultural education, a method that is widely endorsed by selected textbook authors (e.g., Cook, 1947; Crunkilton and Krebs, 1982; Newcomb, McCracken, and Warmbrod, 1993; Phipps and Osborne, 1988) as well as other scholars (Edwards, 2004; Shinn et al., 2003), was supported by findings of this study.

The value of professional development for teachers and its relationship to student achievement (Gordan, 1999; Harwell et al., 2000; Kent, 2004) was also supported by the results of this study. It is important to note that experimental group agricultural education teachers and their math teacher partners participated in approximately 11 days of professional development over the course of this study. Moreover, a review of the agendas from those professional development sessions (see Appendixes Q, V, W, X, and Y) revealed a congruence with five factors identified by Borasi and Fonzi (2002) necessary for professional development that supports school mathematics reform.

The development of communities of practice among the experimental group agricultural education teachers and their math teacher partners, as specific school-based pairs, and the entire group as a whole was supported by Wenger (1998). Wenger outlined three dimensions that are common to all communities of practice: 1) they are a *joint enterprise* that is understood and continually renegotiated by its members; 2) they function with *mutual engagement* that binds members together; and, 3) they produce a *shared repertoire* of communal resources.

The communities of practices that emerged as a result of this study contained all of the dimensions as outlined by Wenger. The agricultural education teachers and the math teachers were engaged in a *joint enterprise,* namely, this study, that was constantly renegotiated during the numerous professional development meetings, math cluster meetings, and one-on-one meetings between the teachers. *Mutual engagement* was assured through the opportunity for all of the experimental group teachers to provide input as the study and its many nuances evolved. The 17 math-enhanced lesson plans that were developed as a result of the efforts of the agricultural education teachers and math teachers would appear to qualify as a *shared repertoire* of communal resources, as well as other related supplemental resources, which emerged and were shared during the course of the study.

The communities of practice that developed as the full-year study progressed became more than just a means by which the math teachers provided the agricultural education teachers with knowledge of and expertise about the teaching of mathematics. The communities of practice appear to have provided a vehicle that allowed the teacher partners to embark on larger more complex activities (Smith, 2003). Anecdotally, teachers reported that their collegial partnerships served as a conduit that informed the practice of both instructors, and thus resulted in changes to each other's classrooms.

The model of teaching and learning posited by Dunkin and Biddle in 1974 (Figure 3) provided a structure to describe and classify the various elements of this study.

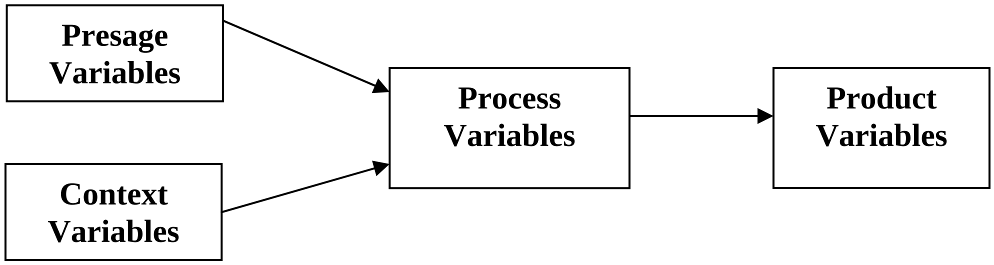

Figure 3. Model for the Study of Classroom Teaching. (Taken from Parr, Edwards, and Leising, in press, p. 4.)

Presage variables were defined by Dunkin and Biddle as the characteristics of teachers that may have an influence on the teaching process. In this study, significant presage variables may have been the professional development sessions that teachers attended, and the emergence of communities of practice between the agricultural education and math teachers. *Context* variables, as defined by Dunkin and Biddle, are those conditions to which a teacher must adjust. Selected characteristics of the students who participated in the study, the Oklahoma agricultural power and technology curriculum, and the math embedded in that curriculum all qualified as context variables.

Process variables are defined as the actual activities that occur during the act of teaching. In this study, "The 7-Elements of a Math-Enhanced Lesson," i.e., the prescribed method for teaching the math-enhanced lessons, served as a significant process variable. Finally, the *product* variables of interest included changes in student behavior resulting from the interaction of all of the other variables. In this study, the product variables were measures of students' performance on three mathematics examinations, (i.e., the posttests) and the assessment of students' technical competence in agricultural power and technology following completion of the study's treatment.

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APPENDIXES

APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL FORM

Oklahoma State University Institutional Review Board

Date: November 6, 2003

IRB Application No: AG-04-11

Proposal Title: Building Academic Skills in Context: Testing the Value of Enhanced Math Learning in CTE

Reviewed and Processed as: Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 10/6/2005

Principal Investigator(s):

Michael Craig Edwards 456 Ag Hall Stillwater, OK 74078	Brian A. Parr 456 Ag Hall Stillwater, OK 74078	Brent Young 459 Ag Hall Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 415 Whitehurst (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Sue C Jacobs

Sue C. Jacobs, Chair
Institutional Review Board

APPENDIX B

EXPERIMENTAL TEACHER CONTINUATION LETTER

March 22, 2004

<Experimental Agriculture Teacher Name>
<Postal Mail Address>

Dear <Teacher Name>:

Allow me to begin by noting the invaluable contribution that you have made to the Math-in-CTE study this year. Without your participation and dedication it would not have been possible. **Thank you!!**

Finally, we have received **OFFICIAL** approval regarding a year two for the Math-in-CTE project. We have spoken with many of you previously about the likelihood of that occurring; your responses were very positive. We sincerely hope that you are still eager to continue your participation in the **experimental** group of this important national study.

In order to participate in year two of the study, your attendance is required at two professional development sessions planned for this summer. The first session is scheduled for **Wednesday, June 23, to begin with a noon meal, and for all day Thursday, June 24, and Friday, June 25** on the campus of Oklahoma State University in Stillwater. The second session is scheduled for the days of **Wednesday, July 21, Thursday, July 22, and Friday, July 23** also in Stillwater. It is very likely that we will meet for one day during both the fall and spring semesters of the 2004-2005 school year as well. As your need dictates, discuss these dates and activities with your school's administrator, and please be certain that you have their continued support.

As in the past, your lodging and meals will be provided and your mileage to and from Stillwater is eligible for reimbursement. **Experimental group participants will receive a stipend of $2000 at the end of year two of the study.** You will receive more information and materials regarding the professional development sessions via postal mail and when you arrive in Stillwater.

We appreciate your professional commitment to implementing this experimental study of national importance and scale. More importantly, you will be helping your students and the field of Agricultural Education.

Please feel free to contact us if you have any questions or concerns. If you decide that you will be unable to participate in year two of the study please notify us at your earliest convenience. You can reach us by calling Brian Parr at 405.744.2972 or Craig Edwards at 405.744.8141, or e-mail: bparr@okstate.edu or edwarmc@okstate.edu.

We look forward to working with you this summer and in the coming school year!

Thanks again,

M. Craig Edwards
Project Director

Brian Parr
Project Coordinator, 2003-2004

APPENDIX C

TEACHER CONSENT FORM, EXPERIMENTAL GROUP, CAREER AND TECHNICAL EDUCATION TEACHER

National Research Center for Career and Technical Education
Math-in-CTE Project
Teacher Consent Form

Experimental Group, Career and Technical Education Teacher

You are invited to continue as an experimental group teacher in Year 2 of the NRCCTE Math-in-CTE research project. Please read this form and ask any questions you may have before agreeing to continue in the study. This study is being conducted by the National Research Center for Career and Technical Education at the University of Minnesota, Dr. James Stone, Principal Investigator.

Background Information:
The purpose of this study is to test whether high school students can learn mathematics in math-enhanced CTE courses. This involves a new way of teaching math in the regular CTE curriculum.

Procedures:
If you agree to be in this study, you will be asked to do the following things:

Participate in the following videotaped professional development activities:

Summer 2004, 5-6 day professional development session.
Late October/early November math support cluster meeting, 2-3 hours.
Fall 2004, 3-day professional development session.
Late January/early February math support cluster meeting, 2-3 hours.
Winter 2005, 3-day professional development session.
March/April math support cluster meeting, 2-3 hours.

Carry out the following instructional responsibilities:

Teach all of the math-enhanced lessons planned for the entire school year.
Consult with your math teacher partner before teaching each of the math-enhanced lessons.
Within one week after teaching each lesson, complete and submit a Post-Teaching Report form.
For each math-enhanced lesson you teach, collect and submit one sample of one student's work related to Element 7: Formal Assessment.
For each math-enhanced lesson you teach, collect and submit instructional artifacts you develop.

Cooperate in the following data collection activities:

Complete questionnaires about your teaching experience and attitudes.
Coordinate with your liaison to schedule testing dates at the beginning of the fall term (2 days) near the end of the fall term (1 day) and near the end of the school year (3 days).
Schedule two classroom observations: one during the fall term and one in the spring term that will be audiotaped for scripting back-up and documentation of reliability.

Coordinate with site researcher and/or liaison to arrange for the videotaping of one math-enhanced lesson that is not observed.
Attend a summer 2005 debriefing session.
Participate in an interview or focus group at the end of the study.

Risks and Benefits of Being in the Study:
This study will test if explicit mathematics instruction in CTE courses will increase students' understanding and performance on standardized tests. You will participate in professional development activities designed to increase your ability to teach mathematical concepts related to your occupational area. If the study procedures are successful, you will be a more effective teacher and your students will increase their understanding of mathematical concepts and their applications.

You will receive a stipend of $2,500 for participating in this study, and all travel, food, and lodging costs associated with participating in the professional development workshops will be reimbursed.

Confidentiality:
The records of this study will be kept private. Professional development activities will be videotaped for the purpose of documentation of the study. Interviews and focus groups will be audiotaped and transcribed. We will keep your name and data, as well as those of your students, completely anonymous and confidential. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Your record for the study may, however, be reviewed by Office of Vocational and Adult Education. To that extent, confidentiality isn't absolute.

Voluntary Nature of the Study:
Your decision whether or not to participate will not affect your current or future relations with the National Research Center for Career and Technical Education or the University of Minnesota. If you decide to participate, you are free to withdraw at any time, but your stipend will be pro-rated for the time that you did participate.

Contacts and Questions:
The researchers conducting this study are part of the National Research Center for Career and Technical Education. You may ask any questions you have now. If you have questions later, you may contact Dr. James Stone at mathincte@umn.edu; Phone: (612) 624-3000.

If you have any questions or concerns regarding the study and would like to talk to someone other than the researchers, contact the Research Subjects' Advocate Line, D-528 Mayo, 420 Delaware St., S.E., Minneapolis, MN 55455; telephone (612) 625-1650.

You will be given a copy of this form to keep for your records.

Statement of Consent:

I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

Your Name (please print): Your Signature: Date:

______________________________ __________________________ ____________

Signed

____

(Principal Investigator or authorized representative)

APPENDIX D

TEACHER CONSENT FORM, CONTROL GROUP, CAREER AND TECHNICAL EDUCATION TEACHER

National Math-in-CTE Project
Teacher Consent Form
Control Group

You are invited to continue as a control group teacher in Year 2 of the NRCCTE Math-in-CTE research project. Please read this form and ask any questions you may have before agreeing to continue in the study. This study is being conducted by the National Research Center for Career and Technical Education at the University of Minnesota, Dr. James Stone, Principal Investigator.

Background Information:
The purpose of this study is: to test whether high school students can learn mathematics in math-enhanced CTE courses. This involves a new way of teaching math in the regular CTE curriculum.

Procedures:
If you agree to participate, you will:

Teach your CTE class following your regular curriculum without any additions or changes as a result of your awareness of this study.

Complete questionnaires about your teaching experience and attitudes.

Coordinate with your liaison to schedule testing dates at the beginning of the fall term (2 days) near the end of the fall term (1 day) and near the end of the school year (3 days).

Participate in a post-study interview.

Risks and Benefits of Being in the Study:
By serving as a control teacher and teaching your regular curriculum without alteration, you are making a critical contribution to the study. The performance of your students will provide us with comparison data against which we can assess the effects of math enhancement in occupational classes.

To compensate you for your participation, you will receive a stipend of $500. In addition, you will be offered the chance to receive the professional development training for enhancing your curriculum with mathematics next summer.

Confidentiality:
The records of this study will be kept private. We will make every effort to keep your name and data, as well as those of your students, completely anonymous and confidential. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Your record for the study may, however, be reviewed by Office of Vocational and Adult Education. To that extent, confidentiality isn't absolute.

Voluntary Nature of the Study:
Your decision whether or not to participate will not affect your current or future relations with the University of Minnesota. If you decide to participate, you are free to withdraw at any time, but your stipend will be pro-rated for the time that you did participate.

Contacts and Questions:
The researchers conducting this study are part of the National Research Center for Career and Technical Education. You may ask any questions you have now. If you have questions later, you may contact Dr. James Stone at mathincte@umn.edu; Phone: (612) 624-3000.

If you have any questions or concerns regarding the study and would like to talk to someone other than the researchers, contact the Research Subjects' Advocate Line, D-528 Mayo, 420 Delaware St., S.E., Minneapolis, MN 55455; telephone (612) 625-1650.

You will be given a copy of this form to keep for your records.

Statement of Consent:
I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

Printed name Signature

______________________________ __________________________ Date ___________

Signed

____
(Principal Investigator or authorized representative)

APPENDIX E

PRINCIPAL ENDORSEMENT FORM
EXPERIMENTAL GROUP, CAREER–TECHNICAL EDUCATION TEACHER

National Research Center for Career and Technical Education
Math-in-CTE Project
Principal Endorsement Form
Experimental Group, Career-Technical Education Teacher

__________________________________ has agreed to continue participation in the Math-in-CTE project, which is a national research study of math-enhanced high school career and technical education being conducted by the National Research Center for Career and Technical Education (NRCCTE). Last year, this teacher was randomly selected from a pool of volunteers to be in the experimental group for this project and has now completed the first part of the study. We ask you to sign this form to indicate that you are informed about the study and support the teacher's continued participation in the 2004-2005 academic year.

Background Information:
The purpose of this study is to test whether high school students can learn mathematics in math- enhanced CTE courses. This involves a new way of teaching math within the regular CTE curriculum without losing CTE skill development.

These are the requirements of the study that the teacher has agreed to meet:

Participate in professional development workshops designed to improve his/her ability to teach mathematical concepts in an occupational area. These workshops will be held in the summer of 2004 and at selected times during the 2004-05 school year. All costs associated with attending these workshops will be paid by the research study.

Teach all of the math-enhanced lessons planned for the year as a part of the regular curriculum.

Cooperate in the data collection activities that include testing of students in the fall, at the end of the fall term, and at the end of the school year; two classroom observations; videotaping of a selected class; and collection of teaching samples. Only students who agree to participate in the study and whose parents do not object to their participation will be tested.

Contacts and Questions:
If you have questions, you may contact Dr. James Stone at mathincte@umn.edu; Phone: (612) 624-1795. If you have any questions or concerns regarding the study and would like to talk to someone other than the researcher(s), contact Patient Relations Department, Mayo Mail Code-310, B310 Mayo Memorial Building, 420 Delaware Street S.E., Minneapolis, Minnesota 55455; telephone (612) 273-5050. Please reference Study #0302S43861.

Please retain a copy of this form to keep for your records.
I have read the above information. I support the participation of the teacher indicated above in this study.

Printed name Signature

______________________________ __________________________ Date ___________

Signed____ (Principal Investigator)

APPENDIX F

PRINCIPAL ENDORSEMENT FORM
CONTROL GROUP, CAREER–TECHNICAL EDUCATION TEACHER

National Math in CTE Project
Principal Endorsement Form
Control Group, Career-Technical Education Teacher

__________________________________ has agreed to participate in a research study of math-enhanced high school career and technical education (CTE). Last year, this teacher was randomly selected from a pool of volunteers to be in the control group for this project and has now completed the first part of the study. We ask you to sign this form to indicate that you are informed about the study and support the teacher's continued participation in the 2004-2005 academic year.

Background Information:

The purpose of this study is: to test whether high school students can learn mathematics in math- enhanced CTE courses. This involves a new way of teaching math in the regular CTE curriculum. Because this teacher was assigned to the control group, this teacher will not have to change their curriculum. However, these are the requirements of the study that he/she has agreed to meet:

> Teach the class as usual, without increased attention to mathematics.
> Cooperate in the data collection activities that include student testing in the fall, at the end of the fall term, and at the end of the school year. Only students who agree to participate in the study and whose parents do not object to their participation will be tested.

Contacts and Questions:

The researchers conducting this study are part of the National Research Center for Career and Technical Education. If you have questions later, you may contact Dr. James Stone at mathincte@umn.edu; Phone: (612) 624-1795. If you have any questions or concerns regarding the study and would like to talk to someone other than the researcher(s), contact Patient Relations Department, Mayo Mail Code-310, B310 Mayo Memorial Building, 420 Delaware Street S.E., Minneapolis, Minnesota 55455; telephone (612) 273-5050. Please reference Study #0302S43861.

Please retain a copy of this form to keep for your records.

I have read the above information. I support the participation of the teacher indicated above in this study.

Printed name Signature

______________________________ ________________________ Date ___________

Signed

____
(Principal Investigator)

APPENDIX G

TEACHER CONSENT FORM, EXPERIMENTAL GROUP, MATH TEACHER

National Research Center for Career and Technical Education
Math-in-CTE Project
Teacher Consent Form

Experimental Group, Mathematics Teacher

You are invited to continue as an experimental group teacher in Year 2 of the NRCCTE Math-in-CTE research project. Please read this form and ask any questions you may have before agreeing to continue in the study. This study is being conducted by the National Research Center for Career and Technical Education at the University of Minnesota, Dr. James Stone, Principal Investigator.
.

Background Information:

The purpose of this study is to test whether high school students can learn mathematics in math-enhanced CTE courses. This involves a new way of teaching math in the regular CTE curriculum.

Procedures:

If you agree to be in this study, you will be asked to do the following things:

Participate in the following videotaped professional development activities:

Summer 2004, 5-6 day professional development session.
Late October/early November math support cluster meeting, 2-3 hours.
Fall 2004, 3-day professional development session.
Late January/early February math support cluster meeting, 2-3 hours.
Winter 2005, 3-day professional development session.
March/April math support cluster meeting, 2-3 hours.

Carry out the following instructional support responsibilities:

Consult with your CTE teacher partner before he or she teaches each of the math-enhanced lessons.
Within one week after consulting with your CTE partner, complete and submit a Pre-Teaching Report form.

Cooperate in the following data collection activities:

Complete questionnaires about your teaching experience and attitudes.
Attend a summer 2005 debriefing session.
Participate in an interview or focus group at the end of the study.

Risks and Benefits of Being in the Study:

This study will test if explicit mathematics instruction in an occupational context increases students understanding and performance on standardized tests. You will participate in professional development activities designed to enhance the teaching of mathematical concepts within occupational contexts. If the study procedures are successful, you will be have learned how to assist occupational teachers incorporate mathematical concepts so that their students increase their understanding of these concepts and their applications.

You will receive a stipend of $2,000 for participating in this study, and all travel, food, and lodging costs associated with participating in the professional development workshops will be reimbursed.

Confidentiality:

The records of this study will be kept private. Professional development activities will be videotaped for the purpose of documentation of the study. Interviews and focus groups will be audiotaped and transcribed. We will keep your name and data, as well as those of the students, completely anonymous and confidential. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Your record for the study may, however, be reviewed by Office of Vocational and Adult Education. To that extent, confidentiality isn't absolute.

Voluntary Nature of the Study:

Your decision whether or not to participate will not affect your current or future relations with the University of Minnesota. If you decide to participate, you are free to withdraw at any time, but your stipend will be pro-rated for the time that you did participate.

Contacts and Questions:

The researchers conducting this study are part of the National Research Center for Career and Technical Education. You may ask any questions you have now. If you have questions later, you may contact Dr. James Stone at mathincte@umn.edu; Phone: (612) 624-3000. If you have any questions or concerns regarding the study and would like to talk to someone other than the researchers, contact the Research Subjects' Advocate Line, D-528 Mayo, 420 Delaware St., S.E., Minneapolis, MN 55455; telephone (612) 625-1650.

Statement of Consent:

I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

Printed name Signature

____________________________ _________________________ Date ___________

Signed

____

(Principal Investigator or authorized representative)

APPENDIX H

PRINCIPAL ENDORSEMENT FORM
MATHEMATICS TEACHER

National Math in CTE Project
Principal Endorsement Form
Mathematics Teacher

___________________________________ has agreed to participate in a research study of math-enhanced high school career and technical education (CTE). This teacher will be working with a CTE teacher who was randomly selected from a pool of volunteers to be in the experimental group for this project. We ask you to sign this form to indicate that you are informed about the study and support the teacher's continued participation in the study during the 2004-2005 academic year.

Background Information:

The purpose of this study is: to test whether high school students can learn mathematics in math-enhanced CTE courses. This involves a new way of teaching math in the regular CTE curriculum. These are the requirements of the study that the teacher has agreed to meet:

> Participate in professional development workshops designed to have this teacher help a CTE teacher partner to teach mathematical concepts in an occupational area. These workshops will be held in the summer of 2004 and at selected times during the 2004-05 school year. All costs associated with attending these workshops will be paid by the research study.
> Assist the CTE teacher in the development of lesson plans and in preparation for teaching the mathematical concepts inherent in the occupational area throughout the year.

Contacts and Questions:
The researchers conducting this study are part of the National Research Center for Career and Technical Education. If you have questions later, you may contact Dr. James Stone at mathincte@umn.edu; Phone: (612) 624-1795. If you have any questions or concerns regarding the study and would like to talk to someone other than the researcher(s), contact Patient Relations Department, Mayo Mail Code-310, B310 Mayo Memorial Building, 420 Delaware Street S.E., Minneapolis, Minnesota 55455; telephone (612) 273-5050. Please reference Study #0302S43861.

Please retain a copy of this form to keep for your records.

I have read the above information. I support the participation of the teacher indicated above in this study.

Printed name Signature

________________________________ ___________________________ Date ____________

Signed____
(Principal Investigator)

APPENDIX I

TEACHER CONSENT FORM, TESTING LIAISON

National Math-in-CTE Project
Teacher Consent Form
Testing Liaison

You are invited to participate as a testing liaison in a research study of math-enhanced high school career and technical education. Please read this form and ask any questions you may have before agreeing to be in the study This study is being conducted by the National Research Center for Career and Technical Education at the University of Minnesota, Dr. James Stone, Principal Investigator.

Background Information:

The purpose of this study is to test whether high school students can learn mathematics in math-enhanced CTE courses. This involves a new way of teaching math in the regular CTE curriculum.

Procedures:

If you agree to participate, you will be asked to do the following:

Participate in training that will explain the study and your responsibilities.

Coordinate with the CTE teacher participating in the study to schedule testing dates at the beginning of the fall term (2 days) near the end of the fall term (1 day) and near the end of the school year (3 days).

Obtain signed consent forms from all students who volunteer to participate in the study.

Assign ID numbers to all the students you will test and ensure that the students put these numbers on all data collection instruments they complete.

Administer tests and student surveys that will be sent to you by your site researcher and distribute gift cards to students who complete the tests.

Return the completed tests and surveys to your site researcher.

Risks and Benefits of Being in the Study:

By serving as a testing liaison you are making a critical contribution to the study. The data you collect will allow us to assess the effects of math enhancement in occupational classes.
To compensate you for your participation, you will receive a stipend of $750 for the three administrations of tests for each class.

Confidentiality:

The records of this study will be kept private. We will make every effort to keep the name and data from all those participating in the study completely anonymous and confidential. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Your record for the study may, however, be reviewed by Office of Vocational and Adult Education. To that extent, confidentiality isn't absolute.

Voluntary Nature of the Study:

Your decision whether or not to participate will not affect your current or future relations with the University of Minnesota. If you decide to participate, you are free to withdraw at any time, but your stipend will be pro-rated for the time that you did participate.

Contacts and Questions:

The researchers conducting this study are part of the National Research Center for Career and Technical Education. You may ask any questions you have now. If you have questions later, you may contact Dr. James Stone at mathincte@umn.edu; Phone: (612) 624-3000.

If you have any questions or concerns regarding the study and would like to talk to someone other than the researchers, contact the Research Subjects' Advocate Line, D-528 Mayo, 420 Delaware St., S.E., Minneapolis, MN 55455; telephone (612) 625-1650.

You will be given a copy of this form to keep for your records.

Statement of Consent:

I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

Printed name Signature

______________________________ __________________________ Date ___________

Signed

____
(Principal Investigator or authorized representative)

APPENDIX J

EXPERIMENTAL TEACHERS' SCRIPT

Script for EXPERIMENTAL TEACHER to Read on the 1st Day of the Course

This year, I have agreed to take part in a national research study which involves making the mathematics that is a part of this ag mechanics course clearer and easier to understand. With everyone so caught up with math these days, it's important to show that math occurs in lots of settings, not just regular math courses. So, we're going to try something a little different this semester. We'll learn all of the regular content, but we'll also work on helping you develop good math skills as well.

The research study that I am a part of is taking place in lots of schools in this state and also around the country. It's important because the U.S. Department of Education is very concerned with students' math scores. You probably all know that American students have been criticized for not doing as well as students from other countries in math. College entrance tests require math skills, and employers want their new employees to have good math skills so that they'll be able to figure out problems on the job, be more productive, and advance in their careers.

Lots of schools around the country are emphasizing math and even making students take more math courses. But the researchers doing this study want to show that people also use math in subjects such as ag mechanics. So, we don't necessarily need to take more math, we want to show everyone that we already use it in lots of applied areas. The researchers would like to find out if using math in ag mechanics really does improve our overall math ability.

During this year, we'll do some interesting new things with math skills that are part of this ag mechanics course. The researchers want to see if this will improve your math understanding, so they'd like to test your math skills now, in the beginning of the course, and at the end of the term. [If applicable: At the end of the second term, we will take a second survey, a math test, and a CTE test].

It's going to be up to you whether you take the surveys and tests. It's important for the research study, but the tests won't have anything to do with your grade in this course. In fact, your name will never be attached to any materials you submit. However, the testing liaison will assign you a number so that the researchers can see your individual changes in learning and attitudes over the course of the study if you choose to take part. It is very important that you do your best and give us honest answers because we are going to be comparing the results from this classroom to other classrooms around the country.

There will be someone coming in later this week to give a survey about you, and then they'll come back a few days later to give you a math test. I will stay in the classroom while you complete these, but I will not be administering them. What's in it for you : You will receive a $10 Wal-Mart card each time you complete a math test.

I am now going to hand out consent forms for your parents or guardians to read. They only have to sign and return the form if they do NOT want you to take part in this study. If they do not have you bring the signed form back, then we will assume they are allowing you to participate. Then, it will be up to you whether or not you want to take part.

The testing person will give you a separate form asking for your consent in a few days. You'll have to turn the consent forms in before you take the survey. We will collect your parent's/guardian's forms here (designate a spot in the room) during the next couple of days. OK?

Are there any questions?

APPENDIX K

CONTROL TEACHERS' SCRIPT

Script for the CONTROL TEACHER to Read on 1st Day

This year, I have agreed to take part in a national research study about the math skills that are naturally a part of ag mechanics courses. Even though this course doesn't focus specifically on math, there are many courses in career and technical education that incorporate some mathematics.

For this research study, we are going to need to see what kind of math skills students in this course have. So, in the next couple of days, we are first going to ask you to fill out a survey and then have you take a math test. At the end of the term, we will take another math test. [If applicable: At the end of the second term, we will take a second survey, a math test, and a CTE test].

It's going to be up to you whether you take the surveys and tests. It's important for the research study, but the tests won't have anything to do with your grade in this course. In fact, your name will never be attached to any materials you submit. The person who will come to give the surveys and tests to our class will assign you a number so that the researchers can see your individual changes in learning and attitudes over the course of the study if you choose to take part. It is very important that you do your best and give us honest answers because we are going to be comparing the results from this classroom to other classrooms around the country.

The testing person will be here later this week to give a survey about you, and then they'll come back a few days later to give you a math test. I will stay in the classroom while you complete these, but I will not be administering them. What's in it for you? You will receive a $10 Wal-Mart card each time you complete a math test.

I am now going to hand out consent forms for your parents or guardians to read. They only have to sign and return the form if they do NOT want you to take part in this study. If they do not have you bring the signed form back, then we will assume they are allowing you to participate. Then, it will be up to you whether or not you want to take part.

The testing person will give you a separate form asking for your consent in a few days. You'll have to turn the consent forms in before you take the survey. We will collect your parent's/guardian's forms here (designate a spot in the room) during the next couple of days. OK?

Are there any questions?

APPENDIX L

EXPERIMENTAL GROUP STUDENT CONSENT FORM

Research Study of Math in CTE

<u>Participant Consent Form</u>
Experimental Group

Check one of these boxes:

☐ I **CONSENT** to participate in math tests, a skills test, short surveys, and classroom observations for the study of math in CTE being conducted by researchers from the University of Minnesota.

☐ I **DO NOT** CONSENT to participate in math tests, a skills test, short surveys, and classroom observations for the study of math in CTE being conducted by researchers from the University of Minnesota.

______________________	______________________	__________
Printed Name	Signature	Date

APPENDIX M

CONTROL GROUP STUDENT CONSENT FORM

Research Study of Math in CTE

<u>Participant Consent Form</u>
Control Group

Check one of these boxes:

☐ I **CONSENT** to participate in math tests, a skills test, and short surveys for the study of math in CTE being conducted by researchers from the University of Minnesota.

☐ I **DO NOT** CONSENT to participate in math tests, a skills test, and short surveys for the study of math in CTE being conducted by researchers from the University of Minnesota.

Printed Name	Signature	Date

APPENDIX N

EXPERIMENTAL GROUP PARENTAL CONSENT FORM

Research Study of Math in CTE
Parent Consent Form
Experimental Group

Return this form **only** if you **do not** want your student to participate in this research study

Print your student's name ____

I **DO NOT CONSENT** to have my child participate in math tests, surveys, a skills test, and class observation for the study of math in CTE being conducted by researchers from the University of Minnesota.

________________________________	______________________________	______________
Printed Name	Signature	Date

If you agree to your student's participation, you can discard this form. If you have signed the form to indicate you do not want your student to take part, have your student return the form to his or her teacher.

APPENDIX O

CONTROL GROUP PARENTAL CONSENT FORM

Research Study of Math in CTE
Parent Consent Form
Control Group

Return this form **only** if you **do not** want your student to participate in this research study

Print your student's name ____

I **DO NOT CONSENT** to have my child participate in math tests, surveys, and a skills test for the study of math in CTE being conducted by researchers from the University of Minnesota.

_______________________	_______________________	____________
Printed Name	Signature	Date

If you agree to your student's participation, you can discard this form. If you have signed the form to indicate you do not want your student to take part, have your student return the form to his or her teacher

APPENDIX P

CURRICULUM MAP

The following is a list of the math identified as part of an agricultural mechanics curriculum. The math applications are similar to those that you might include in your Spring curriculum. Please use this list as a starting point in your discussions of CTE math enhancement. The items you ultimately choose to enhance do not necessarily have to be on the list but should be at least at the algebra and geometry levels if at all possible.

Math in Agricultural Mechanics Education Map

Agricultural Mechanics Problem-Solving Applications	**Mathematics Content Standards**	**PASS Standards**	**NCTM Standards**
Determining sprayer nozzle size given flow rate and speed	Problem solving involving cross-sectional area, volume, and related rates	PASS Process Standard 1: Problem Solving	NCTM Problem Solving Standard for Grades 9-12
Determine pipe size and water flow rates for a water pump	Problem solving involving cross-sectional area, volume, and related rates		
Determine amount of paint needed to paint a given surface (calculate surface area, etc)	Problem solving involving surface area, ratio and proportions		
Determine the concrete reinforcements and spacing needed when building a concrete platform or structure	Problem solving involving cross-sectional area, volume, and related rates		
Determine measurements in feet and inches as well as metric equivalences (meters and centimeters)	Conversions (English-metric and/or within each system)	PASS Algebra I Standard 2-8a	NCTM Measurement Standard for Grades 9-12: Apply appropriate techniques, tools, and formulas to determine measurements
Determine torque wrench conversions (foot pounds, etc)	Conversions (English-metric and/or within each system)		
Determine temperature conversions (Fahrenheit and Celsius)	Conversions (English-metric and/or within each system)		
Develop different bale stacking schemes that maintain balanced loads on a trailer bed of a given dimension	Problem solving involving volumes and weight	PASS Geometry Standard 2-4	NCTM Measurement Standard for Grades 9-12
Determine the time needed to cut a field of a given acreage	Problem solving involving area and related rates		
Determine the volume of a fuel tank	Calculate volume		
Determine engine displacement	Calculate distances is 3-dimensional space		

Calculate the dimensions of a gate, panel, loading ramp, or chute and the number of board feet required to build it.	Calculate surface area/ estimating materials	PASS Geometry Standard 4-4	NCTM Geometry Standard for Grades 9-12
Calculate lengths of diagonals using the Pythagorean theorem while designing and building gates, panels, ramps, chutes, etc.	Solving problems using the Pythagorean theorem		
Calculate the bill of materials, accounting for waste, efficiency, etc.	Estimating costs		
Calculating and using scales for 3-D drawing	Calculating and using scales (ratio and proportion)	PASS Geometry Standard 2-2,2-5	NCTM Geometry Standard for Grades 9-12
Determine the amounts of sand, aggregate, concrete mix, water, etc. needed to make a given amount of concrete	Solving mixture problems using ratio and proportions		
Calculate the required dimensions of a bunker or tank to hold a given volume of feed/fuel and one of the cylinder's dimensions	Calculating cylinder dimensions given volume and one of the dimensions	PASS Algebra I Standard 1-1 and 6a	NCTM Algebra Standard for Grades 9-12
Design bale feeders with equal sections	Using ratio and proportion to solve problems		
Build a materials list for a given project (ex: lbs of penny nails, number of 2x4's, number of 2x6's, etc.)	Calculating materials using estimation, ratio & proportion, charts, and graphs		
Determine center/midpoint of a board or area when calculating center of gravity, etc.	Calculating center/midpoint of a line or area		
Use appropriate graphs and charts to determine welding rod thickness to voltage (and/or amperage) to metal thickness relationships	Using composite graphs to solve problems	PASS Algebra I Standard 3-1a and 3-1b	NCTM Data Analysis and Probability Standard
Read and interpret values from tap and die charts when drilling on metal	Reading and interpreting graphs		
Read and interpret safety charts to determine exposure limits for a potentially unsafe element (ex: excessive noise)	Reading and interpreting graphs		
Use tables and graphs to determine compression ratios	Reading and interpreting graphs	PASS Algebra Standard 2-	NCTM Problem Solving

Calculate the amount of compression/pressure to use for a given set of project specs.	Solve problems involving ratio and proportions	8b	Standard
Use histograms and scatter plots of safety data in making decisions	Reading and interpreting graphs	PASS Algebra I Standard 2-5b, 3-2	NCTM Data Analysis and Probability Standard
Determine flow and distribution rates for a give nozzle	Reading and interpreting graphs		
Graph and interpret time spent and cost of projects	Reading and interpreting graphs		
Chart and interpret water flow and restriction for a given pump	Reading and interpreting graphs		
Plot distribution of seeds from a seed drill and use to determine equal distribution (uniformity)	Reading and interpreting graphs		
Chart water flow differences through straight or bent pipes and pipes of different sizes. Use the charts to determine the best pipe for a given water flow.	Reading and interpreting graphs		

APPENDIX Q

FIRST PROFESSIOINAL DEVELOPMENT SESSION AGENDA

Math-in-CTE
Professional Development Training: Year 2
Agricultural Power & Technology

June 23-25, 2004

Holiday Inn & Conference Center
2515 W. 6th Avenue (Highway 51)
Stillwater, OK

Agenda

Wednesday, June 23

11:30 – 12:30 p.m.	**Arrival, Check-in to Hotel, Pick-up Workshop Notebook & Name Tag (Foyer)**
12:30 – 1:40 p.m.	**Group Lunch (Hotel Restaurant)**
1:45 p.m.	**Workshop Begins (Pioneer Room)**
	Welcome and Staff Introductions, Craig Edwards & Jim Leising, Oklahoma State University
	Completion of Study Consent Forms (as needed)
~1:55 p.m.	**Overview and Purpose of the Research Study: Year 2**
	---Donna Pearson, National Research Center for Career & Technical Education, University of Minnesota & Craig Edwards
	Questions, Comments, & Concerns . . .
~2:25 p.m.	**A “Refresher” about Math Concepts Embedded in the Study’s Lesson Plans; A Standard Coding System for Lesson Plans in Year 2**
	---Brian Parr & Craig Edwards

~2:45 p.m. Instructional Approach: "The Seven Elements (Steps) . . ."
--Craig Edwards, Donna Pearson, & Brent Young

Wednesday, June 23 (cont'd.)

	An Example: "Laying Out and Cutting a Rafter"
	---Brent Young
3:45 p.m.	**Refreshment Break**
~4:05 p.m.	**Improving the Lesson Plans . . . ☺ ☺ ☺**
	Making Math Vocabulary more "User Friendly" in the Lesson Plans . . .
	The Importance of Multiple Examples, Exercises, Worksheets, and Answer Keys . . .
	Emphasize both Related, Contextual Math and "Traditional" Math Components of the Lesson . . .
	---Donna Pearson, Craig Edwards, Brian Parr, & Brent Young
	Questions, Comments, Ideas . . .
~5:00 p.m.	**Overview about Thursday & Friday: Lesson Plan Critiques ("Where were the holes?"); Improving & Reconfiguring the Lessons for Year 2; Please review *Rubric for Critiquing Lesson Plans***
	---Craig Edwards & Donna Pearson
~5:45 p.m.	**Adjourn for the Evening**
	Check-in to Rooms (as needed)
6:30 p.m.	**Group Dinner (Hotel Restaurant)**

Thursday, June 24

til ~8:10 a.m.	**Continental Breakfast in the Hotel Restaurant**
8:15 a.m.	**Day #2 of Workshop Begins/Additional Introductions (as needed) (Pioneer Room)** **Teachers' Critiques of Year 1 Lessons (17) . . .** **Teams Provide a Brief "Refresher" of their Math-Enhanced Lesson for the Group** **Important: Constructive Criticism Focusing on "How to Improve the Lesson Plan" is Essential – Oral & Written (Please use critique form provided)** **---Craig Edwards, Donna Pearson, Brian Parr, & Brent Young, Facilitators**
~10:15 a.m.	**Refreshment Break**
~10:30 a.m.	**Teachers' Critiques of Year 1 Lesson Plans Continues**
~12:15 p.m.	**Group Lunch (Hotel Restaurant)**
1:30 p.m.	**The "Heavy-liftin'" Begins . . . ☺ ☺ ☺** **Teams Modify and Improve Lesson Plans based on Teacher Critiques using the *Rubric for Critiquing Lesson Plans* . . . (See revised "7 Elements," teacher notes, *Rubric*, new references, etc.)** **Revise and Improve Use of Math Vocabulary; Add New Math Examples and Exercises; Improve both Related, Contextual Math and "Traditional" Math Components of the Lesson Plans – See Elements #4, 5, 6, & 7** **---Craig Edwards, Donna Pearson, Brian Parr, & Brent Young, Facilitators**
3:55 p.m.	**Refreshment Break**

<u>Thursday, June 24 (cont'd)</u>

~4:15 p.m. **Continue Improving Lessons, Create Electronic Files ("Save, Save, Save, . . ." ☺)**

Trade Lesson Plans with Other Teams for Critique and Comment (Each Team should have at least <u>one other team's plan</u> to critique and on which to provide feedback . . . The more candid and the more constructive, the better . . . ☺)

~5:15 p.m. **Changes, Responsibilities, & Opportunities in Year 2**

---Donna Pearson, Craig Edwards, & Brent Young

Questions, Comments, Tomorrow . . .

7:00 p.m. **Group Dinner (Hotel Restaurant)**

Friday, June 25

til ~8:00 a.m. **Continental Breakfast in the Hotel Restaurant**

8:05 a.m. **Day #3 of Workshop Begins (Pioneer Room)**

Questions, Thoughts, Ideas from Overnight, Group

Teams Continue to Modify and Improve Lesson Plans based on Teacher Critiques using the *Rubric for Critiquing Lesson Plans* . . . (See "7 Elements," notes, new references, etc.)

Revise and Improve Lesson Plans by Adding New Math Examples, Exercises, Worksheets, and Answer Keys (where needed); Improve both Related, Contextual Math and "Traditional" Math Components of the Lesson Plans (See the "7 Elements" and teachers' critiques)

Up-date Electronic Files ("Save, Save, Save, . . . " ☺)

Trade Lesson Plans with Other Teams for Critique (2nd Time) and Comment (Each Team should have at least <u>one other team's plan</u> to critique and on which to provide feedback . . . The more candid and the more constructive, the better ☺ . . .); Use the *Rubric for Critiquing Lesson Plans*

---Craig Edwards, Donna Pearson, Brian Parr, & Brent Young, Facilitators

10:00 a.m. **Refreshment Break & <u>an Opportunity to Check-out of your room</u>**

~10:30 a.m. **Continue to Respond to 2nd Round Teacher Critiques while Improving Your Lesson Plan. . .**

~11:35 a.m. **Brief Status Report: Teams Report on What They have Improved and What they Intend to Improve Next . . .**

---Brian Parr & Brent Young, Facilitators

~12:15 p.m. Lunch (Hotel Restaurant)

<u>Friday, June 25 (cont'd)</u>

~1:15 p.m. Teams Continue to Make Corrections, Changes, etc. as needed . . .

Teams Finalize Initial Lesson Plan Round #1 Drafts – Generate Hard Copies and Electronic Copies

Provide Project Team with a Hard Copy and an Electronic Copy of Your *Revised Lesson Plan*

---Brent Young, Brian Parr, & J Pye, Facilitators

3:15 p.m. Refreshment Break

~3:30 p.m. Discuss what we will do at the next Professional Development Workshop, July 21-23 . . .

Travel Mileage Forms: Please <u>BE SURE</u> to include your <u>Vehicle License Number</u>

Other Questions for the "Good of the Order" . . . ??? ☺

--- Craig Edwards, Brent Young, & Donna Pearson, Facilitators

Please <u>BE SURE</u> to Provide Project Team with a Hard Copy and an Electronic Copy of Your Revised Round #1 Lesson Plan <u>Before</u> Leaving TODAY ☺ ☺ ☺

~4:30 p.m. Adjourn Year 2 Summer Professional Development, Round #1

Thank You and have a safe trip home!!

APPENDIX R

MATH TEACHER, PRE-TEACHING REPORT

Math Teacher
Pre-Teaching Report

Submit as an e-mail attachment or by fax to your Site Director within one week following each pre-teaching review of a math-enhanced CTE lesson with your CTE instructor.

Your ID #:	CTE teacher's ID #:	Date of review:	
Title of lesson reviewed:			Lesson number:

Answer the following questions by putting an X in the box that best reflects your opinion on the scale following each question:

Question	Not at all / Low / None						Completely / High / A lot
1. In your judgment, how well are the math concepts integrated into the occupational content of this lesson?	Not at all						Completely
2. How adequate is the amount/depth of instruction in this lesson to teach students the math concepts?	Not at all						Completely
3. How would you rate the CTE instructor's "comfort" with teaching the math in this lesson?	Low						High
4. How much assistance do you think you gave the CTE instructor?	None						A lot

5. Are all 7 elements of the math enhancement model clearly presented in the lesson? (put X on line) Yes___No___ If no, what elements are weak or missing?

6. What part(s) of the math in this lesson did the CTE instructor need the most assistance with?

7. Do you have any suggestions for improving the teaching of the math concepts in this lesson?

APPENDIX S

CTE TEACHER, POST-TEACHING REPORT

CTE Teacher
Post-Teaching Report

Submit as an e-mail attachment or by fax to your Site Director within one week following each teaching of a math-enhanced CTE lesson.

Your ID #:	Math teacher's ID #:	Date(s) lesson taught:	
Title of lesson taught:			Lesson number:
Total class time, in minutes, spent on this lesson:		Total number of classes in which the lesson was taught:	

Answer the following questions by putting an X in the box that best reflects your opinion on the scale following each question:

Question	Scale
1. In your judgment, how well were the math concepts integrated into the occupational content of this lesson?	Not at all ☐ ☐ ☐ ☐ ☐ ☐ ☐ Completely
2. How adequate is the amount/depth of instruction in this lesson to teach students the math concepts?	Not at all ☐ ☐ ☐ ☐ ☐ ☐ ☐ Completely
3. How would you rate your "comfort" with teaching the math in this lesson?	Low ☐ ☐ ☐ ☐ ☐ ☐ ☐ High
4. How much assistance did you receive from your math partner prior to teaching this lesson?	None ☐ ☐ ☐ ☐ ☐ ☐ ☐ A lot
5. To what degree do you think your students learned the math in this lesson?	A little ☐ ☐ ☐ ☐ ☐ ☐ ☐ A lot
6. Overall, how successful was the lesson, both the CTE and math components?	Not at all ☐ ☐ ☐ ☐ ☐ ☐ ☐ Completely

7. Were you able to complete the lesson as planned (put X on line) Yes___No___
   a. IF No, What prevented you from completing it?

8. Were you able to teach all 7 elements of the math enhancement model? (put X on line) Yes___No___ If no, what elements were not included?

9. Do you have any suggestions for improving the teaching of the CTE content or the math concepts in this lesson?

APPENDIX T

MATH-IN-CTE LESSON PLAN TEMPLATE

Math-in-CTE Lesson Plan

Lesson Title:	Lesson Number:

Occupational Area: **ex: Business and Marketing**
CTE Concept(s): **ex: Break even points**
Math Concepts: **ex: solving algebraic equations**

Lesson Objective:	
Supplies Needed:	

THE "7 ELEMENTS"	**TEACHER NOTES (and answer key)**
1. Introduce the CTE lesson.	
2. Assess students' math awareness as it relates to the CTE lesson.	
3. Work through the math example *embedded* in the CTE lesson.	
4. Work through *related, contextual* math-in-CTE examples.	
5. Work through *traditional math* examples.	
6. Students demonstrate their understanding.	
7. Formal assessment.	

APPENDIX U

RUBRIC FOR CRITIQUING LESSON PLANS

Rubric for Critiquing Math-Enhanced Lessons

Lesson Title:	Lesson Number:

As you review or observe the lesson, please check the appropriate boxes in the rubric below. Use the comment box to make suggestions and recommendations.

ELEMENTS	***COMPLETE***	***NEEDS IMPROVEMENT***	***COMMENTS***
1. Introduce the CTE Lesson.	□ Specific objectives of CTE lesson are explicit. □ Detailed script is provided for introducing lesson to students as a CTE lesson. □ Math concept(s) embedded in the CTE lesson is clearly identified. □ Script is provided to point out the math in the CTE lesson.	□ Lesson objectives are unclear or not evident. □ Little or no script is provided for introducing lesson as a CTE lesson and/or lesson is introduced as a math lesson. □ Math concept(s) embedded in the CTE lesson is not made clear. □ Script is not provided to point out the math in the CTE lesson.	
2. Assess students' math awareness as it relates to the CTE lesson.	□ Lesson contains learning activities and/or well developed questions that assess <u>all</u> students' awareness of the embedded math concept. □ Math vocabulary and supporting instructional aids are provided to begin bridging of math to CTE.	□ Lesson contains no learning activities and few, if any, questions that support assessment of all students' awareness of the embedded math concept. □ Math vocabulary and/or instructional aids are not provided.	
3. Work through the math example ***embedded*** in the CTE lesson.	□ Script provides specific steps/processes for working through the embedded math example. □ CTE and math vocabulary are explicitly bridged in the script, supported with instructional strategies and/or aids.	□ Steps/processes for working through the embedded math example are incomplete or missing. □ Little bridging of CTE and math vocabulary is scripted; few or no strategies and/or aids are provided to relate the CTE to math.	

4. Work through the ***related, contextual*** examples.	□ Lesson provides a work-through of examples, using the same embedded math concept in similar examples from the same occupational area. □ Example problems are at varying levels of difficulty, from basic to advanced. □ Script continues to bridge the CTE and math vocabulary, supported with instructional strategies and/or aids.	□ Few or no additional examples of the embedded concept are provided. □ Examples do not reflect varying levels of difficulty. □ Little or no bridging of CTE and math vocabulary is evident in the script or supported with instructional strategies and/or aids.	
5. Work through ***traditional math*** examples.	□ A variety of examples are scripted to illustrate the math concept as it is presented in traditional math tests. □ Examples move from basic to advanced. □ Script continues to bridge the CTE and math vocabulary, supported with instructional strategies and/or aids.	□ Few or no math problems illustrate the math concept as it is presented in standardized tests. □ Examples do not reflect varying levels of difficulty. □ Little or no bridging of CTE and math vocabulary is evident in the script or supported with instructional strategies and/or aids.	
6. Students demonstrate understanding.	□ Lesson provides learning activities, projects, etc., that give students opportunities to demonstrate what they have learned. □ Lesson ties math examples back to the CTE content; lesson ends on the CTE topic.	□ No learning activities, projects, etc., provide students with opportunities to demonstrate what they have learned. □ Lesson fails to tie the math back to CTE or end on the CTE topic.	
7. Formal assessment.	□ Lesson provides questions/problems that will be included in formal assessments (tests, projects, etc.) in the CTE unit/ course.	□ Example questions/ problems are not provided for use in formal assessments in the CTE unit/course.	

APPENDIX V

SECOND PROFESSIONAL DEVELOPMENT SESSION AGENDA

Math-in-CTE
Professional Development Training: Year 2
Agricultural Power & Technology

July 21-23, 2004

Atherton Hotel & Student Union
Oklahoma State University
Stillwater, OK

Agenda

Wednesday, July 21

11:30 – 12:30 p.m.	**Arrival, Check-in to Hotel, Pick-up Agenda**
	Team Photos & Certificate Presentations w/ Dr. Jim Stone, Director, National Center for Career & Technical Education (Hotel Foyer)
	---Julie Focht & Brent Young, Facilitators
12:30 – 1:45 p.m.	**Group Lunch (Sequoyah Room, 280 Student Union)**
	Sign & Turn-in Study Consent Forms, Year 2
	Welcome and Staff Introductions, Craig Edwards & Jim Leising, Oklahoma State University
	A Report and Up-date from the National Research Center for Career & Technical Education, Dr. Jim Stone, Director, & Dr. Donna Pearson, Research Associate, University of Minnesota
	Questions, Comments, & Concerns, Group
2:00 p.m.	**Workshop Begins (Case Study 1, 408 SU)**

---Turn-in hard copies of documents that need to be scanned (yellow folder); Please identify lesson the document(s) support
---Brent Young & Brian Parr, Facilitators

Wednesday, July 21 (cont'd.)

Lesson Presentations Begin (3)

Please review *Rubric for Critiquing Lesson Plans*; Be Looking for "The Seven Elements" during the lesson presentations; "What about the math?"

---Drummond/Tuttle – Greg Kokojan, Christine Kokojan, C.L. McGill

Questions, Comments, Ideas . . . .☺ ☺ ☺

~3:15 p.m. Refreshment Break

---Pond Creek-Hunter – Larry Berg, Arnie Smith

Questions, Comments, Ideas . . . .☺ ☺ ☺

---Afton – Joe Wright, Keith Lane

Questions, Comments, Ideas . . . .☺ ☺ ☺

Other Comments about Lesson Presentations . . .

---Brent Young, Brian Parr, Craig Edwards, & Donna Pearson, Facilitators

Check-in to Hotel Rooms (as needed)

6:30 p.m. Group Dinner (Sequoyah Room, 280 SU)

Adjourn for the Evening

Thursday, July 22

til ~8:20 a.m. Continental Breakfast in the Hotel Restaurant

8:25 a.m. Day #2 of Workshop Begins/Additional Introductions (as needed) (Exhibit Rooms 1 and 2, 4th Floor SU)

Questions, Thoughts, Suggestions from Overnight, Group

Lesson Presentations Continue (3.5) . . .

Please review *Rubric for Critiquing Lesson Plans*; Be Looking for "The Seven Elements" during the lesson presentations; "What about the math?"

---Talihina – Cyal Walden, Jennifer King

Questions, Comments, Ideas . . . .☺ ☺ ☺

---Porter – Brad Criner, Sherrye Smith

Questions, Comments, Ideas . . . .☺ ☺ ☺

~9:45 a.m. Refreshment Break

~10:00 a.m. Lesson Presentations Continue . . .

---Stringtown – Dennis Holly, Jay Ward

Questions, Comments, Ideas . . . .☺ ☺ ☺

~11:00 a.m. ---Durant – Arnold Bourne, Christy Dufur; Related Data Collection Activity

---Brent Young, Brian Parr, Craig Edwards, & Donna Pearson, Facilitators

12:30 p.m. **Group Lunch (Sequoyah Room, 280 SU)**
Thursday, July 22 (cont'd)

1:30 p.m. **Lesson Presentations Continue (1.5) . . .**

---Durant – Arnold Bourne, Christy Dufur (cont'd)

Questions, Comments, Ideas . . . .☺ ☺ ☺

---Dickson – Regie Rowe, Chris Grimm

Questions, Comments, Ideas . . . .☺ ☺ ☺

Other Comments about Lesson Presentations . . .

---Brent Young, Brian Parr, Craig Edwards, & Donna Pearson, Facilitators

~3:15 p.m. **Refreshment Break**

3:30 p.m. **Calculator Training, Mrs. Millie Cummins, Math Teacher, Tulsa Union H.S., Presenter**

~4:15 p.m. **Up-date about the Revised Ringwood and Carney Lesson Plans, Gradena Coffey, Math Teacher, Lone Wolf H.S. & Matt Stehr, Math Teacher, Frederick H.S., Presenters**

Proposed Sequencing of Lessons, Group Changes, Responsibilities, & Questions about Year 2 . . .

---Briefings & Reflections . . .

---Craig Edwards, Donna Pearson, & Brian Parr, Facilitators

Tomorrow: Electronic File Expectations, Brent Young

"Math Captains" – Those interested please stay and meet ☺

---Craig Edwards & Brent Young

6:30 p.m. **Group Dinner (Sequoyah Room, 280 SU)**

Adjourn for the Evening

Friday, July 23

til ~8:20 a.m. **Continental Breakfast in the Hotel Restaurant**

8:25 a.m. **Day #3 of Workshop Begins (Exhibit Rooms 1 and 2, 4th Floor SU)**

Questions, Thoughts, Suggestions from Overnight, Group

Reminder about Electronic File Expectations, Brent Young

Teams Modify and Improve Lesson Plans using the *Rubric for Critiquing Lesson Plans* . . . (See "7 Elements," notes, new references, etc.); Be sure to include electronic copies of documents that were turned in for scanning

Trade Lesson Plans with Other Teams for Critique and Comment (Each Team should have at least one other team's plan to critique and on which to provide feedback); Use the *Rubric for Critiquing Lesson Plans*; Respond to Critiques as Needed

Continue to Revise and Improve Lesson Plans by Adding

New Math Examples, Exercises, Worksheets, and Answer Keys (as needed); Improve both Related, Contextual Math and "Traditional" Math Components of the Lesson Plans (See the "7 Elements" and teachers' critiques)

Up-date Electronic Files ("Save, Save, Save, . . . " ☺)

9:45 a.m. **Refreshment Break & <u>an Opportunity to Check-out of Your Room</u> (as needed)**

~11:30 a.m. **More about Sequencing of Lessons, Group**

Use <u>Your</u> School & Program Calendars to Prepare an "Estimated" Schedule for Teaching the Lessons (Please use the brown calendar handout)

--- Brent Young, Brian Parr, Craig Edwards, & Donna Pearson, Facilitators

12:30 p.m. **Lunch (Oklahoma Room, 211 SU)**

<u>Friday, July 23 (cont'd)</u>

~1:30 p.m. **Continue Improving Lesson Plan and Electronic Formatting of Lesson Plan Files (as needed) . . .**

Teams Finalize Revised Lesson Plans – Generate Hard Copies and Electronic Copies

Provide Project Team with Copies of Your *Final Revised Lesson Plan*

Provide Project Team with a Hard Copy of Your *"Estimated" Schedule for Teaching the Lessons*; <u>Important</u>: Identify Starting and Ending

Dates of Your Fall 2004 Semester (Please use the brown calendar handout)

---Brent Young & Brian Parr, Facilitators

Travel Mileage Forms: Please BE SURE to include your Vehicle License Number

3:15 p.m. **Refreshment Break**

Testing, Calculators, Related Questions, . . .

October Professional Development: When? Where? What?

Colorado State University Graduate Credit – Explanation, Handouts, Questions . . .

Other Questions for the "Good of the Order" . . .

??? ☺

--- Craig Edwards, Brent Young, & Donna Pearson,
Facilitators

Please BE SURE to Provide Project Team with Copies of Final Lesson Plan & Estimated Teaching Schedule Before Leaving TODAY ☺ ☺ ☺

~4:30 p.m. **Adjourn Year 2 Summer Professional Development,**
Round #2

Thank You and have a safe trip home!!

APPENDIX W

MASTER SCOPE AND SEQUENCE CHART
(SAMPLE PAGE AUGUST 2004)

AGRICULTURAL MECHANICS CALENDER

Rev.

CTE ID		Pre	Week of: 16-Aug	Post	Pre	Week of: 23-Aug	Post	Pre	Week of: 30-Aug	Post
5102	*Lesson*									
5104	*Lesson*							*X*	**1**	*X*
5106	*Lesson*									
5107	*Lesson*									
5108	*Lesson*									
5109	*Lesson*									
5110	*Lesson*									
5111	*Lesson*									
5112	*Lesson*									
5113	*Lesson*									
5114	*Lesson*									
5115	*Lesson*									
5117	*Lesson*									
5118	*Lesson*									
5119	*Lesson*									
5120	*Lesson*				*X*	**1**	*X*			

APPENDIX X

THIRD PROFESSIONAL DEVELOPMENT SESSION AGENDA

Math-in-CTE
Professional Development Training: Year 2
Agricultural Power & Technology

November 7-8, 2004

Atherton Hotel & Student Union
Oklahoma State University
Stillwater, OK

Agenda

Sunday, November 7

11:30 – 1:00 p.m. **Arrival, Check-in to Hotel, Pick-up Agenda & Name Badges**

---Jamie King & Brent Young, Facilitators

1:00 p.m. **Lunch Available (Exhibit Rooms 1 & 2, 4th floor Student Union)**

1:30 p.m. **Welcome, Craig Edwards & Jim Leising, Oklahoma State University**

A Report and Up-date from the National Research Center for Career & Technical Education, Dr. Donna Pearson, Research Associate, University of Minnesota

A Report on Oklahoma Results from Year 1

---Craig Edwards

Questions, Comments, & Concerns, Group

2:15 p.m. **Status Report: Lessons taught so far . . ., Teachers**

2:45 p.m. **Lesson Presentations and Practice Begins (2)**

Please review *Rubric for Critiquing Lesson Plans*; Be looking for "The Seven Elements" during the lesson presentations; "What about the math?"

---Brent Young, Jamie King, Craig Edwards, & Donna Pearson, Facilitators

Sunday, November 7 (cont.)

---Lesson #9 (Crescent), Christy Jennings & Jan Willson

Questions, Comments, Ideas . . . .☺ ☺ ☺

---Lesson #10 (Lone Wolf #1), Wade Heldermon & Gradena Coffey

Questions, Comments, Ideas . . . .☺ ☺ ☺

~3:45 p.m. Refreshment Break

~4:00 p.m. Lesson Presentations and Practice Continues (4)

---Lesson #11 (Frederick #2 [Formerly Ringwood]), Bill Blankenship & Heath Stehr

Questions, Comments, Ideas . . . .☺ ☺ ☺

---Lesson #12 (Frederick #1), Bill Blankenship & Heath Stehr

Questions, Comments, Ideas . . . .☺ ☺ ☺

---Lesson #13 (Ponca City), Kevin Frazier & Zac Ladner

Questions, Comments, Ideas . . . .☺ ☺ ☺

--- Lesson #14 (Tishomingo), Luther Harbert & Ronnie Walker

Questions, Comments, Ideas . . . .☺ ☺ ☺

Other Comments about Lesson Presentations . . .

Check-in to Hotel Rooms (as needed)

~6:30 p.m. **Group Dinner (Oklahoma Room, 211 SU)**

~7:15 p.m. **Lesson Presentations and Practice Continues (3)**

---Lesson #15 (Sapulpa), Tim Boeder & Millie Cummins

Questions, Comments, Ideas . . . .☺ ☺ ☺

Sunday, November 7 (cont.)

---Lesson #16 (Pauls Valley), Jim Parks & Kenneth Brantley

Questions, Comments, Ideas . . . .☺ ☺ ☺

---Lesson #17 (Lone Wolf #2 [Formerly Carney]), Wade Heldermon & Gradena Coffey

Questions, Comments, Ideas . . . .☺ ☺ ☺

Adjourn for the Evening

Monday, November 8

6:30 a.m. **Continental Breakfast available at the meeting room**

7:00 a.m. **Day #2 of Workshop Begins (Exhibit Rooms 1 and 2, 4th Floor SU)**

Questions, Thoughts, Suggestions from Overnight, Group

Proposed Sequencing of Lessons 9-17, Group

Use Your School & Program Calendars to Prepare an "Estimated" Schedule for Teaching the Remaining Lessons (Please use the calendar handout provided)

--- Brent Young, Craig Edwards, & Donna Pearson, Facilitators

7:30 a.m. **Change Regarding Competency Testing, Jennifer Nuttle, OK CareerTech**

Teams Modify and Improve Lesson Plans using the *Rubric for Critiquing Lesson Plans* , AS NEEDED (See "7 Elements," notes, new references, etc.); Be sure to include electronic copies of any documents turned in for scanning

******AGED 3103 Students, plan to arrive by 8:25 a.m. You will be grouped with an Agriculture teacher—Math teacher team who will discuss the math-enhanced lessons they have developed in the context of Agricultural Power & Technology, their participation in the research study, the effects on student learning they have witnessed, and what they have learned about working together to improve student achievement. Class will end at its regular time—9:20 a.m.**

Monday, November 8 (cont.)

Up-date Electronic Files ("Save, Save, Save, . . .")

~9:30 a.m. **Additional Refreshments Available**

Teams Finalize Revised Lesson Plans & Estimated Teaching Schedules – Generate Hard Copies and Electronic Copies

Discuss Next PD – Dates & Times, Group

Questions about the next Math Cluster meetings

(Discuss MEALS)

Year 2 Payment Forms . . .

Travel Mileage Forms: Please <u>BE SURE</u> to include your <u>Vehicle License Number</u>

Substitute Reimbursement Forms . . .

Please <u>BE SURE</u> to Provide Project Team with Copies of Final Revised Lesson Plans & Estimated Teaching Schedules <u>Before</u> Leaving TODAY!!!!!!

---Brent Young & Craig Edwards, Facilitators

~11:45 a.m. Box Lunches Available

<u>Thank You</u> and have a safe trip home!!!

APPENDIX Y

FOURTH PROFESSIONAL DEVELOPMENT SESSION AGENDA

Math-in-CTE
Professional Development Training: Year 2
Agricultural Power & Technology

January 23-24, 2005

Atherton Hotel & Student Union
Oklahoma State University
Stillwater, OK

Agenda

Sunday, January 23

11:30 – 1:00 p.m. **Arrival, Check-in to Hotel, Pick-up Agenda & Name Badges**

---Jamie King & Brent Young, Facilitators

1:00 p.m. **Snack Available (<u>Exhibit Rooms 1 & 2, 4th floor Student Union</u>)**

Please Turn-in . . .

Samples of student work for <u>Step 7</u>: one for each lesson taught. Include your teacher ID # and remove students' names

Fall and/or spring teaching videotapes

Any changes made to the lesson plans you have already taught

Anything you have added to the lesson plans, such as: additional worksheets, PPts, test questions, class activities, etc. These contributions will be shared with the others and posted on the Web site.

1:30 p.m. **Welcome, Craig Edwards & Jim Leising, Oklahoma State University**

An up-date from the National Research Center for Career & Technical Education, Dr. Donna Pearson, Research Associate, University of Minnesota

Sunday, January 23 (cont.)

Oklahoma Up-date . . .

---Craig Edwards & Brent Young

Questions, Comments, & Concerns, Group

2:15 p.m. **Status Reports: Lessons taught since November PD,**

Teachers

--How many?

--How did it go?

--What did you learn?

--Specific problems/concerns/ideas?

~3:15 p.m. **Refreshment Break**

3:35 p.m. **Reports from Math Captains . . .**

NW/C, SW, NE, & SE . . .

--Themes? --Major concerns?

~4:00 p.m. **Further review and explanation of math concepts**

embedded in the more advanced lessons #14 – 17

---Brent Young, Craig Edwards, & Donna Pearson,

Facilitators

Please consult *Rubric for Critiquing Lesson Plans* -"What about the math?"

---Lesson #14 (Ponca City), Kevin Frazier & Zac Ladner

Questions, Comments, Ideas . . . .☺ ☺ ☺

--- Lesson #15 (Tishomingo), Luther Harbert & Ronnie Walker

Questions, Comments, Ideas . . . .☺ ☺ ☺

Sunday, January 23 (cont.)

---Lesson #16 (Lone Wolf #2 [Formerly Carney]), Wade Heldermon & Gradena Coffey

Questions, Comments, Ideas . . . .☺ ☺ ☺

---Lesson #17 (Pauls Valley), Jim Parks & Kenneth Brantley

Questions, Comments, Ideas . . . .☺ ☺ ☺

Other comments/questions about the advanced Lessons???

Announcements about tomorrow . . .

Check-in to Hotel Rooms (as needed)

~6:30 p.m. **Group Dinner (Oklahoma Room, 211 SU)**

Adjourn for the Evening

Monday, January 24

7:30 a.m. **Juices, Coffee, and Soft Drinks, available at the meeting room**

8:30 a.m. **Day #2 of Workshop Begins**
(Exhibit Rooms 1 and 2, 4th Floor SU)

Questions, Thoughts, Suggestions from Overnight, Group

--- Brent Young, Craig Edwards, & Donna Pearson,
Facilitators

Use Your School & Program Calendars to Adjust Your
"Estimated" Schedule for Teaching the Remaining Lessons (Please use the calendar handout provided)

--Turn-in revised calendars . . .

Center's Recommendations for Change and Improvements to Selected Lesson Plans Shared and Explained (To be done on a team basis) . . .

---Dr. Donna Pearson, Facilitator

Teams Modify and Improve Lesson Plans Using the
***Rubric for Critiquing Lesson Plans* per Center's Recommendations. Be sure to provide electronic copies of all revised documents**

Teams for Lesson Plans #1 – 8 focus on any changes/ improvements/additions that need to be made for "Posterity" (See Handout) . . .

Up-date Electronic Files ("Save, Save, Save, . . .")

--- Brent Young, Craig Edwards, & Donna Pearson,

Facilitators

~10:00 a.m. **Additional Refreshments Available**

Teams Finalize Revised Lesson Plans & Revised "Estimated" Teaching Schedules – Generate Hard Copies and Electronic Copies

~Noon **Group Lunch (Oklahoma Room, 211 SU)**

Monday, January 24 (cont.)

~1:15 p.m. **Important Discussion Items**

Planning/Scheduling of third Math Cluster meetings by cluster

Student work samples . . . (Special Opportunities)

Videotaping . . . IMPORTANT!!! ☺☺☺

Posttesting Procedures . . .

---Math Tests . . .

---On-line Ag Mech Competency Testing . . .

---Timeframe . . .

---Working w/ Testing Liaisons

---Questions . . .???

Summer Debriefing – Date & Time, Group

Important "To Do" Items

Additional Year 2 Payment Forms . . .

Travel Mileage Forms: Please BE SURE to include your Vehicle License Number

Substitute Reimbursement Forms . . .

Please BE SURE to Provide Project Team with Copies of Any Revised Lesson Plans & Revised "Estimated" Teaching Schedules Before Leaving TODAY!!!!!!

---Brent Young & Donna Pearson, Facilitators

~3:00 p.m. **Adjourn**

Thank You and have a safe trip home!!!

APPENDIX Z

FINAL PROFESSIONAL DEVELOPMENT SESSION AGENDA

Math-in-CTE
Year 2: Debriefing Meeting
Agricultural Power & Technology

June 15, 2005

Student Union, 4th Floor, Exhibit Room 1
Oklahoma State University
Stillwater, OK

Agenda

☺ ☺ ☺ . . . Refreshments – Please help yourself . . . ☺ ☺ ☺

Please turn-in any remaining study materials that you may have – teaching videotapes, student work samples, post-study questionnaires, missing reports, etc.

9:30 a.m. **Convene, Welcome, and Review Agenda**

---Dr. Craig Edwards, Brent Young, & Dr. Jim Leising

9:45 a.m. **Focus Group Interview Orientation: Dr. Jim Stone, Director, Dr. Donna Pearson, Research Associate, & Dr. Morgan Lewis, Research Associate, National Research Center for Career & Technical Education, University of Minnesota**

10:00 a.m. – ~11:50 a.m. **Focus Groups: Dr. Jim Stone (Room 413), Dr. Donna Pearson (Room 408), & Dr. Morgan Lewis (Room 420), Facilitators**

Noon – **Group Lunch** **(Oklahoma Room, 211 Student Union)**

~2:00 p.m. **A Report and Up-date from the National Research Center for Career & Technical Education, Dr. Jim Stone, Director**

Questions, Comments, & Concerns, Group

Remarks, Dr. Phil Berkenbile, State Director, Oklahoma
Department of Career & Technology Education;
Mr. Eddie Smith, Program Administrator, AGED

Team Photos, Certificate Presentations, & Confirmation of
Press Release Information

---Julie Focht & Brent Young, Facilitators

~2:15 p.m. **Reconvene 4th Floor, Exhibit Room 1**

Announce videotaping of brief interviews following adjournment

Availability of finalized lesson plans – CD and Web site

What's next???

Workshop for Control Group teachers – Tomorrow

Analysis of Year 2 data and publication of findings

2:45 p.m. **Refreshments arrive . . . ☺ ☺ ☺**

Future teacher-led presentations about the study . . .

---HSTW, SREB, July '05

---ACTE, New Orleans, LA, Dec. '05

---Others?

What will you do locally as a result of your participation in the study ("Communities of Practice")?

Special Presentations . . .

---Craig Edwards, Brent Young, NRCCTE Staff, Facilitators

~3:45 p.m. **Complete Travel Mileage Forms: Please BE SURE to include your Vehicle License Number**

---Brent Young, Facilitator

~4:00 p.m. **Adjourn**

Note: If you are an agriculture teacher who is not assisting with tomorrow's workshop but you wish to provide a short videotape interview about your experience with the project, please plan to stay for a short time following the adjournment.

If you are assisting with tomorrow's workshop for control group teachers, please plan to stay for a short time to discuss tomorrow's activities.

Thank You for all that you have done to make this a successful project!! Have a safe trip home.

APPENDIX AA

DEBRIEFING SESSION FOR CONTROL TEACHERS AGENDA

Math-in-CTE

Control Teacher Debriefing Meeting

Agricultural Education: A Powerful Tool for Helping Students Learn Math Better!

June 16, 2005

Student Union, 4th Floor, Exhibit Rooms 1 & 2
Oklahoma State University
Stillwater, OK

Agenda

8:30 a.m. **Welcome, Introductions, and Workshop Overview**

---Dr. Craig Edwards, Mr. Brent Young, Dr. Jim Leising, OSU, & Dr. Donna Pearson, Research Associate, National Research Center for Career & Technical Education, University of Minnesota

8:45 a.m. **Overview of the Math-in-CTE Study (NRCCTE) . . .**

Overview of the Oklahoma Ag Power & Technology portion of the study: Findings from Spring 2004, etc.

---Dr. Craig Edwards et al.

Questions, Comments, Group

9:20 a.m. **Explanation of Curriculum Mapping and Sequencing Procedures,Oklahoma**

---Dr. Craig Edwards and Select Experimental Teachers

Questions & Comments, Group

9:45 a.m. **Explanation of the "7 Elements" Teaching Approach**

---Mr. Brent Young and Select Experimental Teachers

Questions & Comments, Group

~10:15 a.m. Break

10:30 a.m. Lesson Presentations/Demonstrations: Examples of lessons taught and how . . .

---Mr. C.L. McGill, Tuttle
---Mr. Larry Berg, Pond Creek-Hunter

Tips from a Math Teacher Partner, Mrs. Gradena Coffey, Lone Wolf

Questions, Comments, & Concerns, Group

12:00 – ~1:15 p.m. <u>Group Lunch</u> (Sequoyah Room, 280 Student Union)

1:25 p.m. Reconvene 4th Floor, Exhibit Room 1 & 2

Lesson Presentations/Demonstrations: Examples of lessons taught and how (cont.) . . .

---Mr. Bill Blankenship, Frederick
---Mr. Wade Heldermon, Lone Wolf

Tips from a Math Teacher Partner, Mrs. Gradena Coffey, Lone Wolf

Questions, Comments, & Concerns, Group

2:30 p.m. Preliminary planning of a math-enhanced lesson in Agricultural Power & Technology, Group

---Teacher Facilitators and Project Staff

~3:45 p.m. What's next???

NRCCTE Information . . .

Analysis of Year 2 data and publication of findings

Availability of finalized lesson plans – CD and Web site

Special Presentations . . .
---Project Staff, Facilitators

~4:30 p.m. Adjourn

<u>Thank You</u> for all that you have done to make this a successful project!! Have a safe trip home.

VITA

Roy Brent Young

Candidate for the Degree of

Doctor of Philosophy

Thesis: EFFECTS OF A MATH-ENHANCED CURRICULUM AND INSTRUCTIONAL APPROACH ON THE PERFORMANCE OF SECONDARY EDUCATION STUDENTS ENROLLED IN A YEAR-LONG AGRICULTURAL POWER AND TECHNOLOGY COURSE: AN EXPERIMENTAL STUDY

Major Field: Agricultural Education

Biographical:

Personal Data: Born at Friona, Texas on January 23, 1960, son of Roy and Loretta Young, married May 26, 1978, husband of Karla Sue Young, father of Nathanial, Tasha, and Kathryn, grandfather of Aly, Zoë, Aden, and Holland.

Education: Graduated from Olathe High School, Olathe, Colorado in May 1978; received Bachelor of Science Degree in Vocational Agriculture from Colorado State University, Fort Collins, Colorado in May 1982; received Masters of Education Degree in Vocational Education from Colorado State University, Fort Collins, Colorado in August of 1986. Completed the requirements for the Doctor of Philosophy Degree in Agricultural Education at Oklahoma State University, Stillwater, Oklahoma in (May, 2006).

Experience: Graduate Teaching and Research Associate, Department of Agricultural Education, Communications, and 4-H Youth, Oklahoma State University; Area Agent, 4-H Youth, Colorado State University Cooperative Extension; Area Agent, Agricultural Marketing, Colorado State University Cooperative Extension; Agricultural Instructor, Fruita Monument High School, Fruita, Colorado; Instructor of Agriculture, Mesa State College, Grand Junction, Colorado; Production Agriculture Coordinator, Northeastern Junior College, Sterling, Colorado, Graduate Teaching Assistant, Vocational Education Department, Colorado State University; Vocational Agriculture Instructor, Paonia High School, Paonia, Colorado; Vocational Agriculture Instructor, Wiggins High School, Wiggins, Colorado.

Professional Memberships: National FFA Alumni Association (Lifetime Member); American Association for Agricultural Education.

Name: Roy Brent Young Date of Degree: May, 2006

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: EFFECTS OF A MATH-ENHANCED CURRICULUM AND INSTRUCTIONAL APPROACH ON THE PERFORMANCE OF SECONDARY EDUCATION STUDENTS ENROLLED IN A YEAR-LONG AGRICULTURAL POWER AND TECHNOLOGY COURSE: AN EXPERIMENTAL STUDY

Pages in Study: 226 Candidate for the Degree of Doctor of Philosophy

Major Field: Agricultural Education

Scope and Method of Study: The purpose of this study was to empirically test the posit that students who participated in a contextualized, mathematics-enhanced high school agricultural power and technology curriculum and aligned instructional approach would develop a deeper and more sustained understanding of selected mathematics concepts than those students who participated in the traditional curriculum and instruction. This study included teachers and students from 32 high schools in Oklahoma (16 experimental classrooms; 16 control classrooms). Students were enrolled in an agricultural power and technology course during the 2004-2005 school year. The experimental design employed was a posttest only control group; unit of analysis was the classroom. One-way analysis of variance (ANOVA) and analysis of covariance (ANCOVA) were used to test the study's null hypotheses.

Findings and Conclusions: The math-enhanced curriculum and aligned instruction did not significantly affect ($p < .05$) students' mathematics ability as measured by a traditional test of student math knowledge, by an "authentic" assessment of student ability to use math to solve workplace problems, or by an examination used to determine students' need for math remediation at the post-secondary level. In addition, the experimental group students' technical competence in agricultural power and technology did not diminish as a result of the study's experimental treatment. Thus, the study's null hypotheses were not rejected. However, the measure of students' need for mathematical remediation at the post-secondary level and the traditional test of student math knowledge did reveal results that held practical significance and favored the experimental group students.

ADVISER'S APPROVAL: James G. Leising