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

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TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

LIST OF TABLES

Table Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

The lack of connection between subject matter in secondary schools has been widely recognized for a number of years (Glasgow, 1997; NASSP, 1996). Glasgow illustrated this separation when he said, "the only thing that connects classes in secondary schools are the corridors" (1997, p. ix). A clear picture of this lack of connection may be seen when evaluating the relationship between vocational and academic education. Many vocational courses are taught simply by showing a student how to perform an operation without properly training the student in the theory behind the operation (Parnell, 1996). The opposite is true about many academic programs (Grubb, 1995). In many academic programs the student is lectured to about theories and principles, but is never shown how these theories and principles can be applied to real situations (Bottoms & Sharpe, n.d.).

Parnell (1996) described the two categories: "Academic education: learning to know is most important; application can come later. Vocational education: learning to do is most important, and knowledge will somehow seep into the process" (p. 19). This dichotomy of instruction seems to be based on the distinction between "procedural knowledge" or knowing how to implement strategies toward the successful completion of a task and "conceptual knowledge" or knowing why the strategy was successful in the completion of the task (Crowley, 2003; Tall et,al. 2001). What is more, Crowley maintained that academic gains could be achieved through a proper mix of the two. This gap between practice and theory must be bridged. According to a guide for implementing curriculum integration published by The Ohio State University (Center on Education and Training for Employment, 1998), this bridge could come in the form of contextualized learning.

Studies have concluded that agricultural education has the potential to serve as a resource that provides practical applications of scientific principles (Chiasson & Burnett, 2001; Enderlin & Osborne, 1992). For many years, secondary agricultural education has been built on the foundation of making knowledge practical (Phipps & Osborne, 1988). Inquiries involving contextualized learning practices have been conducted by researchers in secondary agricultural education (Beadles, 1992; Christian, 1993; Hitz & Scanlon, 2001; Johnson, Wardlow, & Franklin, 1997; Balschweid, 2001; Roegge & Russell, 1990). A major contributor to the need for this type of research has been the advancements in biological and technical applications in the field of agriculture (Wilson, 2002). More directly, for agriculturalists to be productive and competitive in modern society, they must be better educated in the scientific and mathematical principles supporting their practice. In fact, Shepardson (1929) proclaimed that, "Agriculture is a meeting-ground of 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).

Recently, professionals in mathematics and science education have embraced the concept of applied or "hands on" learning as an effective form of instruction that improves student learning. This approach is not designed to replace content with meaningless activities, but to enhance the student's comprehension of the content (Bailey, 1998; Haury & Rillero, 1994; Kahle, 1998; Prescott, Rinard, Cockerill, & Baker, 1996; Romberg & Kaput, 1999).

The need for increased achievement in mathematics is well established. The National Assessment of Educational Progress (NAEP) (2003) reported that 37% of 12th grade students performed at a "Below Basic" level on the math portion of their test. In addition, 63% of students performed at a "Basic" level, a step lower than "Proficient" (National Center for Education Statistics, 2003). In 2000, Parsad, Lewis and Greene determined that 22% of postsecondary students require remedial coursework in mathematics.

The need for improved student performance in mathematics is especially apparent in the state of Oklahoma. In 2004, the Oklahoma state board of education reported that only 27% of all students who had completed an algebra 1 class scored in the range of "satisfactory" or "advanced" performance level on the Oklahoma core curriculum end of instruction examination for algebra 1. Forty-eight percent of Oklahoma algebra 1 students scored at a level of "limited knowledge" while a full one-fourth of all algebra 1 students in the state scored "unsatisfactory" on their end of instruction examination (Oklahoma State Board of Education, 2004). These achievement levels must be addressed if public schools are to continue to prepare students to be contributing members of society as well as participants in the agriculture, food and fiber, natural resources system.

Statement of the Problem

While several studies have been conducted to determine the effects of contextual learning on student attitudes toward subject matter (Hitz & Scanlon, 2001; Johnson, Wardlow, & Franklin, 1997; Balschweid, 2001; Roegge & Russell, 1990), very little research has been carried out to actually measure the effects of contextualized teaching and learning on student achievement. The question at this point is as follows: Can secondary agricultural education provide students with a contextualized curriculum in mathematics and an instructional approach that increases student achievement in mathematics?

Purpose

The purpose of this study was to empirically test the hypothesis that students who participate in a contextualized, mathematics-enhanced high school Agricultural Power and Technology curriculum (i.e., experimental curriculum) 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, Alfeld, Jensen, Morgan, & Pearson, 2004) in their technical field and more broadly. Mathematics achievement was measured by student performance on three standardized, "paper-and-pencil" tests: Terra Nova, Work Keys, and ACCUPLACER. Student technical competence was measured by the National Occupational Competency Testing Institute (NOCTI) - Agriculture Mechanics 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 math.

Research Questions

The following research questions guided the study:

1. What is the effect of a math-enhanced Agricultural Power and Technology curriculum and an 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 a student's need for postsecondary math remediation?

3. Does a math-enhanced Agricultural Power and Technology curriculum and aligned instructional approach diminish a student's 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 spring semester of 2004?

5. Does teacher adherence to the seven-step 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 conventional standardized tests 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 a student's 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 a student's need for math remediation at the post-secondary level.

Scope of the Study

This study included subjects from 38 high schools in the state of Oklahoma. Each of these subjects was enrolled in the Agricultural Power and Technology Course in the spring of 2004. Total number of subjects tested was 443 with 200 experimental group participants and 243 control group participants.

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 professional development meetings.
4. Experimental group teachers presented each lesson employing the "seven-step" math-enhanced instructional model.
5. Each student performed to the best of their ability on each measure.

Delimitations of the Study

This study was delimited to 443 students enrolled in Agricultural Power and Technology and to 38 teachers of that course during the spring of 2004 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 courses as to bias findings.
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 student's general math ability i.e., Terra Nova Basic Battery, 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 spring 2004. 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

The results of this study demonstrate a valuable educational resource that already exists in public schools (i.e., secondary agricultural education), yet may be untapped. Based on the effects of the treatment described in this study, Oklahoma agricultural educators may choose to adopt the practices tested in the study for the benefit of all students enrolled in Agricultural Power and Technology. This study may also provide significant evidence that could support a rationale for further investigation of this topic in other school settings. This study made a contribution toward the goals of educational reform legislation including *Perkins III* and *No Child Left Behind* ("A New Age", 2002; U.S. Department of Education, n.d.).

The mixed-method multiple measure approach ensured the quality of the research so that results can be used by teachers, administrators, and policymakers to make informed decisions about curriculum choices related to improving student math achievement in the future. Demonstrating that a math-enhanced Agricultural Power and Technology curriculum improved the math achievement of a range of high school students holds consistent with the claim that agricultural education contributes to not only educational objectives associated directly with agricultural education, but to general education objectives as well. To this end, Phipps and Osborne (1988) posited that,

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

In addition, this study provides evidence useful in future considerations of federal policy on secondary education, and, in particular, career and technical education.

Operational Definitions

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

<u>Agricultural Education</u>- ". . . 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? section, ¶8, 2004; Oklahoma Department of Vocational and Technical Education, 2000).

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).

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 (Bottoms & Sharp, n.d.).

Enhanced Math 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.

Enhanced Math Instruction- Instruction in Agricultural Power and Technology that employs an enhanced math curriculum and is delivered through the following seven-step teaching procedure:

1. Teacher recognizes math with the class.
2. Teacher assesses students' math awareness.
3. Teacher walks through a "pulled out" example.
4. Teacher explains math concepts, integrating math terminology with Agricultural Power and Technology terminology.
5. Teacher reinforces student understanding by having students try similar agricultural and math examples.
6. Teacher checks for understanding.
7. Students either create or are presented with new agricultural as well as broader math examples to be solved. (Bickmore-Brand, 1993; Stone, et al., 2004)

Enhanced Math Lesson Plan- A teaching plan that outlines a series of instructional steps involving math and Agricultural Power and Technology curriculum and includes each of the seven steps necessary to carry out the enhanced math instructional intervention employed in this study (Stone, Alfeld, Jensen, Morgan, & Pearson, 2004).

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

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).

National Occupational Competency Testing Institute (NOCTI) – Agriculture Mechanics- Examination used to assess a student's Agricultural Power and Technology competence.

Oklahoma Priority Academic Student Skills (PASS) in Mathematics for High School- Curriculum framework prepared through 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 Department of Education, 2004).

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.

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

Terra Nova CAT™ Survey Edition (CTB/McGraw-Hill) – An examination employed to determine a student's level of general math aptitude following the experimental treatment.

Traditional Mathematics Instruction- Mathematics instruction rooted in cognitive development with little attention to practical application (Parnell, 1996).

Traditional Science Instruction- Science instruction rooted in cognitive development with little attention to practical application (Parnell, 1996).

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

Work Keys Applied Mathematics Assessment (ACT)- An examination that measures a student's ability to use math to solve workplace-related problems.

CHAPTER 2

REVIEW OF LITERATURE

Introduction

The purpose of this chapter is to present a review of the related literature for this research study. This review will shed light on the effectiveness of contextualized learning when executed properly as well as the need for further study of the subject. The review is divided into the following sections: (1) Introduction; (2) History of Contextualized Learning; (3) Rationale for Contextualized Learning; (4) Related School Reform Issues; (5) Review of Mathematics Education Literature Related to Learning Through Contextualized Curriculum; (6) Congruency of Mathematics Education Philosophy and that of Secondary Agricultural Education; (7) Barriers to Contextualized Learning; (8) Theoretical Framework; (9) Summary.

History of Contextualized Learning

The importance of making learning relevant to the student through the context of agriculture is not exactly a new concept but it is one that may have never fully reached its potential. In fact, this idea is supported by research done in the early to mid 20th century by Jean Piaget (1968).

In 1994, Haury and Rillero exhibited Piaget's position on contextualized learning in the following passage,

> Piaget stressed the importance of learning by doing, especially in science. According to Piaget, "a sufficient experimental training was believed to have been provided as long as the student had been introduced to the results of past experiments or had been allowed to watch demonstration experiments conducted by his teacher, as though it were possible to sit in rows on a wharf and learn to swim merely by watching grown-up swimmers in the water" (as cited in section 2).

John Dewey presented his stance on contextualized learning in 1897 when recording his pedagogical creed. Dewey stated, "I believe that education which does not occur through forms of life, or that are worth living for their own sake, is always a poor substitute for the genuine reality and tends to cramp and deaden" (as cited in Dworkin 1959, p. 23). Dewey felt very strongly about the importance of curriculum integration and the consequences of separating knowledge from application. This state of mind 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 & McCarthey, 1997, p. 180).

Alfred North Whitehead recognized the need for the integration of curriculum as early as 1929. Whitehead asserted, "The solution which I am urging is to eradicate the fatal disconnection of subjects which kills the vitality of our modern curriculum. There is only one subject matter for education, and that is Life in all its manifestations" (p. 10).

In 1947, *A Handbook on Teaching Vocational Agriculture*, identified agricultural education as an integral piece of public secondary school education that contributed to the general objectives and philosophy of a student's education (Cook). The author identified how agricultural education contributed to the "seven cardinal principles of an education" (p. 50). For example, "Vocational agriculture instruction develops abilities in constructive thinking and problem solving which enables the student to have a better command of the fundamental processes" (p. 5). This book was written over a half century ago, yet some of the recommendations for successful education programs are nearly identical to those of present day education.

The importance of contextualized learning has been a very prominent topic in agricultural education for the past 10 to 15 years. The National Research Council vividly brought this topic to the forefront in 1988. The council published the book, *Understanding Agriculture: New Directions for Education*, calling for the integration of sciences into the agricultural curriculum (p. 11). The book describes changes needed to be made to the then current system of secondary vocational agriculture. The Council determined that vocational agriculture needed to broaden the educational opportunities that it afforded to reflect the new definition of agriculture including aspects ranging from traditional production agriculture to agricultural science concepts far removed from the farm or production setting. This evaluation of the agricultural education program not only lead to changes in curriculum that involved incorporating more academics into the agricultural curriculum, but also a new name. In 1989, the name *vocational agriculture* was replaced with *agricultural education*. This name change was an attempt to reflect the new nature of the educational program, which no longer only focused on vocational training but also on stronger academic learning and preparation.

The importance of such concepts as contextualized learning was also reflected in the Carl D. Perkins act of 1990, which called for integration of science into agricultural education. Through this act, some degree of curriculum integration must be accomplished for vocational education programs to receive federal funding (Public Law 101-392).

Rationale for Contextualized Learning

In order for secondary agricultural education to remain effective in turning out well prepared and highly qualified graduates, programs must provide a strong emphasis on traditional academic skills (National Research Council, 1988). L.H. Newcomb (1995) supported this claim when he stated, "The need to have students graduate with the demonstrated capacity to think at the higher levels of Bloom's taxonomy is more urgent than ever. The nature of the world we live in demands it." (p. 4). Moreover, it is essential that the modern agricultural education department develop well-rounded individuals capable of adapting to the ever-expanding agricultural world in which we live (National Research Council).

One approach to developing this type of individual is described as "facilitative instruction that motivates students to learn" (Bodilly, Ramsey, Stasz, & Eden, 1994, section 2, ¶ 1). Facilitative instruction as it is described here involves applying scientific principles to an agricultural application that requires some degree of problem solving. By using this type of instruction, not only will the students be better motivated to learn, but also the transfer of learning can be boosted tremendously (Eggebrecht, et al., 1996). Eggebrecht et al. claimed that, "If learning has value, students should be able to transfer the knowledge they acquire in school to the world beyond the classroom" (p. 5). Eggebrecht and his colleagues put together a team of researchers to identify possibilities of instructional methods that would serve to create a higher level of transfer of learning. The team discovered that transfer of knowledge was greatly enhanced when multiple contexts for learning were employed. Newcomb, McCracken, and Warmbrod (1993) supported this claim by determining that students were much more inclined to learn things that they could put into practice immediately. Newcomb et al. defended the use of real life problems as teaching tools by making the argument that the natural process by which students learn should be identified and harnessed for use in the classroom. Johnson, Wardlow, and Franklin (1997) found, that students' attitudes about the subject matter were more positive when learning took place utilizing hands-on activities when compared to the worksheet instruction. These authors even went as far as to claim that the increase of motivation achieved through curriculum integration could possibly decrease high school drop-out rates.

According to Bottoms and Sharp (n.d.), integration of academic and vocational studies holds great potential for enhancing student learning in critical academic, technical, and personal areas. To that end,

> Integration is how people learn in the real world. In the school-based scenarios, concepts, issues, and ideas flow in many directions; few of them are related to the

real world. Students learn more quickly and easily if information is given in context. (p. 41)

Phipps and Osborne (1988) contended that most educators would agree that information gathered because it is necessary to the solution of a problem is learned more permanently. These problems can be presented to the student through the use of agriculture as a context in which the learning occurs. This view about student learning is constructivist in its approach (Brown, 1994). Brown concluded that student-centered teaching, project-oriented instruction, problem-based learning, and contextual teaching and learning are currently promoted as strategies for implementing constructivism and that these ideas also reflect the philosophy on which academic and vocational integration are based. This philosophy implies that education must forge connections between knowledge development and its application in the world.

Research performed within the Hodgson Vocational Technical High School in Delaware revealed that providing a context for learning mathematics not only improved student achievement but also provided math teachers with familiar examples that could be used in the course of teaching their subject matter (Ancess, 2001). Ancess stated, "Math teachers visited shop [vocational] classrooms and while there they taught math that corresponded to shop units so that students learned math when they needed to know it for their shop projects" (p.74). The author also concluded, "In their own classrooms, math teachers began to use shop references to teach math . . ." (p. 74). According to the New Castle County Vocational Technical District, the following year saw an increase of 13% on the Delaware math assessment for students involved in the integration movement over the previous year's students (as cited in Ancess, 2001).

Related School Reform Issues

General Education

The need for educational reform was expressed strongly in the report, *A Nation at Risk* (The National Commission on Excellence in Education, 1983). The seriousness of this need was conveyed through the following statement.

> If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war. As it stands, we have allowed this to happen to ourselves. We have even squandered the gains in student achievement made in the wake of the Sputnik challenge. Moreover, we have dismantled essential support systems which helped make those gains possible. We have, in effect, been committing an act of unthinking, unilateral educational disarmament. (section 1, ¶ 2)

Among the recommendations put forth by the commission, was a call for changes to be made in graduation requirements that increased the number of required academic classes. According to Barrick (1992),

> The back to basics approach advocated by the 1983 book *A Nation at Risk* and subsequent publications included stringent graduation requirements with an increase in the number of credits required in the 'core academic' courses (language arts, mathematics, science, social studies, history). (p. 6)

While these changes appear to be reasonable on the surface, they have often been at the expense of the vocational education program. Cetron and Gayle (1991) deem this to be a mistake considering that two-thirds of vocational education program graduates go on to two or four-year colleges. Other evidence that this "indirect" reduction of vocational education may be ill conceived include several studies indicating students who were provided a proper application for their instruction (i.e., a contextualized approach to learning) actually achieved higher scores on standardized general education tests (Chiasson & Burnett, 2001; Enderlin & Osborne, 1992).

While it would seem that some efforts toward educational reform have been at the expense of vocational education, others have been supportive of the vocational education model. In fact, in 1991 the Secretary's Commission on Achieving Necessary Skills (SCANS) produced the report *What Work Requires of Schools* describing education reform that called for more practical application of knowledge. This point of view is reflected through the following statement:

> We believe, after examining the findings of cognitive science, that the most effective way of learning skills is "in context," placing learning objectives within a real environment rather than insisting that students first learn in the abstract what they will be expected to apply. (SCANS, 1991, p. 16)

The idea of contextualized learning suggests that neither vocational nor general education is completely capable of standing alone but must be integrated to maximize benefits for the students (Prescott, Rinard, Cockerill, & Baker, 1996). To that end, Parnell (1996) stated,

> No longer can the debate over the importance of vocational or academic programs be allowed to degenerate into an either/or argument. The basis for good teaching is combining an information rich subject matter content with an experience rich context of application. (p. 1)

Cetron and Gayle (1991) stated in their book, *Educational Renaissance,* that, "This integrated approach may give students a finer grounding in the 'three R's' than do book and blackboard classes" (p. 72). The authors predicted that in the future students will value vocational education more, but this may only hold true if reform in the form of curricular and instructional integration occurs.

In 1996, the National Association of Secondary School Principals (NASSP) released a report entitled *Breaking Ranks: Changing an American Institution.* Within this report were many recommendations for reform in secondary education including a call for the integration of curriculum. According to the report, "Teaching subjects in isolation of each other, as high schools are wont to do, distorts knowledge" (p. 13). They also recommended that teachers form interdisciplinary teams to better familiarize themselves with related curriculum and to provide a more comprehensive, well-rounded education for students. Further, the report asserted that, "The content of the curriculum, where practical, [should] connect itself to real-life applications of knowledge and skills to help students link their education to the future" (p. 15). The NASSP recognized the need for knowledge to be made practical and useful for the student. The report posited that,

> This requires that high schools do more to present the curriculum in the context of experiences that call upon students to apply knowledge in situations

approximating those in which they will use knowledge in real life— 'authentic learning,' if you will. (p. 15)

In addition, the report recognized that not only would this practical application approach to learning help students to more readily understand the subject matter but would also serve to provide a source of interest to the students thus improving their attitudes about *what* they were learning.

Career and Technical Education Reform

In 1984, the first major revision to the vocational education act of 1963 was put into place. This reauthorization was to be for a time of four years and with it came a new name: the Carl D. Perkins Vocational Education Act of 1984 (Public Law 98-524). The major focus of this revision was to provide vocational education to special populations of citizens. A total of 57% of the state budgets for vocational education was required to be allocated for providing education to populations such as handicapped individuals, single parents, adults in need of retraining as well as criminal offenders (Public Law 98-524).

In September of 1990, President George W. Bush signed the second of the Perkins acts: The Carl D. Perkins Vocational and Applied Technology Education Act Amendments of 1990 (Public Law 101-392). The reform most prominent within this act was the call for integration of curriculum among academic and vocational programs. Supporting this notion was the concept of "Tech Prep" which has been described as ". . . the cooperative arrangement that combines academic and technical courses at the secondary and postsecondary levels" ("A New Age," 2002, p. 41). Through this act, a portion of a state's budget for vocational education was to be spent on providing students with an academic and vocational integrated curriculum.

The National School-to-Work Opportunities Act was enacted in 1994 (Public Law 103-239). This act was designed to provide students with necessary training in secondary schools to successfully enter the work force. According to *Techniques* magazine,

> The program components of School-to-Work included school-based learning, work-based learning and activities connecting the two. The internships and apprenticeships of school-to work have long been aspects of career tech, so many career and technical educators were involved in school-to-career programs in their districts. ("A New Age," 2002, p. 42)

The most recent of the Perkins' Acts was signed in 1998. This act focused on accountability of the vocational program toward the education of the student as well as the need for increased technology in the classroom (Public Law 105-332). A result of this revision included a system of "core indicators" by which the success of the vocational education program may be judged. These "indicators" range from measures of student achievement in vocational and academic areas to measures of students who successfully obtain employment as a result of their vocational training (McHewitt & Taylor, 2003).

This theme for increased accountability has carried over into other acts of education reform. For example, this theme is prevalent throughout the No Child Left Behind Act of 2001 (U.S. Department of Education, n.d.). According to the U.S. Department of Education, "Under the act's accountability provisions, states must describe how they will close the achievement gap and make sure all students, including those who are disadvantaged, achieve academic proficiency" (Accountability section, ¶ 1, n.d.).

In light of recent legislation effecting vocational and general education, student achievement and school accountability appear to be at the forefront of educational reform today.

Review of Mathematics Education Literature Related to Learning Through Contextualized Curriculum

Traditional secondary instruction in mathematics has been recognized as flawed in its delivery by researchers and practitioners (Romberg & Kaput, 1999). Class periods consisting of the repetitious process of students checking homework, teachers providing new examples for the day and a large amount of time allotted for the practice of the new concept or concepts have been criticized. According to Romberg and Kaput, "This mechanistic approach to instruction of basic skills and concepts isolates mathematics from other disciplines" (p. 4). The researchers concluded, "Traditional school mathematics has failed to provide students with any sense of importance of the discipline's historical or cultural importance, nor any sense of its usefulness" (p. 4). This approach has done little to connect the mathematical subject matter with that of other disciplines.

The abstract principles presented in these classrooms are often presented without meaningful context or explanation of how they may actually benefit the student other than memorization of facts and figures in the pursuit of a passing grade (Parnell, 1998). Parnell spoke of this shortcoming when he said, "Aside from the occasional lab, workbook, or 'story problem,' the element of contextual teaching is absent and little attempt is made to connect what students are learning and the real world in which they will be expected to work and spend their lives" (p. 15). In support, Yager (n.d.) stated, "Typical school mathematics and science seem unrelated to the real world. The skills and concepts taught are rarely internalized and rarely used" (¶ 3). Further, Parnell (1998) opined that the lack of meaningful instruction was the ". . . greatest sin committed in the teaching of mathematics today. . ." (p. 15). Parnell defined this "sin" as failure to provide connections between various aspects of education including academic and vocational education as well as between those experiences encountered within the classroom and outside of the confines of school.

An evaluation of selections from recent secondary mathematics education literature suggests that a trend toward reform in mathematics education has materialized as a form of contextualized learning. The impetus for this movement was summarized by Yager (n.d.) when the author stated, "Since the mid 1980s, we have learned more about learning. We now know that most students do not learn what teachers teach. Instead they retain explanations personally constructed to account for phenomena in the rational universe" (¶ 7). Romberg (1994) has gone as far as to make claims of increased retention due to presentation of subject matter through a familiar context. Bailey (1998) contended that specific coursework should be developed through which mathematics may be presented in a contextual manner. Agricultural Education was among the subjects discussed by Bailey,

> Agriculturally based activities, such as 4H and Future Farmers of America [, now FFA,] have for many years used the farm setting and students' interests in farming

> to teach a variety of skills. It only takes a little imagination to think of how to use the social, economic, and scientific bases of agriculture to motivate and illustrate skills and knowledge from all of the academic disciplines. (p. 27)

Also in support of contextually-based instruction in mathematics is the National Council of Teachers of Mathematics (NCTM). The council has determined that effective instruction in mathematics should include providing students with the opportunity to develop a deeper sense of meaning relative to their instruction (Kahle, 1998). Bay (n.d.) outlined a procedure by which students could build this understanding through the pursuit of solutions to specific problems. However, this use of problem-solving to deliver math education should not be confused with the use of math problems and repetition delivered as abstract principles; rather, Bay contended that, "Teaching *via* problem solving is teaching mathematics content in a problem-solving environment. [And that,] Learning in this approach involves learning through a concrete problem and eventually moving to abstraction" (Different Types of Problem Solving section, ¶ 4). This approach reflects closely an inductive approach to learning where students are instructed toward very specific situations or problems that will later be tied to a general principle (Saskatchewan Education, 1991). A similar approach was also proposed by John Dewey who described the instructional method as "'reflective thinking'" (as cited in Lass & Moss, 1987, p. 279).

In recent years, researchers and practitioners of mathematics education have recognized the value of language as it relates to effective instruction in mathematics (Bickmore-Brand, 1993; Diaz, 1998; Gawned, 1993). Bickmore-Brand (1993) stated,

> I believe that there has been a breakdown in communication with students not getting the message or making the meaning that their teachers wished for them. We need to look at the language that underpins the transmission of the knowledge, and hence need to give consideration to the extrapolation from those researchers in the language field, and apply their insights to communication in mathematics. (p. 8)

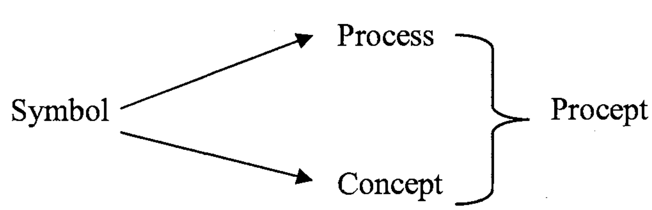
Reeves (1993) recognized a need for mathematical language to be introduced and maintained in courses other than mathematics. Reeves stated, "The creation of contexts to provide quality experience is what multi-sensory mathematics education has been advocating for several years, setting up experiences that are relevant and appropriate to young children whence mathematical information can be gleaned" (p. 92).

Kiong and Yong (2001) identified the role of language in mathematics education as a means of reflection and also as a means by which students may be formatively assessed by their instructor. Kiong and Yong recommended that math educators provide students with the opportunity to ". . . learn to explain and justify the legitimacy of their solutions" (p. 4). These opportunities may come in the form of group discussions or interactive activities. The authors go on to recommend reflective language be encouraged in the classroom as well as activities that show the relationship among different concepts. The researchers posited that mathematics instruction may be most effective when language is employed in helping students create "cognitive scaffolding" that will help them progress through mathematical problems. Wallace and Ellerton (2004) declared the role of language in the teaching of mathematics as "critical" and have described math language as a separate language "genre" (p. 3).

Diaz (1998) proposed a "whole math" approach to education based on the "whole language approach" initiative. Characteristics outlined by Diaz for a "whole math" approach to education include instruction that ". . . emphasizes the functionality of mathematics" (p. 107) as well as an atmosphere where students are active participants in an integrated curriculum design that crosses content areas

Clearly, language is a major factor in the design and delivery of effective instruction in mathematics. This importance is not limited to spoken language but also written language. In 2001, Tall et al. posited that the use of written language in the form of mathematical symbols represents a complex relationship between procedural and conceptual knowledge. The researchers termed this element of written language as "procept" (p. 5) to reflect the representation of both procedural and conceptual knowledge (see Figure 1).

Figure 1



Use of Written Language to Represent Procedural and Conceptual Knowledge (Taken from Tall et al., 2001)

Congruency of Mathematics Education Philosophy and that of Secondary Agricultural Education

Agricultural education has been based on practical application of knowledge since its inception (Conroy, Trumbull, & Johnson, 1999). Theories concerning effective teaching and learning in the field of agriculture (Lancelot, 1944; Newcomb, 1995; Phipps & Osborne; 1988; Shinn et al., 2003) have long reflected the values present in much of the recent mathematics education literature. Inherent to these values is the emphasis placed on method(s) used to deliver instruction. The problem-solving method of instruction as employed by, and endorsed by agricultural educators for many years, relies on a contextually bound "problem" through which instruction toward a more general or abstract principle may be delivered (Boone, 1990; Cano & Martinez, 1989; Conroy et al., 1999; Crunkilton & Krebs, 1982; Dyer & Osborne, 1996; Flowers & Osborne, 1988; Hammonds, 1950; Krebs, 1967; Newcomb et al., 1993; Phipps & Osborne, 1988; Torres & Cano, 1995). This approach to teaching can be traced back through secondary agricultural education as early as 1918 when Nolan recorded his stance on the value of such practice. Later, Shepardson (1929) expressed his support for this notion when he stated, "Agriculture is a meeting-ground of 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).

By 1944, Lancelot was convinced that not only was the problem-based approach to teaching and learning effective but that any and all subjects could be taught effectively through its use. Lancelot tied the use of the problem-solving method directly to student engagement and interest when he stated, "In general, those teachers who keep their students thinking teach their subjects by means of problems . . . " (p. 144). This school of thought concerning the value of the problem-based approach to learning has been prevalent with several influential agricultural education scholars including textbook authors, e.g., Cook, Crunkilton, Phipps, Newcomb, and Warmbrod, propounding its value.

At the heart of the problem-based approach to teaching and learning is the philosophy of constructivism. This constructivist approach to teaching and learning is observed easily through the problem-based method that has been described as " . . . teaching and learning [that] is a cooperative venture between the students and teacher rather than a completely teacher-dominated process" (Warmbrod, 1969, p. 231). Other researchers have described the problem-solving method as a valuable tool for inspiring students to think critically and achieve higher order thinking skills (Torres & Cano 1995).

Clearly, a similarity exists among the learning theories espoused by mathematics and agricultural educators about the use of meaningful problems embedded in specific contexts to deliver quality instruction that may be more easily learned by students. Shinn et al. recognized this similarity when the authors stated,

> The use of problem-based learning experiences as methods by which concepts and principles can be learned and applied are held in high regard by each discipline [, i.e., math and agricultural education]. It is apparent that both math educators and agricultural educators recognize the value of providing a meaningful context in which their instruction provides students with a deeper understanding of the usefulness and an application of their learning. (2003, p. 21)

The literature presented in the preceeding paragraphs demonstrates a strong connection between the pedagogical philosophies posited by many mathematics educators and agricultural educators. The use of meaningful and problematic situations as vehicles by which concepts and principles may be learned appears to be held in high regard by each discipline. It is also apparent in this literature that each discipline places great importance on providing a meaningful context in which instruction may be set to provide the learner with a more solid understanding of the usefulness of their education.

Barriers to Contextualized Learning

Contextualized learning may be provided to students through various approaches. Not the least of which is formal integration of subject matter between disciplines in the secondary school. While this curriculum integration appears to be a valuable teaching and learning resource for students and teachers alike, it may not be accomplished easily. Enderlin and Osborne (1992) identified many barriers to contextualized learning through curriculum integration. These barriers included insufficient planning time, incomplete teacher training as well as lack of administrative support. Through research, these authors determined that while curriculum integration proved to be very beneficial, it was also time consuming and sometimes difficult. The specific area of integration that Enderlin and Osborne focused on was that of agricultural science and biology. They studied student performance in a course that was developed through curriculum integration — Biological Science Applications in Agriculture (BSAA). These researchers determined that science teachers must feel that curriculum integration is important and work cooperatively with agricultural teachers to achieve effective results.

This reflects the vital importance of educating the general education teacher on the many benefits associated with contextual learning.

Enderlin and Osborne also determined that agriculture teachers must be committed to implementing curriculum integration to the extent they are willing to initiate the implementation process and subsequent relationships. The main reason for this is the simple fact that many academic teachers are unaware of the value of integrating with agricultural education. This research also exposed the need for administrators to realize the importance of promoting and supporting the implementation of curriculum integration in their schools. This statement reflects the essential element for curriculum integration. If the school administration is convinced that it is a useful tool then many of the other barriers such as time and training may be solved more easily.

Thompson (1998) also identified barriers such as lack of preparation time, lack of knowledge concerning how to integrate subject matter, as well as a lack of administrative support. Warnick and Thompson (2002) described some barriers to integration from the perspective of the general education teacher. Through their study it was clear that a major barrier to integration was the general education teacher's lack of agricultural knowledge. The teachers were obviously unaware of how they could achieve integration with agricultural educators.

The most recurrent themes concerning barriers to contextualized learning included lack of knowledge concerning common content areas between curriculums, lack of time for planning such projects and lack of administrative support (Enderlin & Osborne, 1992; Thompson, 1998; Warnick & Thompson, 2002; Whent, 1994).

Theoretical Framework

At the base of the theoretical framework for this study is pedagogical philosophy of constructivism. Doolittle and Camp (2003) described constructivism as ". . . the belief that learners construct their own knowledge from their experiences" (p. 2). To that end, Berns and Erikson (2001) stated that, "In this teaching and learning model, students construct their own knowledge by testing ideas based on prior knowledge and experience, applying these ideas to a new situation, and integrating the new knowledge gained with pre-existing intellectual constructs" (From Behaviorism to Constructivism and Contextual Teaching and Learning section, ¶ 2). This constructivist theory places a great deal of importance on providing students with authentic examples and situations in which they can interact and manipulate in a fashion that brings meaning to their learning (Dworkin, 1959; Haury & Rillero, 1994). Fosnot (1996) echoed this perspective when she referred to the constructivist educator as one who ". . . gives learners the opportunity for concrete, contextually meaningful experience through which they can search for patterns, raise their own questions, construct their own models, concepts and strategies" (p. ix). To this end, Buriak, McNurlen, and Harper (1996) posited, "The best way for learners to learn how to use knowledge in multiple contexts is to have the experience of applying knowledge in multiple contexts" (p. 32).

Constructivism theory has been described (Doolittle & Camp, 1999) as a "continuum"(p. 9) ranging from a very radical position that embraces the idea that knowledge is constructed through experiences yet this knowledge acquisition may not be quantified due to the impossibility of truly measuring a person's knowledge level to a form of constructivism referred to as "cognitive constructivism" (p. 9) that stresses primarily the cognitive processes of construction of knowledge in the student. While it is noted that the treatment described in this study does not align with the radical form of constructivism, agreement among constructivists across the spectrum exists concerning the value of contextual learning. Doolittle and Camp (1999) determined that providing "authentic and real-world environments" (p. 14) in which learning may take place is an "Essential Factor of Constructivist Pedagogy" (p. 14). Additionally, previous research has shown that it is extremely important to provide students with a real-life context in which they can readily apply the knowledge they are learning while learning it (Bottoms & Sharp, n.d.; Buriak, et al., 1996; Enderlin & Osborne,1992; Glasgow, 1997; Parnell, 1996).

John Dewey believed that the only true education that could be received had to come in the form of experience. Dewey wrote many books concerning this subject, each with a central message of the importance of providing knowledge through real life experiences. Dewey believed that teachers must make every effort to provide students with genuine problems or situations that will increase their level of interest and motivation. Dewey studied the ways in which people learn outside the school setting and developed a teaching philosophy that would attempt to replicate these circumstances in the classroom (Fishman & McCarthy, 1998).

Relying on the aforementioned framework, it seems reasonable to believe that approaching education from a contextualized teaching and learning perspective, i.e., where students are provided hands-on, true-to-life situations as a context for understanding abstract principles, should be an effective and beneficial method for improving student achievement.

Summary

This review of literature described many potential benefits that hold promise for improving student learning and understanding through contextualized teaching and learning methods. A contextualized approach to learning has shown promise for many years, yet not all educators have implemented it effectively. This may be due to the many barriers that must be overcome before this learning tool can be used effectively. The literature review demonstrated that reform is needed in the public school system and that all means of boosting student achievement should be exhausted. Accordingly, is it possible that an excellent tool for improving student performance is sitting just under the noses of those who are looking to improve student achievement, yet it goes virtually unnoticed? The literature suggests that contextualized learning is beneficial, but gives little account of just how valuable especially from an evidence-based, empirical perspective. For example, studies concerning student and teacher attitudes toward curriculum integration have been reported in the literature, but now rigorous research should be conducted on examining how a contextualized curriculum and aligned instructional approach delivered through a career and technical education course affects student performance in a broader sense, e.g., student achievement in mathematics. The purpose of this study was to determine the value of this educational approach under a specific set of learning circumstances.

Chapter 3

METHODOLOGY

Introduction

The purpose of this study was to empirically test the hypothesis that students who participate in a contextualized, mathematics-enhanced high school Agricultural Power and Technology curriculum (i.e., experimental curriculum) 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 et al., 2004) in their technical field and more broadly. Mathematics achievement was measured by student performance on three standardized, "paper-and-pencil" tests: Terra Nova, Work Keys, and ACCUPLACER. Student technical competence was measured by the National Occupational Competency Testing Institute (NOCTI) - Agriculture Mechanics 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 math.

This study was conducted as a portion of a larger study carried out in six separate sights nationwide. The larger study was conducted by the National Research Center for Career and Technical Education (NRCCTE) and was designed to empirically test the hypothesis that students who participated in an integrated, mathematics-enhanced high school career and technology curriculum would develop a deeper and more sustained understanding of selected mathematical concepts than those students who participated in the traditional curriculum and instructional approach. All random assignments performed within the study were computer generated by researchers at the NRCCTE.

The methodology for this study was adapted from the method and procedures set forth for the larger study (Stone et al., 2004).

Institutional Review Board

Federal regulations and Oklahoma State University policy require review and approval of all research studies that involve human subjects before investigators can begin their research. The office of University Research and the Institutional Review Board at Oklahoma State University conducted the aforementioned review to protect the rights and welfare of human subjects involved in biomedical and behavioral research. In compliance with this policy, this study received the proper surveillance and was granted permission to be executed. The institutional review board code for this study was AG0411 and a copy of the approval form is presented in Appendix A.

Population

Students

Two groups of ninth, tenth, eleventh, and twelfth grade Oklahoma high school students enrolled in 38 schools who received instruction in agricultural power and technology during the spring 2004 semester provided data for this study:

Group 1. Pupils identified as agricultural power and technology students who participated in a traditional curriculum during the spring 2004 semester (i.e., control group students).

Group 2. Pupils identified as agricultural power and technology students who participated in a math-enhanced curriculum and instructional approach during the spring 2004 semester (i.e., experimental group students).

Teachers

Two groups of Oklahoma agricultural education teachers who taught agricultural power and technology during the spring 2004 semester provided the classrooms and students for this study as well as data about selected teacher characteristics and perceptions. Teachers were randomly assigned to either the control group (n = 20) or to the experimental group (n = 18) for the purpose of the study. Initially, 41 teachers volunteered to participate in the study. Before the treatment began, two teachers who had been assigned to the experimental group removed themselves from the experiment as did one teacher who had been assigned to the control group; thus, 38 teachers participated.

Group 1. Instructors identified as agricultural education teachers who taught the traditional agricultural power and technology curriculum during the spring 2004 semester (i.e., control group teachers).

Group 2. Instructors identified as agricultural education teachers who taught a math-enhanced agricultural power and technology curriculum, e.g., prescribed math-enhanced lesson plans, and who used a standardized instructional approach when teaching (i.e., experimental group teachers).

Design of the Study

This study employed a posttest only control group experimental design (Campbell & Stanley, 1963). Each classroom was randomly assigned to either the experimental or control group but the assignment involved intact groups of students; thus, the "unit of analysis" was by classroom. In addition to the random assignment to groups, the two groups (experimental and control) were pretested to determine level of equivalence concerning basic mathematical aptitude (Campbell & Stanley, 1963; Tuckman, 1999). Following the treatment, comparisons were made between group means on each posttest measure. The research design is described in Figure 2.

Figure 2.

Research Design

Group		Time	
Experimental	R	X	O
Control	R	_____	O

This design was chosen primarily on the basis of its robust nature concerning validity and reliability. According to Tuckman (1999), this type of experimental design "... provide(s) completely accurate controls for all sources of internal validity" (p. 161).

The exams employed for comparisons were chosen to reduce threats to validity and reliability related to testing. These exams were very similar to those used often to assess student mathematic comprehension in secondary education. According to Campbell and Stanley (1963),

> ... in research on teaching, one is interested in generalizing to a setting in which testing is a regular phenomenon. Especially if the experiment can use regular classroom examinations as *O*s, but probably also if the experimental *O*s are similar to those usually used, no undesirable interaction of *testing* and *X* would be present. (p. 18)

Each of the examinations employed were highly valid and reliable. The Terra Nova Basic Battery examination used to establish equivalence of groups prior to the treatment had an internal reliability coefficient of .91 (Cronbach's alpha) (McGraw-Hill, 2000). The ACCUPLACER examination had an internal consistency reliability coefficient of .92 (Cronbach's alpha) (The College Entrance Examination Board, 2002). The Terra Nova CAT Survey exam used as a post-treatment measure for comparison of general math aptitude has a reliability coefficient of .84 (Cronbach's alpha) (McGraw-Hill, 2000). The NOCTI - Agriculture Mechanics examination had an internal reliability coefficient of .91 (Cronbach's alpha) (A.Thomas, personal communication, November 16, 2004). The Work Keys examination has scored a .88 (KR-20) reliability estimate (B. Ziomek, personal communication, December 2, 2004).

Recruitment of Study Participants

Recruitment for participation in the study was accomplished through meeting with agricultural education instructors at their district Chapter Officer Leadership Training (COLT) Conferences. To avoid sampling bias, a conference occurred in each of the five administrative districts for secondary agricultural education in Oklahoma during September 2003: Central, Northwest, Northeast, Southwest, and Southeast. Through inviting teachers from all agriculture programs in the state to participate, a more representative sample of volunteers from the state was obtained (Campbell & Stanley, 1963).

A presentation was made that described the proposed study. Teachers who expressed an interest in participating in the study completed an "expression of interest form" (Appendix B). In addition, teachers who indicated an interest were presented with an application for participation in the study (Appendix C). This application required the signature of the teacher as well as a school administrator to indicate that the teacher's participation in the study would be supported. The application also called for the identification of a math teacher who would partner with the agricultural education teacher if he/she were selected for the experimental group. In an attempt to reach a pool of 40 "interested" teachers, follow-up telephone calls were made to selected teachers per recommendation of program specialists for the five administrative districts for secondary agricultural education in Oklahoma.

Following the recruitment efforts, teachers who returned their completed applications were randomly assigned to either the experimental or control group. The random assignment was conducted by staff members of the National Research Center for Career and Technical Education (NRCCTE); it was completed in mid fall 2003. Lists of the assigned teachers were then provided to the researcher.

Due to the time and resource limitations imposed by this study, self-selection bias (Patten, 2002) by teachers was inevitable. These teachers likely shared more measurable and unmeasurable attributes than teachers in the general population, and probably were more comfortable with teaching mathematics than those who did not choose to participate. It is acknowledged that this was a limitation to generalizability. However, any bias affected both groups equally because of the randomized design (Campbell & Stanley, 1963).

Eighteen agricultural power and technology teachers and their math teacher partners were randomly assigned to the experimental group, and 20 agricultural power and technology teachers to the control group. As will be discussed in the treatment section of this chapter, the experimental group teachers implemented a math-enhanced agricultural power and technology curriculum and instructional approach. The control group teachers taught the traditional agricultural power and technology curriculum and were instructed to use the same instructional approach they used in the past. This design yielded an overall N of 443 agricultural power and technology students (experimental n = 200; control n = 243) who provided data for aggregated analysis by classroom. Classroom size varied in number of students (see Appendix D).

Incentives

Teachers in the experimental group (both agricultural power and technology and math) received a $1,500.00 stipend for their participation, plus teachers' travel, food, and lodging costs to attend five days of professional development workshops were reimbursed. Agricultural power and technology teachers in the control group received a $500.00 stipend for their participation in the study and were offered the option to receive professional development about math enhancement of the agricultural power and technology curriculum in the summer of 2004. (Due to the study's continuation, professional development for control group teachers was deferred until summer 2005.) All students taking the pre and posttests, including both experimental and control groups, received a gift card valued at $10 per testing session.

Curriculum Artifacts

As a component of treatment fidelity, instructors provided copies of teaching materials involving the use of mathematics that they used previously when teaching agricultural power and technology. Teachers were provided guidelines (Appendixes E & F) and a collection packet for this purpose. The curriculum artifacts of experimental group teachers were collected at the beginning of the first round of professional development in November 2003. The artifacts of the control group teachers were solicited and collected via postal mail prior to beginning of the spring 2004 semester (Appendixes E & F). Each of the submitted artifacts were analyzed by a researcher at the National Research Center for Career and Technology Education (NRCCTE) to determine the types of artifacts submitted as well as the content of those artifacts. This analysis was employed to determine the amount and type of explicit math instruction presently being delivered within the agricultural power and technology classes (see Tables 30 & 31).

Administration of Tests and Questionnaire

Each school had a designated testing liaison who administered student tests as well as distributed and collected student questionnaires and student and parental consent forms. The liaisons were recommended to the researcher by the building principal who was contacted via postal mail. At the time of this study, public schools in Oklahoma had staff members at each school who served as designated, campus-level testing liaisons for the purpose of administering various local, state, and federally mandated examinations. Many of these individuals were identified as testing liaisons for this research project. In other cases, school principals designated themselves or a school guidance counselor as the testing liaison for this study. This part of the study's design was implemented according to recommendation by Campbell and Stanley (1963) which states, ". . . experimentation within schools must be conducted by regular staff of the schools concerned, whenever possible, especially when findings are to be generalized to other classroom situations" (p. 21).

Very early in the spring 2004 semester, testing liaisons visited teachers' classrooms to 1) read a prepared script to students explaining the purpose of the study (Appendix G), 2) distribute student (Appendix H) and parental consent forms (Appendix I), and 3) answer any questions of a general nature about the study posed by students. Liaisons returned in a few days to collect signed consent forms. Students who chose to not participate in the study or whose parents opted that they not participate were provided an alternative assignment or activity to do during testing. Neither non-participating students or agricultural power and technology teachers were present during student testing.

Other pre-experimental activities were completed over a two-day period, including administration of a student questionnaire (National Research Center for Career and Technical Education, 2004a) (day 1) to gather selected characteristics about students and a general math aptitude test (Terra Nova CAT™ Basic Battery CTB McGraw-Hill Level 21/22 Form A; 46 items) to determine the degree of equivalence in general math aptitude between control and experimental groups (day 2). In most cases, two class periods were devoted to completing the student questionnaire and to administering the pre-treatment measure of general math aptitude equivalence.

Both experimental and control group teachers completed a questionnaire (National Research Center for Career and Technical Education, 2004b) that described selected personal and school setting characteristics as well as perceptions related to their mathematics education preparation, the infusion of mathematics into their curriculum, and their levels of math anxiety. The participating math teachers completed a questionnaire as well. The experimental group agricultural power and technology teachers and math teacher partners turned in their completed questionnaires to the researcher prior to the beginning of the first round of professional development. The control group teachers' questionnaires were solicited, delivered, and returned via postal mail. All participating teachers completed another questionnaire at the conclusion of the study. The instrument was delivered and returned to the researcher via postal mail. The data collected from student and teacher questionnaires were primarily for the purposes of the larger national study (Stone et al., 2004); however, demographic data was gleaned from these instruments for the purpose of this study.

The posttest procedure was accomplished over the course of two class periods as well. Posttesting consisted of the administration of an agricultural power and machinery (technology) aptitude test (NOCTI - Agriculture Mechanics) to all participating students on day one of posttesting; it was composed of 42 items. On day two of posttesting, each student was randomly assigned (within the class) to one of three posttest measures. This random assignment was performed for at least two purposes. First, the administration of four posttests to each student could have introduced a level of test fatigue that may have had negative effects on the students' performance (Enerlin & Osborne, 1992). Secondly, this decision was made to reduce the expense of posttesting while protecting the integrity of posttest results. These measures included an examination to determine a student's need for mathematical remediation in college (ACCUPLACER Elementary Algebra test, The College Board; 35 items), a general math aptitude test (Terra Nova CAT™ Survey Edition, CTB McGraw-Hill; 25 items), and a test to determine student math aptitude as applied to workplace problems (Work Keys Applied Mathematics Assessment, ACT; 33 items). Students, experimental and control groups, were provided calculators that had limited capabilities (i.e., addition, subtraction, multiplication, division, square root, and percentage function) to be used as needed in the completion of all examinations.

Data were aggregated by classroom; thus individual student data was not reported. All individual data were masked with ID numbers and kept anonymous and confidential; only aggregated data were used for analysis.

Curriculum Mapping

A panel of experts was convened in mid-October 2003 for the purpose of developing a curriculum map to guide the math-enhanced lesson planning process. The curriculum mapping task involved identifying math competencies (e.g., constructs or concepts involving algebra, geometry, and trigonometry) embedded within existing high school agricultural power and technology curricula used in Oklahoma. The panel consisted of two Oklahoma agricultural education teachers who frequently taught the course agricultural power and technology, two Oklahoma high school math teachers, a math education expert from the National Research Center for Career and Technical Education, and three university teacher educators in agricultural education. The mapping process involved identification of math competencies or skills that were embedded in the existing agricultural power and technology curriculum. For example, the use of proportions and ratios is critical to the preparation of concrete, which is curriculum content frequently included in Oklahoma agricultural and power technology courses.

The accumulated "points of intersection" formed a draft curriculum map that identified embedded math concepts. Oklahoma State Department of Education Priority Academic Student Skills (PASS) objectives for high school mathematics were also aligned with the math concepts found embedded in the agricultural power and technology curriculum. Oklahoma math PASS objectives/standards are aligned with National Council for the Teaching of Mathematics (NCTM) standards for high school mathematics as well (Oklahoma State Department of Education, 2002). The result of the meeting was a "working" curriculum map, as described, that identified possible agricultural power and technology lesson topics supporting each of the math concepts (Appendix J). It was determined that nine math constructs were embedded in the agricultural power and technology curriculum, and that these constructs aligned with existing standards/objectives for student math performance as identified by Oklahoma PASS standards/objectives and related NCTM standards. To avoid contamination, agricultural education teachers who participated on the panel were not permitted to serve as a control group teacher for the study.

Teacher Teams

The experimental intervention embedded in this design required the preparation of agricultural education teachers to develop and implement a math-enhanced curriculum in the context of an agricultural power and technology course. The experimental group agricultural education teachers had math teacher "partners" to assist them in developing math-enhanced lesson plans in the context of agricultural power and technology, and in how to enhance student understanding of the embedded mathematic vocabulary, principles, and concepts identified within the lessons.

For 17 of the 18 experimental group agricultural education teachers, their math teacher partner was a member of the local high school faculty. This design of pairing teachers from the same school was recommended by Garet, Porter, Desimone, Birman, and Yoon (2001). The authors stated, "First, teachers who work together are more likely to have the opportunity to discuss concepts, skills and problems that arise during their professional development experiences" (p. 918). The authors also posited that, ". . . teachers who share the same students can discuss students' needs across classes and grade levels" (p. 918). One agricultural education teacher did not have a resident math teacher who was willing to participate in the study. Accordingly, they partnered with a math teacher from another high school that was not a part of the study. These instructors worked together during the professional development workshops similar to the school-based teacher teams, e.g., lesson plan development. Thereafter, they communicated by telephone and by electronic mail.

The partnering of high school math teachers with agricultural power and technology teachers encouraged instructors to function as a team, each learning how the other's expertise and practice could enhance his/her own teaching. The role of the math teacher was to work with their agricultural education teacher partner to identify and develop content as well as to design strategies to more fully contextualize mathematic terminology, principles, and concepts found in the agricultural power and technology curriculum. Ultimately, 17 lessons were developed that emphasized selected math concepts determined to be embedded in the agricultural power and technology curriculum. During the spring 2004 semester, the math teacher continued to collaborate with the agricultural power and technology teacher concerning specific questions related to the math-enhanced lessons as well as to hear teachers' reflections about lessons taught. Accordingly, math teachers submitted de-briefing forms that summarized their meetings with the agricultural power and technology teachers (Appendix K). Additional math support was provided by the researchers and by selected math specialists who were affiliated with the National Research Center for Career and Technical Education (NRCCTE).

Professional Development

To prepare the teacher teams to function collaboratively during the study, a two-part professional development was conducted in the fall of 2003 (November and December) preceding the study's implementation in January, 2004. As an incentive to the agricultural power and technology teachers who were randomly selected to be in the control group, a similar professional development was planned for the summer of 2004.

Individuals with expertise in teacher professional development and curriculum integration worked as consultants to plan and conduct the professional development workshops. To ensure that experimental group teachers received high-quality professional development and to better ensure consistency in treatment implementation between sites, workshop facilitators met in mid-fall 2003 to receive training related to planning and executing professional development for the purposes described.

First Professional Development Meeting

The first round of professional development was carried out over a three-day period (Appendix L) in November 2003. The purpose of this professional development activity was four-fold: 1) reach group consensus about the curriculum map developed by the panel of experts (Appendix J); 2) develop math-enhanced lesson plans in the context of the agricultural power and technology curriculum; 3) ensure that all teachers understood the seven-step teaching procedure model to be used when teaching the math-enhanced lessons (Appendix M); 4) address questions and concerns that teachers had about the study, e.g., student testing procedures and the role of testing liaisons. All experimental group agricultural power and technology teachers and their math teacher partners attended this professional development.

During this meeting, the curriculum map (Appendix J) created earlier by a panel of experts was presented to the group. The group agreed that the curriculum map was accurately aligned and elected to move forward with the development of lesson plans that addressed the embedded math constructs identified by the map. Each teacher team (agricultural education teacher and math teacher) chose a math construct to guide the development of a math-enhanced lesson plan, i.e., two teams per construct for a total of 18. For this task, teacher teams were provided examples of contextual or "applied" math lessons and activities to help stimulate and guide their planning (Appendix N). Teams were also given electronic versions of the seven-step lesson plan template in which to develop and write their plans. The lessons were to be developed such that the agricultural power and technology teachers would teach the lessons without any outside assistance from their math teacher partners or other math education professionals.

On completion of rough drafts of the lesson plans, it was determined that two of the plans were very similar; thus, these plans were merged and the two teams worked on one lesson plan together thereafter. The final result was 17 math-enhanced lesson plans in the context of agricultural power and technology. One of the math constructs was supported by only one lesson plan while two lesson plans were developed for each of the remaining eight. The remainder of this three day professional development session was spent critiquing, expanding, and refining the group's lesson plans.

Teams were expected to develop their lesson plans further over the course of three weeks and to refine them as they continued working together before assembling for the second round of professional development. Agriculture teachers were also asked to present their lessons to a group of high school students on a "trial-basis," who would not participate in the research project during spring 2004, to identify weaknesses and to explore plans for additional improvement of their lessons.

Second Professional Development

The teacher teams reconvened for a second round of professional development in December 2003 (Appendix O). During the two-day session, teams reported on reactions of students toward the lessons presented on a trial-basis and spent time in review and further development of lesson plans and supporting materials (e.g., student worksheets, quizzes, and answer keys) in preparation for the spring 2004 semester. Two teacher teams shared the complete content of their lesson plan with the group, modeled and discussed their intended teaching procedures, and answered participants' questions about their plans and intended lesson presentations.

The agricultural power and technology teachers agreed to teach at least one lesson for each math construct during the spring 2004 semester for a total of nine math-enhanced lessons. In addition, teachers developed a timeline in which they anticipated teaching the various lessons and provided a copy to the researcher so that he could schedule fidelity observations for all 18 experimental school sites.

Finalized lesson plans (17) for all teams—electronic and hard copy—were collected by the researchers at the conclusion of the second round of professional development. Accordingly, the lesson plans were reviewed by the researcher for content, alignment with established math constructs, and adherence to standardized formatting. The final lesson plans were postal mailed as a packet—paper, hard copies and compact discs (CDs)—to both experimental agricultural power and technology teachers and to their math teacher partners during early January 2004.

Treatment

The treatment was defined as a series of math-enhanced learning experiences (i.e., lessons) designed to raise the embedded, contextualized mathematics found in the agricultural power and technology curriculum to a level of explicit instruction intended to facilitate student learning of selected math competencies and to improve a student's ability to transfer that competence to new and novel settings (Stone et al., 2004). The treatment was delivered as a series of nine lessons over the spring 2004 semester. Each lesson was designed around a specific math construct (Appendix J). The lessons were to be delivered using the "seven-step enhanced math instruction model" that was developed by researchers and experts in career and technical education (C. Alfeld, personal communication, October 21, 2004). This approach was supported by mathematics education literature that propounded the role and value of the specific language employed during the teaching and learning of mathematics (Bickmore-Brand, 1993; Diaz, 1998; Gawned, 1993) as well as the order and manner in which mathematics instruction should be delivered to provide students with a maximum amount of quality, retainable instruction (Kiong & Yong, 2001). It was intended that agricultural power and technology teachers would teach their lessons without any outside assistance from their math teacher partners or other math education professionals. However, in the case of one school, the agricultural power and technology teacher did receive direct assistance from his math teacher partner during the course of teaching the math-enhanced lessons, i.e., at least portions of the lessons were "team taught." Important to the effectiveness of the design was the delivery of the treatment by the regular agricultural power and technology teacher. To that end, Campbell and Stanley (1963) posited that results will be more valid and reliable when the experiment is delivered, ". . . through alternative teaching procedures presented without announcement or apology in the regular teaching process . . ." (p. 22).

A more comprehensive view of the treatment implemented in this study and listing of each facet thereof is presented in Table 1. The elements of the treatment described below were delivered only to experimental group teachers and students. While control group students were told that their class would be participating in the research project, control group teachers were instructed to make no change relative to the teaching of mathematics in their agricultural power and technology classes.

Table 1.

Overview of the Treatment

Experimental Group Teachers	Experimental Group Students
Preparation Phase	Preparation Phase
Math and agriculture teacher collaboration and professional development Teachers participated in: - Team building activities - Curriculum mapping - Lesson plan development and refinement - Evaluate lessons, provide feedback to other teachers - Training in seven-step instructional approach	Students were told that their class would be participating in the study
Presentation Phase	Presentation Phase
Implementation of the seven-step instructional approach - Presentation of curriculum materials developed in professional development	Students received math-enhanced lessons delivered through the seven-step approach
Continued collaboration/ reflection between math and agriculture teachers throughout the semester - Debriefing following each math enhancement	
Observation of math-enhanced lesson by researcher - Researcher observed and scripted one lesson presentation per teacher	

Three variations in school-day schedule existed within the experimental group of classrooms that received the treatment. Fifteen of the 18 schools were on a traditional school-day schedule that consisted of periods or classes that were about 50 minutes in duration. Two schools were on a trimester schedule in which class periods were about 70-75 minutes long. One school was on a "block" schedule that divided class periods into 90 minute blocks. Regardless of school-day schedule, teachers were expected to teach at least nine math-enhanced lessons (at least one for each identified construct) during the spring 2004 semester.

The dependent variable in the study was student math achievement. Differences between the experimental and the control groups were measured on three levels: 1) a traditional measure of math performance (Terra Nova CAT™ Survey Edition, CTB McGraw-Hill; 25 items); 2) a problem-based measure of work related math performances (Work Keys Applied Mathematics Assessment, ACT; 33 items); 3) a college-level math placement examination (ACCUPLACER Elementary Algebra test, The College Board; 35 items). To address the issue of difference in technical competence in agricultural mechanics, a technical skills test for agricultural power and technology developed by the National Occupational Competency Testing Institute (NOCTI; 42 items) was employed.

Data Collection

Data collection occurred in spring 2004 for both the experimental and control groups. Student questionnaires and a pre-treatment measure of equivalence concerning mathematical aptitude were administered in mid-January; posttests were administered in early May 2004.

Essential to the data collection within each school was the role of the testing liaison. Each school had a designated testing liaison who administered student tests as well as distributed and collected student questionnaires and student and parental consent forms. Liaisons were provided with all testing materials and questionnaires by the researcher through postal mail. Liaisons were also provided with instructions for administering each measure as well as instructions concerning return of the test data to the researcher. Large envelopes with postage paid mailing labels were provided to the liaisons by the researcher. The liaisons placed completed answer sheets which identified students only by the identification number assigned to them by the liaison in the envelopes and returned them to the researcher through postal mail.

In addition, descriptive data were collected to monitor the fidelity of the treatment. Observations of each teacher presenting a math enhanced lesson provided both evidence and descriptions of the enhanced math treatment "as it happened" in the classroom. The researcher received fidelity observation training from a recognized expert employed by the NRCCTE. The training occurred January 19, 2004. During the training, scenarios were presented through video for the purpose of establishing proper use of the observation instrument (Appendix P) as well as coding of lesson plans (Appendix N) to determine if the seven steps of the math-enhanced lesson plan template were present.

Measures

Students in each of the two groups completed a battery of examinations prior to and following the treatment that measured their academic and technical competence.

Quantitative

The Terra Nova CAT™ Basic Battery (CTB/McGraw-Hill) examination was employed as a pre-treatment measure in the establishment of the equivalence of groups concerning general math aptitude. The decision to limit the pre measure to one class period was made to prevent test fatigue on the part of the students. Conversely, the examination employed for this measure was designed to be administered over a 70 minute period and the length of class period for the classrooms involved in the study was about 45 to 50 minutes. Therefore, students were instructed to complete as much of the examination as they could in an allotted 40 minute time period. This decision was made by the research team at the National Research Center for Career and Technical Education and was based on advice from testing experts (Stone et al., 2004). Students were only scored as to the number of correct responses that they provided.

A variety of tests were used to measure differences between groups at the end of the implementation of the treatment. Each student was randomly assigned (within the class) to one of three posttest measures. Specifically, because it is a nationally-normed and reliable test of math skills, the algebra portion of the Terra Nova CAT™ Survey Edition (CTB/McGraw-Hill) was employed as a traditional cognitive test. WorkKeys (ACT) was specifically designed to test math skills in applied, work-related situations; National Occupational Competency Testing Institute (NOCTI) has created a technical competency test in agricultural power and technology, and it was used for that purpose; and ACCUPLACER (The College Board) is a widely-used test in the United States for placement related to a student's need for math remediation at the post-secondary level. Each of these assessments provided data to test the study's hypotheses.

Qualitative

Each experimental classroom was visited by the researcher to observe teachers' execution of the intervention as a way to monitor and assess the study's fidelity of treatment, i.e., "Did teachers implement the prescribed treatment?" Each visit was conducted by the researcher to ensure consistency among observations between the 18 experimental classrooms. The researcher observed instructors teaching the nine math-enhanced lessons in all 18 experimental classrooms. During each observation a rubric was completed that documented the implementation of the treatment (Appendix P).

Data Analysis

Frequencies and percentages were calculated for selected demographic data to accurately portray both the student participants in the study as well as the teacher participants. One-way analysis of variance (ANOVA) was used to compare the different sets of experimental and control classroom means to address the primary research hypotheses. All quantitative analysis was completed using the *Statistical Package for the Social Sciences version 11.01.*

The qualitative data collected from fidelity observations allowed the researcher to document the process of implementation and to monitor fidelity of the treatment across sites (i.e., classrooms). For the experimental classrooms, this procedure helped the researcher determine whether teachers implemented the math-enhanced curriculum as designed. This data was analyzed through the observation and recording of frequencies and percentages of teachers who implemented each of the seven steps of the math-enhanced lessons.

Communication and Support from the Researcher

Various methods of communication (i.e., telephone, electronic mail, postal mail) were used throughout the spring 2004 semester to provide support from the researcher to the teachers, testing liaisons, and principals who participated in the study.

CHAPTER 4

FINDINGS AND DISCUSSION

Introduction

The purpose of this study was to empirically test the hypothesis that students who participate in a contextualized, mathematics-enhanced high school Agricultural Power and Technology curriculum (i.e., experimental curriculum) 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 et al., 2004) in their technical field and more broadly. Mathematics achievement was measured by student performance on three standardized, "paper-and-pencil" tests: Terra Nova, Work Keys, and ACCUPLACER. Student technical competence was measured by the National Occupational Competency Testing Institute (NOCTI)- Agriculture Mechanics 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 math (Stone et al.).

Research Questions

The following research questions guided the study:

1. What is the effect of a math-enhanced Agricultural Power and Technology curriculum and an 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 a student's need for postsecondary math remediation?

3. Does a math-enhanced Agricultural Power and Technology curriculum and aligned instructional approach diminish a student's 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 spring semester of 2004?

5. Does teacher adherence to the seven-step 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 conventional standardized tests 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 a student's 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 a student's need for math remediation at the post-secondary level.

The research questions and null hypotheses served as a guide for presenting the findings of the study. Information concerning each question will be presented in separate sections.

General Description of Participants

The respondents that provided the basis for the findings and results presented in this chapter consisted of students and teachers from 38 secondary schools in the state of Oklahoma.

Selected Student Personal and Educational Characteristics

Student participants were asked to respond to questions that described selected personal characteristics. This information has been summarized and reported to provide a profile of the students participating in this study.

Of the 443 students who completed the questionnaire (control n= 243 experimental n= 200), 84.4% were male, 14.7% were female, and .9% elected not to specify their gender (see Table 2). The experimental group (n=200) consisted of 81% male and 17.5% female students while 1.5% of the experimental group did not report their gender. The control group (n=243) consisted of 87.2% male and 12.3% female students while .4% of the control group did not report their gender (see Table 3).

Table 2

Gender of Student Participants Overall (N=443)

Gender	N	Percent
Male	374	84.4
Female	65	14.7
No Response	4	.9

Table 3

Gender of Student Participants by Group (N=443)

Gender	Experimental Group n	Experimental Group Percent	Control Group n	Control Group Percent
Male	162	81	212	87.2
Female	35	17.5	30	12.3
No Response	3	1.5	1	.4

Regarding student ethnicity or race, 58.5% reported that they were Anglo (European descent), 4.3% were Hispanic, 2.9% reported being African-American, 25.1% were American Indian, and .5% designated their ethnicity or race as Asian. Thirty-nine or 8.8% of the students did not report their ethnicity (see Table 4). The experimental group (n=200) consisted of 54.5% Anglo (European descent), 4% Hispanic, 3.5% who reported being African American, 23.5% who were American Indian, and 1% designated their ethnicity as Asian. Twenty seven students or 13.5% of the experimental group did not report their ethnicity (see Table 5). The control group (n=243) consisted of 61.7% Anglo (European descent), 4.5% Hispanic, 2.5% who reported being African-American, and 26.3% who were American Indian, while no students designated their ethnicity as Asian. Twelve students or 4.9% of the control group did not report their ethnicity (see Table 5).

Table 4

Ethnicity of Student Participants Overall (N=443)

Ethnicity	N	Percent
European/Anglo	259	58.5
American Indian	111	25.1
Hispanic	19	4.3
African-American	13	2.9
Asian	2	.5
No Response	39	8.8

Table 5

Ethnicity of Student Participants by Group (N=443)

Ethnicity	Experimental Group n	Experimental Group Percent	Control Group n	Control Group Percent
European/Anglo	109	54.5	150	61.7
American Indian	47	23.5	64	26.3
Hispanic	8	4	11	4.5
African-American	7	3.5	6	2.5
Asian	2	1	0	0
No Response	27	13.5	12	4.9

Regarding the students' current high school grade classifications, 31.8% responded that they were twelfth graders, 34.5% said they were eleventh graders, 26.4% indicated they were tenth graders, and 6.1% identified themselves as being in the ninth grade (see Table 6). Five students (1.1%) did not specify their grade classification (see Table 6). The experimental group (n=200) consisted of 28.5% twelfth graders, 33.5% eleventh graders, 29.5% tenth graders, and 7.5% who identified themselves as being in the ninth grade (see Table 7). Two students (1%) did not specify their grade classification (see Table 7). The control group (n=243) consisted of 34.6% twelfth graders, 35.4% eleventh graders, 23.9% tenth graders, and 4.9% who identified themselves as being in the ninth grade (see Table 7). Three students (1.2%) did not specify their grade classification (see Table 7).

Table 6

Grade Classification of Student Participants Overall (N=443)

Grade Classification	N	Percent
Senior	141	31.8
Junior	153	34.5
Sophomore	117	26.4
Freshman	27	6.1
No response	5	1.1

Table 7

Grade Classification of Student Participants by Group (N=443)

Grade Classification	Experimental Group n	Experimental Group Percent	Control Group n	Control Group Percent
Senior	57	28.5	84	34.6
Junior	67	33.5	86	35.4
Sophomore	59	29.5	58	23.9
Freshman	15	7.5	12	4.9
No response	2	1	3	1.2

When questioned about their age at the time of the experiment, 2.5% of the students responded that they were nineteen years of age, 22.6% said they were eighteen years old, 38.1% reported to be seventeen, 23% claimed to be sixteen, and 13.8% responded that they were fifteen years old (see Table 8). In the experimental group(n=200), 2% responded that they were nineteen years of age, 20.5% said they were eighteen years old, 36% reported to be seventeen, 26.5% claimed to be sixteen, and 15% responded that they were fifteen years old (see Table 9). In the control group, (n=243) 2.9% responded that they were nineteen years of age, 24.3% said they were eighteen years old, 39.9% reported to be seventeen, 20.2% claimed to be sixteen, and 12.8% indicated they were fifteen years old (see Table 9).

Table 8

Age of Student Participants Overall (N=443)

Age	N	Percent
19	11	2.5
18	100	22.6
17	169	38.1
16	102	23
15	61	13.8

Table 9

Age of Student Participants by Group (N=443)

Age	Experimental Group n	Experimental Group Percent	Control Group n	Control Group Percent
19	4	2	7	2.9
18	41	20.5	59	24.3
17	72	36	97	39.9
16	53	26.5	49	20.2
15	30	15	31	12.8

Regarding student overall secondary grade point average, .7% reported to have a grade point average in excess of 4.0 on a 4 point scale, 24.3% indicated an average in the range of 3.6 to 4.0, 21.4% reported their average in the range of 3.1 to 3.5, 26.8% identified their average as between 2.6 and 3.0, 13.2% claimed to have an average between 2.1 and 2.5, 1.3% specified their average to be between1.6 and 2.0, 1.1% had an average between 1.0 and 1.5, and one student (.2%) reported a grade point average of below 1.0 (see Table 10). Forty-nine students (10.9%) failed to report their grade point average (see Table 10).

Concerning the experimental group grade point average (n=200), 1% reported to have a grade point average in excess of 4.0 on a 4 point scale, 31.5% identified an average in the range of 3.6 to 4.0, 17% indicated their average was in the range of 3.1 to 3.5, 27.5% reported their average to be between 2.6 and 3.0, 8.5% claimed to have an average between 2.1 and 2.5, 6% specified their average as between 1.6 and 2.0, 2% had an average between 1.0 and 1.5, and one student (.5%) reported a grade point average of below 1.0 (see Table 11). Twelve students in the experimental group (6%) failed to report their grade point average (see Table 11). Control group grade point averages (n=243) varied as follows: .4% reported to have a grade point average in excess of 4.0 on a 4 point scale, 18.1% identified an average in the range of 3.6 to 4.0, 26.3% indicated their average was in the range of 3.1 to 3.5, 24.3% reported their average to be between 2.6 and 3.0, 9.9% claimed to have an average between 2.1 and 2.5, 6.2% specified their average to be between1.6 and 2.0, and .4% had an average between 1.0 and 1.5. Thirty-five students (14.4%) did not report their grade point average (see Table 11).

Table 10

Overall Grade Point Average [a] of Student Participants on 0-4.0 Scale, Both Groups (N=443)

Grade Point Average	N	Percent
Greater than 4.0	3	.7
3.6-4.0	107	24.2
3.1-3.5	98	22.1
2.6-3.0	114	25.7
2.1-2.5	41	9.3
1.6-2.0	27	6.1
1.0-1.5	5	1.1
Less than 1.0	1	.2
No response	47	10.6

Note. [a]Self-reported

Table 11

Overall Grade Point Average[a] of Student Participants on 0-4.0 Scale by Group (N=443)

Grade Point Average	Experimental Group n	Experimental group Percent	Control Group n	Control Group Percent
Greater than 4.0	2	1	1	.4
3.6-4.0	63	31.5	44	18.1
3.1-3.5	34	17	64	26.3
2.6-3.0	55	27.5	59	24.3
2.1-2.5	17	8.5	24	9.9
1.6-2.0	12	6	15	6.2
1.0-1.5	4	2	1	.4
Less than 1.0	1	.5	0	0
No response	12	6	35	14.4

Note. [a]Self-reported

Selected Characteristics of Participating Teachers

Teacher participants were asked to respond to questions that described selected personal characteristics. This information has been summarized and reported to provide a limited profile of the teachers participating in this study.

Of the 38 participating agricultural teachers (control n= 20; experimental n= 18), 86.8% were male and 2.6% were female and the remaining teachers did not report their gender (see Table 12). The experimental group of teachers (N=18) consisted of 88.9% male and 5.5% female teachers while 5.5% of the experimental group did not report their gender (see Table 13). The control group of teachers (N=20) consisted of 85% male and no teachers reporting to be female while 15% of the control group did not report their gender (see Table 13).

Regarding teacher ethnicity, 73.7% reported that they were Anglo (European descent) and 15.8 % were American Indian. Four teachers or 10.8% of the group did not report their ethnicity (see Table 14). The experimental group of teachers consisted of 77.8% Anglo (European descent) and 22.2 % were American Indian. (see Table 15). The control group of teachers consisted of 75% Anglo (European descent) and 10 % were American Indian. Three teachers or 15% in the control group did not report their ethnicity (see Table 15).

Table 12

Gender of Teacher Participants Overall (N=38)

Gender	N	Percent
Male	33	86.8
Female	1	2.6
No Response	4	10.8

Table 13

Gender of Teacher Participants by Group (N=38)

Gender	Experimental Group n	Experimental Group Percent	Control Group n	Control Group Percent
Male	16	88.9	17	85
Female	1	5.5	0	0
No Response	1	5.5	3	15

Table 14

Ethnicity of Teacher Participants Overall (N=38)

Ethnicity	N	Percent
European/Anglo	28	73.7
American Indian	6	15.8
No Response	4	10.8

Table 15

Ethnicity of Teacher Participants by Group (N=38)

Ethnicity	Experimental Group n	Experimental Group Percent	Control Group N	Control Group Percent
European/Anglo	14	77.8	15	75
American Indian	4	22.2	2	10
No Response	0	0	3	15

This study was a posttest only control group experimental design (Campbell & Stanley, 1963). Each classroom was randomly assigned to either the experimental or control group but the assignment involved intact groups of students; thus, the "unit of analysis" was by classroom. Students in each of the two groups completed a battery of posttests that measured their academic and technical competence. The two groups (experimental and control) were pretested to determine level of equivalence concerning basic mathematical aptitude. Following the treatment, comparisons were made between group means on each posttest measure.

Quantitative Data Analysis

A variety of tests were used to measure differences between groups at the end of the study's treatment. Specifically, because it is a nationally-normed and reliable test of math skills, the algebra portion of the Terra Nova (2nd Ed., CTB/McGraw-Hill) was employed as a traditional cognitive test of students' general math aptitude. Work Keys (ACT) was specifically designed to test math skills in applied, work-related situations; National Occupational Competency Testing Institute (NOCTI) has created a technical competency test in agricultural power and technology, and it was used for that purpose; and ACCUPLACER (The College Board) is a widely-used test in the United States for placement related to a student's need for math remediation at the post-secondary level. These assessments provided data to test the study's hypotheses.

Means were calculated by group for the purpose of comparative statistical analysis. One-way analysis of Variance (ANOVA) analyses were used to compare the different sets of experimental and control classroom means to address the study's research hypotheses.

Pretest Analysis

The two groups of student participants were pretested using a basic math aptitude achievement examination (Terra Nova Basic Battery) to determine equivalence of groups concerning math aptitude. The control group mean score for this exam was 20.3089 with a standard deviation of 3.59572 while the experimental group had a mean score of 22.3364 with a standard deviation of 3.14666 (see Table 16). The result of this test showed no significant difference between the two groups on general math aptitude with an *a priori* determined alpha level of .05 ($p = .074$, see Table 17).

Table 16

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

	n	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Control	20	20.3089	3.59572	.80403	15.88	30.78
Experimental	18	22.3364	3.14666	.74167	17.71	28.24
Total	38	21.2693	3.49873	.56757	15.88	30.78

Table 17

Comparative Analysis of Student Math Performance by Group Means as Measured by the Terra Nova Basic Battery Examination

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	38.942	1	38.942	3.386	.074
Within Groups	413.980	36	11.499		
Total	452.921	37			

* $p < .05$

Posttest Analysis

$H_o 1$ 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, an analysis was conducted on student math performance by group (control and experimental) on a general math aptitude examination (i.e., the Terra Nova Survey) taken by students after the treatment was administered. The control group posted a mean score of 11.6993 on this measure with a standard deviation of 3.11472 while the mean score of the experimental group was 11.7676 with a standard deviation of 3.00736 (see Table 18). The analysis of this examination revealed no significant difference in general math aptitude between groups following the treatment ($p = .946$) at an *a priori* determined alpha level of .05 (see Table 19). Based on this analysis, the null hypothesis was not rejected.

Table 18

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

	n	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Control	20	11.6993	3.11472	.69647	6.33	16.00
Experimental	18	11.7676	3.00736	.70884	7.67	20.00
Total	38	11.7316	3.02299	.49039	6.33	20.00

Table 19

Comparative Analysis of Student Math Performance by Group Means as Measured by the Terra Nova Survey Examination

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.044	1	.044	.005	.946
Within Groups	338.080	36	9.391		
Total	338.124	37			

* $p < .05$

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, an analysis was conducted on student math performance by group (control and experimental) on an examination to measure students' ability to use math to solve workplace-related problems (i.e., Work Keys) taken by students after the treatment was administered. The control group mean score for this examination was 73.2275 with a standard deviation of 2.92598 while the experimental group mean was 73.6889 with a standard deviation of 3.91958 (see Table 20). The analysis of this examination revealed no significant difference in level of performance between the groups following the treatment (*p*=.681) at an *a priori* determined alpha level of .05 (see Table 21). Based on this analysis, the null hypothesis was not rejected.

Table 20

Descriptive Statistics for Student Math Performance by Group on the Work Keys Examination

	n	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Control	20	73.2275	2.92598	.65427	68.50	80.83
Experimental	18	73.6889	3.91958	.92385	68.00	80.33
Total	38	73.4461	3.39258	.55035	68.00	80.83

Table 21

Comparative Analysis of Student Math Performance by Group Means as Measured by the Work Keys Examination

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2.017	1	2.017	.171	.681
Within Groups	423.839	36	11.773		
Total	425.855	37			

* $p < .05$

H_0 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 a student's Agricultural Power and Technology competence.

To address null hypothesis three, an analysis was conducted on student technical performance by group (control and experimental) on an examination to measure achievement in Agricultural Power and Technology (i.e., the NOCTI- Agriculture Mechanics test) taken by students after the treatment was administered. The control group of students achieved a mean score of 16.1798 with a standard deviation of 2.88053 on this measure while the experimental group had a mean score of 16.3080 with a standard deviation of 2.41596 (see Table 22). The analysis detected no significant difference in student technical competence between groups following the treatment (p = .883) at an *a priori* determined alpha level of .05 (see Table 23). Based on this analysis, the null hypothesis was not rejected.

Table 22

Descriptive Statistics for Student Math Performance by Group on the NOCTI-Agriculture Mechanics Examination

	n	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Control	20	16.1798	2.88053	.64411	11.62	20.77
Experimental	18	16.3080	2.41596	.56945	12.88	21.70
Total	38	16.2405	2.63569	.42757	11.62	21.70

Table 23

Comparative Analysis of Student Math Performance by Group Means as Measured by the NOCTI-Agriculture Mechanics Examination

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.156	1	.156	.022	.883
Within Groups	256.878	36	7.136		
Total	257.034	37			

* $p < .05$

H_0 4 There is no difference between the two study groups on a math placement test used to determine a student's need for math remediation at the post-secondary level.

To address null hypothesis four, an analysis was conducted on student math performance by group (control and experimental) on an examination to assess a student's need for math remediation as measured by a college placement test (i.e., ACCUPLACER) taken after the treatment was administered. The control group of students achieved a mean score of 13.0053 on this measure with a standard deviation of 3.24324 while the experimental group had a mean score of 15.5593 with a standard deviation of 2.917775 (see Table 24). The analysis of this examination revealed a significant difference in level of performance between groups following the treatment ($p = .017$) at an *a priori* determined alpha level of .05 (see Table 25). Based on this analysis, the null hypothesis was rejected.

Table 24

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

	n	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Control	19	13.0053	3.24324	.74405	6.67	21.33
Experimental	18	15.5593	2.91775	.68772	11.00	22.00
Total	37	14.2477	3.30972	.54411	6.67	22.00

Table 25

Comparative Analysis of Student Math Performance by Group Means as Measured by the ACCUPLACER Examination

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	60.293	1	60.293	6.317	.017[a]
Within Groups	334.060	35	9.545		
Total	394.352	36			

* $p < .05$

Note. Degrees of freedom differ for the ACCUPLACER examination when compared to other posttest measures due to the random assignment of three posttest measures to a group of classes which included one class of 2 students which prevented all 3 measures from being administered in that particular classroom.

[a] Effect size = .83 per Cohen's d (Shavelson, 1996)

Qualitative Data Analysis

Each experimental classroom was visited by the researcher to observe teacher implementation of the intervention as a way to monitor and assess the study's fidelity of treatment, i.e., "Did teachers implement the prescribed treatment?"

An observation instrument designed to determine if the seven steps of the math-enhanced agricultural power and technology lesson were implemented was completed by the researcher during observations of the 18 experimental teachers (see Appendix P). Analysis of aforementioned instruments revealed that all experimental group agriculture teachers included one through six of the seven steps; while only one experimental group agriculture teacher exhibited all seven steps during the lessons observed (see Table 26).

Table 26

Researcher's Observation of Teachers' Implementation of the Seven Steps of the Math-Enhanced Agricultural Power and Technology Lesson

Step	n of teachers observed implementing step	Percent of teachers observed implementing step
1. Teacher recognizes math with the class.	18	100
2. Teacher assesses student's math awareness.	18	100
3. Teacher walks through a "pulled out" example.	18	100
4. Teacher explains math concepts, integrating math terminology with Agricultural Power and Technology terminology.	18	100
5. Teacher reinforces student understanding by having students try a similar agricultural and math examples.	18	100
6. Teacher checks for understanding	18	100
7. Students either create or are presented with new agricultural as well as broader math examples to be solved.	1	5.5

To address the issue of compromise to fidelity of the treatment, a comparison was made between the classroom where all seven steps of the math-enhanced lesson were observed and the remaining 17 experimental classrooms. The analysis detected no significant difference in performance between groups following the treatment at an *a priori* determined alpha level of .05 (see Table 28).

Table 27

Descriptive Statistics of Observations Documenting Teachers' Implementation of the Seven Step Math-Enhanced Instructional Approach

	Group	n	Mean	Std. Deviation	Std. Error	Minimum	Maximum
ACCU PLACER	0	17	15.6804	2.96052	.71803	11.00	22.00
	1	1	13.5000	.	.	13.50	13.50
	Total	18	15.5593	2.91775	.68772	11.00	22.00
Terra Nova Battery	0	17	22.1797	3.17030	.76891	17.71	28.24
	1	1	25.0000	.	.	25.00	25.00
	Total	18	22.3364	3.14666	.74167	17.71	28.24
Terra Nova Survey	0	17	11.6657	3.06771	.74403	7.67	20.00
	1	1	13.5000	.	.	13.50	13.50
	Total	18	11.7676	3.00736	.70884	7.67	20.00
Work Keys	0	17	73.9059	3.92719	.95248	68.00	80.33
	1	1	70.0000	.	.	70.00	70.00
	Total	18	73.6889	3.91958	.92385	68.00	80.33
NOCTI	0	17	16.4290	2.43339	.59018	12.88	21.70
	1	1	14.2500	.	.	14.25	14.25
	Total	18	16.3080	2.41596	.56945	12.88	21.70

Table 28

Comparison of Means Between Classroom Where All Seven Steps Were Observed and All Other Classroom Observations (n = 18)

		Sum of Squares	df	Mean Square	F	Sig.
ACCUPLACER	Between Groups	4.490	1	4.490	.512	.484
	Within Groups	140.235	16	8.765		
	Total	144.725	17			
Terra Nova Battery	Between Groups	7.512	1	7.512	.747	.400
	Within Groups	160.813	16	10.051		
	Total	168.325	17			
Terra Nova Survey	Between Groups	3.178	1	3.178	.338	.569
	Within Groups	150.574	16	9.411		
	Total	153.751	17			
Work Keys	Between Groups	14.408	1	14.408	.934	.348
	Within Groups	246.765	16	15.423		
	Total	261.173	17			
NOCTI	Between Groups	4.484	1	4.484	.757	.397
	Within Groups	94.742	16	5.921		
	Total	99.227	17			

$^{*}p < .05$

Additional data concerning delivery of the treatment were collected through a post-treatment questionnaire which queried the teachers concerning the number of math-enhanced lessons that they actually taught during the spring 2004 semester. Teachers were instructed to teach at least one lesson supporting each of the nine identified mathematical constructs. Two lessons were developed for each construct with the exception of one for a total of 17 math-enhanced lessons. Teachers were free to teach as many of the remaining eight lessons as they wished. One teacher reported that they taught all 17 lessons, two teachers said they taught 14 lessons, one teacher taught 13 lessons, two teachers reported to have taught 11 lessons, five teachers reported teaching nine lessons, two participants responded that they taught eight lessons, two stated they had taught seven lessons, while one teacher reported to have only taught three of the 17 lessons (see Table 29). Two teachers did not return the survey concerning the number of lessons that they taught.

Table 29

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

Number of Lessons Taught	Number of Teachers	Percentage of Teachers
17	1	5.6
14	2	11.1
13	1	5.6
11	2	11.1
9	5	27.8
8	2	11.1
7	2	11.1
3	1	5.6
No Response	2	11.1

As another component of treatment fidelity, instructors provided copies of teaching materials involving the use of mathematics that they used previously when teaching agricultural power and technology. Teachers were provided guidelines

(Appendix E & F) and a collection packet for that purpose. The curriculum artifacts of experimental group teachers were collected at the beginning of the first round of professional development in November 2003. The artifacts of control group teachers were solicited and collected via postal mail prior to beginning of the spring 2004 semester. The type of artifacts collected varied from worksheets to textbooks to blueprints. A list of the types of curriculum artifacts collected is presented in Table 30.

Table 30

Types of Math-Related Curriculum Artifacts Collected from Study Participants Prior to Treatment

Type of Artifact	Experimental Group Frequency	Control Group Frequency	Experimental Group Percent	Control Group Percent
Worksheets	7	7	38.9	35
Course Syllabus\Outline	6	4	33.3	20
Evaluation\Assessment Instruments	4	4	22.2	20
Textbook- *Agricultural Mechanics: Fundamentals and Applications*	7	0	38.9	0
Unit\Lesson plans	3	2	16.7	10
Blueprints	1	2	5.6	10
Information Sheets	1	1	5.6	5
Curriculum and Instructional Materials Center- Curriculum Materials developed/recommended for the course- Agricultural Power and Technology in Oklahoma	1	0	5.6	0
Teachers Submitting Artifacts	13	10	72.2	50

The analysis of the content of the curriculum artifacts also resulted in much variability. The content of the curriculum artifacts is presented in Table 31.

Table 31

Content of Math-Related Curriculum Artifacts Collected from Study Participants Prior to Treatment

Document Content	Experimental Group Frequency	Control Group Frequency	Experimental Group Percent	Control Group Percent
Measurement	7	8	38.9	40
Simple Mathematics\Calculation	11	3	61.1	15
Reading a Tape Measure	1	3	5.6	15
Fractions	1	3	5.6	10.5
Geometry	0	2	0	10
Angles	0	1	0	5
Percentage	0	1	0	5
Use of Formulas	1	0	5.6	0
Estimation	1	0	5.6	0
Physics	1	0	5.6	0
Teachers Submitting Artifacts	13	10	72.2	50

Summary

The student questionnaire revealed that the majority of student participants were male (84.4%) and of European descent (58.5%), while one-fourth of the students reported their race as native American. One hundred forty-one (31.8 %) of the student participants were seniors in high school, 153 (34.5%) were juniors and 117 (26.4%) were sophomores with the remaining student participants either being freshmen (6.1%) or non responders to the question of grade level. Most of the student participants (82.7%) were between the ages of 16 and 18 at the time of the experiment, and the majority of the student participants held a grade point average ranging between 2.6 and 4.0 (72%).

The majority of the teacher participants were male (86.8%) and of European descent (73.7%).

Three of the four null hypotheses were not rejected based on the analysis; the remaining one was rejected. The quantitative analyses determined that no significant differences existed between groups (control and experimental) regarding general math achievement as measured by two standardized examinations either prior to or following the study's treatment, i.e., Terra Nova Basic Battery and Terra Nova Survey, respectively. The quantitative analysis also determined that there was no significant difference in level of performance between groups on an examination designed to measure students' ability to use math to solve workplace-related problems (i.e., Work Keys) taken after the treatment was administered. No significant difference was detected between the two groups as measured by an examination designed to measure student achievement in Agricultural Power and Technology (i.e., NOCTI - Agriculture Mechanics) taken after the treatment was administered.

A significant difference ($p = .017$) was observed between groups following the treatment regarding student performance on a math aptitude examination taken after the treatment was administered to determine one's need for math remediation at the post-secondary level (i.e., ACCUPLACER). The practical significance of this difference ($d =$

.83) falls well within the category of a "large" effect size as defined by Cohen (as cited in Shavelson, 1996, p. 318).

Qualitative analysis determined that all 18 of the experimental group agriculture teachers implemented at least six of the seven steps of the math-enhanced instructional approach but only one teacher implemented all seven steps. This variation in implementation did not yield a significant difference on any of the posttest measures (see Tables 27 & 28). The qualitative analysis also revealed that there was variation in the number of math-enhanced lessons presented between classrooms. Accordingly, eleven teachers of the 18 experimental group teachers indicated that they taught nine or more of the math-enhanced lessons per the researcher's request.

Analysis of curriculum artifacts revealed a great deal of variability in types of artifacts submitted as well as the content of those artifacts.

CHAPTER 5

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to empirically test the hypothesis that students who participate in a contextualized, mathematics-enhanced high school Agricultural Power and Technology curriculum (i.e., experimental curriculum) 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 et al., 2004) in their technical field and more broadly. Mathematics achievement was measured by student performance on three standardized, "paper-and-pencil" tests: Terra Nova, Work Keys, and ACCUPLACER. Student technical competence was measured by the National Occupational Competency Testing Institute (NOCTI)- Agriculture Mechanics 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 math (Stone et al., 2004).

Research Questions

The following research questions guided the study:

1. What is the effect of a math-enhanced Agricultural Power and Technology curriculum and an 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 a student's need for postsecondary math remediation?

3. Does a math-enhanced Agricultural Power and Technology curriculum and aligned instructional approach diminish a student's 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 spring semester of 2004?

5. Does teacher adherence to the seven-step 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 conventional standardized tests 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 a student's 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 a student's need for math remediation at the post-secondary level.

Population

Students

Two groups of ninth, tenth, eleventh, and twelfth grade Oklahoma high school students enrolled in 38 schools who received instruction in agricultural power and technology during the spring 2004 semester provided data for this study:

Group 1. Pupils identified as agricultural power and technology students who participated in a traditional curriculum during the spring 2004 semester (i.e., control group students).

Group 2. Pupils identified as agricultural power and technology students who participated in a math-enhanced curriculum and instructional approach during the spring 2004 semester (i.e., experimental group students).

Teachers

Two groups of Oklahoma agricultural education teachers who taught agricultural power and technology during the spring 2004 semester provided the classrooms and students for this study as well as data about selected teacher characteristics and perceptions. Teachers were randomly assigned to either the control group (n = 20) or to the experimental group (n = 18) for the purpose of the study. Initially, 41 teachers volunteered to participate in the study. Before the treatment began, two teachers who had been assigned to the experimental group removed themselves from the experiment as did one teacher who had been assigned to the control group; thus, 38 teachers participated.

Group 1. Instructors identified as agricultural education teachers who taught the traditional agricultural power and technology curriculum during the spring 2004 semester (i.e., control group teachers).

Group 2. Instructors identified as agricultural education teachers who taught a math-enhanced agricultural power and technology curriculum, e.g., prescribed math-enhanced lesson plans, and who used a standardized instructional approach when teaching (i.e., experimental group teachers).

Design of the Study

This study employed a posttest only control group experimental design (Campbell & Stanley, 1963). Each classroom was randomly assigned to either the experimental or control group, but the assignment involved intact groups of students; thus, the "unit of analysis" was by classroom. In addition to the random assignment to groups, the two groups (experimental and control) were pretested to determine level of equivalence concerning basic mathematical aptitude (Campbell & Stanley, 1963; Tuckman, 1999). Following the treatment, comparisons were made between group means on each posttest measure. The research design is described in Figure 2.

Figure 2

Research Design

Group		Time	
Experimental	R	X	O
Control	R	______	O

Treatment

The treatment was defined as a series of math-enhanced learning experiences (i.e., lessons) designed to raise the embedded, contextualized mathematics found in the agricultural power and technology curriculum to a level of explicit instruction intended to facilitate student learning of selected math competencies and to improve a student's ability to transfer that competence to new and novel settings (Stone et al., 2004). The treatment was delivered as a series of nine lessons over the spring 2004 semester. Each lesson was designed around a specific math construct (Appendix J). The lessons were to be delivered using the "seven-step enhanced math instruction model" that was developed by researchers and experts in career and technical education (C. Alfeld, personal communication, October 21, 2004). This approach was supported by mathematics education literature that propounded the role and value of the specific language employed during the teaching and learning of mathematics (Bickmore-Brand, 1993; Diaz, 1998; Gawned, 1993) as well as the order and manner in which mathematics instruction should be delivered to provide students with a maximum amount of quality, retainable instruction (Kiong & Yong, 2001). It was intended that agricultural power and technology teachers would teach their lessons without any outside assistance from their math teacher partners or other math education professionals. However, in the case of one school the agricultural power and technology teacher did receive direct assistance from his math teacher partner during the course of teaching the math-enhanced lessons, i.e., at least portions of the lessons were "team taught." Important to the effectiveness of the design was the delivery of the treatment by the regular agricultural power and technology teacher. To that end, Campbell and Stanley (1963) posited that results will be more valid and reliable when the experiment is delivered, ". . . through alternative teaching procedures presented without announcement or apology in the regular teaching process . . ." (p. 22).

A more comprehensive view of the treatment implemented in this study and listing of each facet thereof is presented in Table 1. The elements of the treatment described below were delivered only to experimental group teachers and students. While control group students were told that their class would be participating in the research project, control group teachers were instructed to make no change relative to the teaching of mathematics in their agricultural power and technology classes.

Table 1

Overview of the Treatment

Experimental Group Teachers	Experimental Group Students
Preparation Phase	Preparation Phase
Math and agriculture teacher collaboration and professional development Teachers participated in: - Team building activities - Curriculum mapping - Lesson plan development and refinement - Evaluate lessons, provide feedback to other teachers - Training in seven-step instructional approach	Students were told that their class would be participating in the study
Presentation Phase	Presentation Phase
Implementation of the seven-step instructional approach - Presentation of curriculum materials developed in professional development	Students received math-enhanced lessons delivered through the seven-step approach
Continued collaboration/ reflection between math and agriculture teachers throughout the semester - Debriefing following each math enhancement	
Observation of math-enhanced lesson by researcher - Researcher observed and scripted one lesson presentation per teacher	

The dependent variable in the study was student math achievement. Differences between the experimental and the control groups were measured on three levels: 1) a traditional measure of math performance (Terra Nova CAT™ Survey Edition, CTB McGraw-Hill; 25 items); 2) a problem-based measure of work related math performances

(Work Keys Applied Mathematics Assessment, ACT; 33 items); 3) a college-level math placement examination (ACCUPLACER Elementary Algebra test, The College Board; 35 items). To address the issue of difference in technical competence in agricultural mechanics, a technical skills test for agricultural power and technology developed by the National Occupational Competency Testing Institute (NOCTI; 42 items) was employed.

Data Collection

Data collection occurred in spring 2004 for both the experimental and control groups. Student questionnaires and a pre-treatment measure of equivalence concerning mathematical aptitude were administered in mid-January; posttests were administered in early May 2004. Measures are described below.

Essential to the data collection within each school was the role of the testing liaison. Each school had a designated testing liaison who administered student tests as well as distributed and collected student questionnaires and student and parental consent forms. Liaisons were provided with all testing materials and questionnaires by the researcher through postal mail. Liaisons were also provided with instructions for administering each measure as well as instructions concerning return of the test data to the researcher. Large envelopes with postage paid mailing labels were provided to the liaisons by the researcher. The liaisons placed completed answer sheets which identified students only by the identification number assigned to them by the liaison in the envelopes and returned them to the researcher through postal mail.

In addition, descriptive data were collected to monitor the fidelity of the treatment. Observations of each teacher presenting a math enhanced lesson provided both evidence and descriptions of the enhanced math treatment "as it happened" in the classroom. The researcher received fidelity observation training from a recognized expert employed by the NRCCTE. The training occurred January 19, 2004. During the training, scenarios were presented through video for the purpose of establishing proper use of the observation instrument (Appendix P) as well as coding of lesson plans to determine if the seven steps of the math-enhanced lesson plan template (Appendix N) were present.

Measures

Students in each of the two groups completed a battery of examinations prior to and following the treatment that measured their academic and technical competence.

Quantitative

The Terra Nova CAT™ Basic Battery (CTB/McGraw-Hill) examination was employed as a pre-treatment measure in the establishment of the equivalence of groups concerning general math aptitude. The decision to limit the pre measure to one class period was made to prevent test fatigue on the part of students. Conversely, the examination employed for this measure was designed to be administered over a 70 minute period and the length of class period for the classrooms involved in the study was about 45 to 50 minutes. Therefore, students were instructed to complete as much of the examination as they could in an allotted 40 minute time period. This decision was made by the research team at the National Research Center for Career and Technical Education and was based on advice from testing experts (Stone et al., 2004). Students were only scored as to the number of correct responses that they provided.

A variety of tests were used to measure differences between groups at the end of the implementation of the treatment. Each student was randomly assigned (within the class) to one of three posttest measures. Specifically, because it is a nationally-normed and reliable test of math skills, the algebra portion of the Terra Nova CAT™ Survey Edition (CTB/McGraw-Hill) was employed as a traditional cognitive test. Work Keys (ACT) was specifically designed to test math skills in applied, work-related situations; National Occupational Competency Testing Institute (NOCTI) has created a technical competency test in agricultural power and technology, and it was used for that purpose; and ACCUPLACER (The College Board) is a widely-used test in the United States for placement related to a student's need for math remediation at the post-secondary level. Each of these assessments provided data to test the study's hypotheses.

Qualitative

Each experimental classroom was visited by the researcher to observe teachers' execution of the intervention as a way to monitor and assess the study's fidelity of treatment, i.e., "Did teachers implement the prescribed treatment?" Each visit was conducted by the researcher to ensure consistency among observations between the 18 experimental classrooms. The researcher observed instructors teaching the nine math-enhanced lessons in all 18 experimental classrooms. During each observation a rubric was completed that documented the implementation of the treatment (Appendix P).

Data Analysis

Frequencies and percentages were calculated for selected demographic data to accurately portray both the student participants in the study as well as the teacher participants. One-way analysis of variance (ANOVA) was used to compare the different sets of experimental and control classroom means to address the primary research hypotheses. All quantitative analysis was completed using the *Statistical Package for the Social Sciences version 11.01.*

The qualitative data collected from fidelity observations allowed the researcher to document the process of implementation and to monitor fidelity of the treatment across sites (i.e., classrooms). For the experimental classrooms, this procedure helped the researcher determine whether teachers implemented the math-enhanced curriculum as designed. This data was analyzed through the observation and recording of frequencies and percentages of teachers who implemented each of the seven steps of the math-enhanced lessons.

Results

The student questionnaire revealed that the majority of student participants were male (84.4%) and of European descent (58.5%), while one-fourth of the students reported their race as native American. One hundred forty one (31.8 %) of the student participants were seniors in high school, 153 (34.5%) were juniors and 117 (26.4%) were sophomores; the remaining student participants were either freshmen (6.1%) or non responders to the question of grade level. Most of the student participants (82.7%) were between the ages of 16 and 18 at the time of the experiment, and the majority of the student participants held a self-reported grade point average ranging between 2.6 and 4.0 (72%) (see Tables 2-12).

The majority of the teacher participants were male (86.8%) and of European descent (73.7%) (see Tables 13-15).

Three of the four null hypotheses were not rejected based on the analysis; the remaining hypothesis was rejected. The quantitative analyses determined that no significant differences existed between groups (control and experimental) regarding general math achievement as measured by two standardized examinations either prior to or following the study's treatment, i.e., Terra Nova Basic Battery and Terra Nova Survey, respectively (see Tables 16-19). The quantitative analysis also determined that there was no significant difference in level of performance between groups on an examination designed to measure students' ability to use math to solve workplace-related problems (i.e., Work Keys) taken after the treatment was administered (see Tables 20 and 21). No significant difference was detected between the two groups as measured by an examination designed to measure student achievement in Agricultural Power and Technology (i.e., NOCTI- Agriculture Mechanics) taken after the treatment was administered (see Tables 22 and 23).

A significant difference ($p = .017$) was observed between groups following the treatment regarding student performance on a math aptitude examination administered to determine one's need for math remediation at the post-secondary level (i.e., ACCUPLACER) (see Tables 24 and 25). The practical significance of this difference ($d = .83$) fell well within the category of a "large" effect size as defined by Cohen (as cited in Shavelson, 1996, p. 318).

Qualitative analysis per researcher observations, (one per teacher) determined that all 18 of the experimental group agriculture teachers implemented at least six of the seven steps of the math-enhanced instructional approach but only one teacher implemented all seven steps (see Table 26). This variation in implementation did not yield a significant difference on any of the posttest measures (see Tables 27 & 28). The qualitative analysis also revealed that there was variation in the number of math-enhanced lessons presented between classrooms. Accordingly, eleven teachers of the 18 experimental group teachers indicated that they taught nine or more of the math-enhanced lessons per the researcher's request (see Table 29). The average number of math-enhanced lessons taught across the experimental group was 5.1 lessons per teacher (see Table 29).

Analysis of curriculum artifacts revealed variability in types of artifacts submitted prior to the treatment as well as in the content of those artifacts.

Conclusions

Conclusions were based on analysis of data as related to the research questions.

1. What is the effect of a math-enhanced Agricultural Power and Technology curriculum and an 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?

The conclusion drawn from this study concerning research question one was that within this particular population, a math-enhanced Agricultural Power and Technology curriculum and an 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 (Terra Nova Survey) ($p = .946$) or by (b) an "authentic" assessment of student ability to use math to solve workplace problems (Work Keys) ($p = .681$).

2. Does a math-enhanced Agricultural Power and Technology curriculum and aligned instructional approach affect a student's need for postsecondary math remediation?

The conclusion drawn from this study concerning research question two was that within this particular population, a math-enhanced Agricultural Power and Technology curriculum and an aligned instructional approach did significantly affect ($p < .05$) a student's need for postsecondary math remediation as measured by a math placement test used to determine a student's need for math remediation at the post-secondary level (ACCUPLACER) ($p = .017$).

3. Does a math-enhanced Agricultural Power and Technology curriculum and aligned instructional approach diminish a student's acquisition of technical skills?

The conclusion drawn from this study concerning research question three was that within this particular population, a math-enhanced Agricultural Power and Technology curriculum and an aligned instructional approach did not appear to significantly diminish ($p < .05$) a student's acquisition of technical skills as measured by an examination used to assess a student's Agricultural Power and Technology competence (NOCTI – Agriculture Mechanics) ($p = .883$).

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

The conclusion drawn from this study concerning research question four was that the majority of student participants were male (84.4%) and of European descent (58.5%); however, one fourth of the students reported their race as Native American. Regarding grade level, 411 (92.7%) of the student participants were high school seniors, juniors, or sophomores. The remaining participants were either freshmen (6.1%) or non responders to the question of grade level. Most of the student participants (82.7%) were between the ages of 16 and 18 at the time of the experiment and the majority of the student participants held a self-reported grade point average ranging between 2.6 and 4.0 (72%).

The majority of the teacher participants were male (86.8%) and of European descent (73.7%).

5. Does teacher adherence to the seven-step instructional model in the context of Agricultural Power and Technology affect student achievement as measured by conventional standardized tests?

The conclusion drawn from this study concerning research question five is that all 18 of the experimental group agriculture teachers implemented at least six of the seven steps of the math-enhanced instructional approach but only one teacher implemented all seven steps. This variation in implementation did not yield a significant difference on any of the posttest measures.

Implications

This study proved to be consistent with much of the previously published literature concerning the value of contextually based teaching and learning. The results do imply that previous researchers and practitioners (Chiasson & Burnett, 2001; Enderlin &

Osborne, 1992; Parnell, 1996; SCANS, 1991) were correct in their conclusions that providing a context in which learning may take place does hold much value toward student comprehension and retention of subject matter. Findings in this study were consistent with the stance taken by Shinn et al. (2003), i.e., "Secondary agricultural education, through the use of relevant curriculum delivered from a student-centered perspective by skillful teachers, has high potential for engaging students in active, hands-on/minds-on learning environments rich with opportunities for learning mathematics" (p. 16).

This study supported claims made by John Dewey and other educational researchers (Brown, 1994; Enderlin & Osborne,1992; National Research Council, 1988; Whitehead, 1929) dealing with the value of experience in education by demonstrating that a solid context in which education could be applied did provide a significant increase in student performance. This study also provided support for legislation in career and technical education mandating the integration of general education subject matter with that of career and technical education (e.g., the Perkins' Acts). Additionally, this study has shown promise in contributing to some of the goals of the No Child Left Behind (2001) legislation by offering support for improving student achievement in mathematics.

While the treatment outlined in this study was administered over a relatively short period of time (one semester) the results show that within this particular population, a math-enhanced Agricultural Power and Technology curriculum and an aligned instructional approach did positively effect the post-treatment performance of experimental group students on all measures (see Tables 18-25). Moreover, a significant effect ($p < .05$) on a student's need for postsecondary math remediation ($p = .017$) was found. Not only did this comparison result in a significant difference, the practical significance fell within the category of a "large" effect size (per Cohen's *d* as cited in Shavelson, 1996). Notably, the generalizability of these results should not extend beyond the 38 classrooms involved in this study. However, serious consideration should be given to investigating the possibility that the treatment described in this study could have similar effects on other groups of agricultural power and technology students.

Because the other comparisons of measures did not reveal a significant difference between the groups ($p < .05$), perhaps the short time period over which the study was conducted did not allow enough time for significant differences in student math achievement to emerge. Perhaps implementing the treatment over an entire school year would provide students with a more substantial increase in achievement. Also, in light of the findings that the average number of math-enhanced lessons taught per teacher was just over five, perhaps an increase in this number would also result in increased student performance.

According to the *National Assessment of Vocational Education* (U.S. Department of Education, 2004), presently there is little concrete evidence of how career and technical education can contribute to student performance in other subject areas such as mathematics. However, this study contributes some empirical evidence toward that end.

The results of this study indicated that the math-enhancement delivered through the context of agricultural power technology did not significantly diminish the students' acquisition of agricultural power and technology skills ($p = .883$). These findings suggest that the math-enhancements described in the study may be a viable way of increasing student math achievement without decreasing a student's acquisition of technical competence. The fear of such curriculum integration projects resulting in inferior career and technical training was stated clearly by Stasz and Bodilly (2004):

> State academic standards and assessments reportedly had widespread influence over vocational courses and programs at the local level. In particular, teachers reported reduced vocational enrollments stemming from pressure to meet higher academic standards and increased course requirements; reduced time on vocational tasks arising from increased time on academic requirements and test preparation; and possible reduced quality of instruction, given the emphasis of some tests on simplistic understanding and answers. (p. 20)

Recommendations

Recommendations for Research

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 (Stone et al., 2004). 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.

Further investigation should be conducted concerning the evaluation instruments employed in this study. Because the comparison of group scores on the ACCUPLACER examination did show a significant difference favoring the experimental group, this test should be analyzed to determine more precisely its content to determine which specific mathematical concepts or principles may be taught more effectively through the use of a contextualized, math-enhanced curriculum delivered in the context of agricultural power and technology.

The treatment described in this study involved several different elements and was of a somewhat complex nature (Table 1) which could result in various "rival hypotheses" when interpreting results (see Campbell & Stanley, 1963, pp. 7, 13, 14). Accordingly, further investigation should be conducted into the specific effects each of the elements of the treatment may have had on student math performance.

To that end, additional inquiry should be carried out concerning the effectiveness of the seven step instructional approach employed by teachers in this study. While only one teacher was observed implementing all seven steps, no significant difference was detected between that classroom and the other classrooms where only six steps were observed (see Table 28). Perhaps this step could be replaced with an element that would be more effective toward providing quality instruction or perhaps the step should be discarded. In future studies, classrooms should be observed more than once to provide more comprehensive data concerning the implementation of the seven-step method and its role in improving student mathematic achievement.

More investigations should be performed concerning the specific effects that collaboration between math and agriculture teachers may have on student achievement. For example, the teachers involved in this study spent several hours over the course of the semester reflecting and debriefing with their math teacher partner concerning the delivery of the math-enhanced lessons. So, research should be performed to more accurately determine the value of this type of cross-disciplinary interaction.

Each of the experimental classrooms in this study were observed by the researcher during the implementation of one of the math-enhanced lessons. Consequently, inquiry should be directed toward the effects of such observations on teacher behavior and student performance.

Myers and Dyer (2004) recommended that empirical research should be performed to determine how agricultural education could contribute to student achievement across the school curriculum. This study adds to the limited body of literature that deals with that issue. Additionally, Myers and Dyer recommended that, "Once this information is obtained, studies are needed to identify the best methods teacher educators can employ to prepare teachers for this expanded role" (p. 50). Accordingly, additional inquiry should be carried out regarding effective preparation of pre-service secondary agricultural education teachers to provide contextualized instruction. This training could be incorporated into pre-service student requirements within agriculture teacher preparation programs.

Teacher educators in the fields of mathematics and agriculture should take note of the results of this study when developing the plans of study for pre-service teachers. Perhaps future coursework should be designed that reflects the value of teaching mathematics through the context of agricultural power and technology. This approach could involve cooperation between the two teacher preparation programs and may be presented by teacher educators in the form of team teaching activities (Conroy & Sipple, 2001) or through field experiences. Collaboration among different disciplines in preparation of teachers could provide future educators with a more holistic approach to educating students (Dworkin, 1959; Fishman & McCarthy, 1998; Romberg & Kaput, 1999).

Teacher preparation programs in all disciplines should make every effort to stress the value of the role of teachers as supporters of education across the curriculum not just the value of a specific subject area (Dare, 2000; Lewis, 2000; Stewart, Moore, & Flowers, 2004). In a study performed at The Ohio State University, Miller and Gliem (1996) tested a group of pre-service agricultural education instructors and determined that, ". . . preservice agricultural educators were not capable of applying basic mathematics skills to agricultural problems" (p. 18). Perhaps this type of integration at the post-secondary level could help to better prepare agricultural education teachers to apply and teach the mathematics that is found in their curriculum

Finally, this experiment should be replicated with a larger population, e.g., multi-state participants over a longer period of time so that additional generalizations may be drawn.

Recommendations for Practice

Based on the findings of this study, a math-enhanced Agricultural Power and Technology curriculum and an aligned instructional approach did have a positive effect on student math performance. In light of this study, practitioners should be encouraged to work toward further integration of mathematics and agricultural power and technology.

This study revealed that school-based reform concerning curriculum integration is effective but requires a significant investment of time and other resources. These findings are consistent with conclusions published in the *National Assessment of*

Vocational Education (*NAVE*) (U.S. Department of Education, 2004). The authors stated,

> While positive change is certainly happening at the high school level, secondary vocational education itself is not likely to be a widely effective strategy for improving academic achievement or college attendance without substantial modifications to policy, curriculum, and teacher training. (p. 2)

The NAVE report provided evidence that such "substantial" modifications could result in a significant increase in student achievement. The modifications implemented in this study dealt with three primary areas: teacher development, curriculum development, and curriculum implementation. Accordingly, this study provided support for an increase in cross-disciplinary team building activities among teachers. According to the U.S. Department of Education (2004), "Current vocational teachers are less likely to than academic teachers to have bachelors' degrees and many do not feel that they have received sufficient professional development on the key strategy of integration" (p. 10). Consequently, every effort should be made by school administrators to provide teachers with opportunities for professional development that will include a focus on integration of subject matter as well as team building between teachers of different disciplines, including career and technical education teachers (Hernandez & Brendefur, 2003).

Those charged with the task of creating curriculum materials for the purpose of integrating subject matter should examine the results of this experiment. This study demonstrated that teachers from different disciplines could come together to create a useful body of curriculum materials that supported an increase in student math performance. Curriculum developers may wish to replicate this model and provide necessary resources to support the involvement of teachers in the development of contextualized curriculum materials in the future.

The seven-step method of instruction employed in this experiment did prove to be effective, especially as it related to reducing a student's need for math remediation at the post-secondary level. This may warrant a deeper inquiry by those who have the responsibility of identifying effective means of instruction toward that end. In addition, special attention should be paid regarding the value of the various steps, their order of presentation, and related procedural questions.

Results of this study demonstrated that inservice education for teachers concerning contextualized teaching and learning did help instructors recognize opportunities, as well as the knowledge and skills needed, to increase the math performance of their students. The professional development activities delivered through this study helped to build functional teams of inter-disciplinary teachers that developed and delivered effective contextually-based instruction (Hernandez & Brendefur, 2003). However, consistent with the observations of previous researchers (Enderlin & Osborne, 1992; Thompson, 1998; Warnick & Thompson, 2002), there was a large monetary investment associated with such activities as well as a substantial time commitment required of participating teachers. For this reason, school administrators should look seriously into setting aside adequate resources to support this type of professional development for their teachers. These resources should include release time for the purpose of team building and curriculum development sessions between career and technical teachers and general education teachers (Garet et al., 2001). This process would require a great deal of teacher time and effort; thus, school leaders should plan accordingly.

The issue of increased student achievement in mathematics appears to be a serious matter facing public education today. Not only is concern for student math achievement in the general population of secondary students at a high level; but, specifically, the math achievement scores of agricultural education students in at least one state have been examined and found to be below the state average as well as below the level of other career and technical education concentrators (Woglom, Parr, & Morgan, in press). With that in mind, educators should be encouraged to put substantial and concerted effort toward developing and implementing contextualized curriculums and teaching approaches that show promise for the more holistic development of all students.

Currently, legislation concerning contextual learning leaves a certain amount of interpretation to the local school system as to how curriculum integration should be accomplished (U.S. Department of Education, 2004). In the future, legislators should consider studies such as this one when outlining requirements for curriculum integration and thus provide school leaders with a more focused approach to professional development for the support of contextualized teaching and learning practices.

Finally, the results of this study could prove to empower mathematics teachers who have long been searching for a way to make their subject matter more meaningful to students (Parnell, 1998; Romberg & Kaput, 1999; Yager, n.d.) by providing them a context for the application of mathematical principles and concepts already available on many local high school campuses, i.e., secondary agricultural education.

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APPENDIXES

APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL FORM

Oklahoma State University
Institutional Review Board

Protocol Expires: 11/5/2004

Date: Thursday, November 06, 2003 IRB Application No AG0411

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

Principal
Investigator(s):

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

Reviewed and
Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

Dear PI :

Your IRB application referenced above has been approved for one calendar year. Please make note of the expiration date indicated above. 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.

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 projects are subject to monitoring by the IRB. If you have questions about the IRB procedures or need any assistance from the Board, please contact me in 415 Whitehurst (phone: 405-744-5700, colson@okstate.edu).

Sincerely,

Carol Olson, Chair
Institutional Review Board

APPENDIX B

PARTICIPANT EXPRESSION OF INTEREST FORM

Expression of Interest
Math-in-CTE Project
Ag Power & Technology
Spring 2004

Name: ______________________________ **School:** ____________________

School Mailing Address: ____

____

____

Ag Department Tel. # ____

Best Times to Call: ____

____

High School Tel. # ____

Home Tel. # ____

Mobile Tel. # ____

FAX # ____

Email Addresses: ____

____

____

Name of High School Principal:

____

Name of Prospective Math Teacher Partner:

____

Thank you very much for your interest in participating!!

APPENDIX C

APPLICATION FOR PARTICIPATION

Math-in-CTE Study Application

Thank you for your willingness to participate in the Math-in-CTE project. The following information will help us identify the school programs and curricula that fit best with our study.

1. Your name ______________________________
   First name   Last name   MI

2. What is the name of your school? ______________________________

3. What is the full address of your school? ______________________________
   Street number and name

   ____
   City   State   Zip code

4. In what area(s) do you teach? (Circle all that apply.)
   a. CTE
   b. Math

5. Are you willing to participate in the professional development workshops?
   a. Yes
   b. No

6. Does your school participate in any kind of formal cooperative relationship (such as Tech Prep, dual enrollment, etc) with a post-secondary institution?
   a. Yes (please describe) ______________________________
   b. No

7. Are any of your classes articulated with, or provide dual-credit for post-secondary education?
   a. Yes
   b. No

   Q7a. If so, which ones? ______________________________

8. What classes a do you expect to teach Spring 2004, what grade-level(s) does each class serve, how many sections are there, and how many students do you expect in each section? Please indicate the primary source for the course curriculum. Please circle the most appropriate code using:
   (N) if the curriculum is primarily based or uses national standards (e.g., NATEF)
   (S) if the curriculum follows a state curriculum guide or is based on state standards
   (NP) if the curriculum is primarily based on national professional guides (e.g. NBEA, FFA, Skills USA)
   (T) if the curriculum is primarily based on guides provided by textbook publishers
   (L) if the curriculum is based primarily on your experience
   or Other (please explain).

Class title	Grade	# of sections	# of students	Curriculum source (Circle one for each class.)
a.				N S NP T L Other ________
b.				N S NP T L Other ________
c.				N S NP T L Other ________
d.				N S NP T L Other ________

About you:

9. Do you specialize in areas other than CTE and/or Math? If so, which areas?

____

10. How many **total** years of teaching experience have you had? __________ Years

11. Please circle all forms of professional preparation you have acquired:

    a. Occupational experience (What type?) ________________________

    b. Associates Degree (Major) ________________________

    c. Baccalaureate Degree (Major) ________________________

    d. Master's Degree (Major) ________________________

    e. Other ________________________

12. What certifications, if any, do you hold?________________________

____

13. With which professional organizations, if any, are you affiliated (e.g., ACTE, etc.)? __________

____

Potential Math teacher-partner: We ask that you recommend a math teacher partner to work with you on this study. If you are unable to find an appropriate math teacher we will provide a math consultant.

14. Recommended teacher-partner ________________________
First name Last name

Contact information (if known): ________________________

15. Which Math do they teach? (Circle all that apply.)
   a. General math
   b. Algebra I
   c. Algebra II
   d. Geometry
   e. Calculus
   f. Trigonometry
   g. Other math (please identify) ______________________________

Your school:

16. How would you classify your school?
   a. Comprehensive High School
   b. Vocational High School
   c. Regional Vocational Center (Career Center/Joint Vocational School/Technical Education Center or other label)
   d. Other (specify) ______________________________

17. What type of scheduling does your school employ?
   a. Block
   b. Traditional → How many periods are there per day? _____ periods/day
   c. Other (specify) ______________________________

18. Your Principal's name ______________________________
First name Last name

19. Your Principal's address ______________________________
Street number and name

____
City State Zip code

Email address: ______________________________

Phone number: ______________________________

20. What is your preferred mailing address?

____
Street number and name

____
City State Zip code

Math-in-CTE Signature Page

This signature page needs to be sent or faxed to the research study center in order for your application to be considered.

The fax number is: 612-624-7757

The address is: Math-in-CTE project
National Research Center for Career and Technical Education
University of Minnesota
1954 Buford Ave.
St. Paul, MN 55108-6197

Your principal:
Please have your principal sign after reading the following statement.

I support this teacher in his/her participation in this research study.

____________________________ ____________________________
Principal's name (print) Principal's signature

Please read the following statement and sign below:
By submitting this application for entry into the pool of potential teacher participants for this project, I agree that if I am selected randomly for either the experimental or the control group, I will do my best to fulfill the requirements for participation in the study and will inform the researchers as soon as possible if I cannot meet the expectations.

____________________ ____________________ __________
Name (print) Your signature Date

Please verify your address ____________________________________
Street number and name

____
City State Zip code

____
Email address

Thank you for your interest in our project!

APPENDIX D

CLASSROOM ENROLLMENT

Classroom	Number of Students
5001	13
5002	9
5003	13
5004	10
5005	15
5006	9
5007	9
5008	7
5009	15
5010	18
5011	2
5012	9
5013	8
5014	12
5016	21
5017	15
5018	26
5019	10
5020	13
5021	9
5102	10
5104	7
5106	12
5107	8
5108	13
5109	16
5110	9
5111	10
5112	18
5113	12
5114	17
5115	12
5117	15
5118	7
5119	7
5120	14
5121	6
5122	7

Note. Experimental Classrooms, 5102-5122; Control Classrooms 5001-5021

APPENDIX E

GUIDELINES FOR CONTROL TEACHERS TO FOLLOW WHEN SUBMITTING CURRICULUM ARTIFACTS

Math-in-CTE Project
Agricultural Power & Technology
"Control Group" Teachers

Guidelines for Request of Instructional Materials:

As a participant in the Math-in-CTE study, you are asked to provide copies of instructional materials from the *Agricultural Power & Technology* course you will teach in the Spring 2004 semester. Here is what you are asked to provide:

Copies of your overall course plan or syllabus for the *Ag & Power & Technology* course you will teach in Spring 2004. Examples: "block" plan, a course outline, a course related description with objectives, a concept map with sets of objectives, etc. (We expect this to vary from teacher to teacher.)

Copies of any math-related instructional materials you currently use in your course, such as:

a. Activity sheets
b. Worksheets
c. Lesson plans
d. Lesson objectives
e. Evaluation and/or assessment tools
f. Criteria used for evaluation and assessment
g. Descriptions of work-based learning activities or other training experiences
h. Demonstration plans
i. Table of contents of any textbooks that you may use
j. Other materials that you identify

Important Note: Please do not be concerned if you do not have math-related teaching materials to send, but do return the expandable folder and its files.

APPENDIX F

GUIDELINES FOR EXPERIMENTAL TEACHERS TO FOLLOW WHEN SUBMITTING CURRICULUM ARTIFACTS

Math-in-CTE Project
Agricultural Power & Technology
NRCCTE

What to bring to the professional development sessions
A checklist for the "experimental group" teachers

Please bring:

____1. Any related instructional materials you would like to have on hand to reference during the workshop

Examples: curriculum notebooks, sets of lesson plans and activity sheets, student worksheets, textbooks, tests and assessments, etc.

Please bring the following to give to the researchers:

____2. Signed consent form for participating in the study **IF** you have not previously returned this directly to the national center or to Oklahoma State University.

____3. Copies of your overall course plan or syllabus for the *Ag & Power & Technology* course you will teach in Spring 2004

Examples: "block" plan, a course outline, a course related description with objectives, a concept map with sets of objectives, etc. (We expect this to vary from teacher to teacher. Also, we are not interested in collecting large sets of curriculum notebooks.)

Note: Please be prepared to leave the appropriate copies with the researchers.

____4. Copies of any math-related instructional materials you currently use in your course, such as:

a. Activity sheets
b. Worksheets
c. Lesson plans
d. Lesson objectives
e. Evaluation and/or assessment tools
f. Criteria used for evaluation and assessment
g. Descriptions of work-based learning activities or other training experiences
h. Demonstration plans
i. Other materials that you identify

Note: Please be prepared to leave the appropriate copies with the researchers.

Important Note: Please do not be concerned if you do not have math-related teaching materials to bring.

APPENDIX G

PRE-TREATMENT SCRIPT

Script for LIAISON to Read in Classrooms

Good morning/afternoon,

I will just take a few minutes of your time today. Your teacher, [insert name of teacher], has been selected to take part in a national research study that focuses on the math skills that come up in *Agricultural Mechanics* courses. Even though this course doesn't focus specifically on math, there are many courses in career and technical education that nevertheless 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 weeks, we are first going to ask you to fill out a survey about your math attitudes and then have you take a math test. At the end of the semester, we'll do the same thing again. Each time, you will be given a **$10 Walmart Gift Card** which I will distribute directly to you.

These surveys and tests have nothing to do with your grade in this course, and your name will not be associated with your answers. However, 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.

I am now going to hand out consent forms for you and parents. Your parents only have to sign and return the form if they do NOT want you to take part in this study. If your parents 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. Either way, you must indicate your decision by checking the appropriate box on the student consent form, signing it, and returning it. **I will be back in a few days to collect all the student and parent consent forms and have you take the survey.** I will stay in the classroom while you complete the surveys; your teacher will not be in the room. The same goes for the math tests.

Are there any questions?

APPENDIX H

STUDENT CONSENT FORM

January, 2004

Dear Student:

Your class, ____________, with __(name of teacher)___has been randomly selected to participate in a national study of mathematics in career and technical education.

We are university researchers who work with high schools and students. The study will require you to take a math pre-test in the beginning of the course, and a math post-test at the end. We will pay you $10 for each one. In addition, we'd like you to fill out a short survey about your educational experiences, and we'd like to come and observe your class once per semester.

You can be assured that these records, as well as your responses to the tests and survey, will remain completely anonymous and confidential, and will not be used for any other purpose than this important research. Your name will not be associated with any results.

Participation in interviews is strictly voluntary. Anyone can withdraw from the study at any time. **Please fill out the attached form and return it to the researchers indicating whether you would like to participate.**

If you want to ask someone about this study, you may call us at (405) 744-8141; email us at edwarmc@okstate.edu; or write us at Craig Edwards, Oklahoma Math-in-CTE Project Director, Oklahoma State University, Agricultural Hall Room 448, Stillwater, OK 74078.

Sincerely,

Dr. M. Craig Edwards
Oklahoma Math-in-CTE Project Director

Research Study of Math-in-CTE – Agricultural Education

Participant Consent Form

I, ______________________________ (Participant's Name), **CONSENT** to participate in math tests, survey, and classroom observation for the study of math in CTE -- Agricultural Education being conducted by researchers from Oklahoma State University.

I, ______________________________ (Participant's Name), **DO NOT CONSENT** to participate in math tests, survey, and classroom observation for the study of math in CTE -- Agricultural Education being conducted by researchers from Oklahoma State University.

TEACHER, PLEASE RETURN THIS FORM TO:

Brian Parr
Oklahoma Math-in-CTE Project Coordinator
Oklahoma State University
Agricultural Hall Room 448
Stillwater, OK 74078

APPENDIX I

PARENTAL CONSENT LETTER

January, 2004

Dear Parent:

Your child's Agricultural Power & Technology class at ____________High School has been randomly selected to participate in a research study on the effects of a math-enriched career and technical curriculum on students' math achievement.

The U.S. Department of Education reports that most students leave high school without basic knowledge or understanding of essential math and require remediation when they attempt to enter community, technical or four-year colleges, or many career positions. Employers and groups like the National Council of Teachers of Mathematics (NCTM) tell us that math is one of the 'new basic skills' for industry. We have learned that higher wages depend on the ability to think mathematically. The ability to use math to solve problems is no longer a job requirement only for scientists and engineers; all careers with promising futures now require math skills.

The major goal of our project is to study whether students' math understanding can be improved through their career and technical education (CTE) courses. The teacher will be using applied situations in Agricultural Power & Technology to demonstrate how mathematics is used in real world situations, and students *including your child* will be given pre- and post-tests to determine their math understanding. The test results will be used for research purposes only and will not affect their grade in the course. Students will also be asked to complete a short survey, and their classroom will be observed once by the researchers. No information collected for this study will be released to the school or any other recipient, and all identifying information will remain anonymous and confidential.

If you prefer that your child not participate in this study, please contact me as soon as possible. If we do not hear from you, we will ask your child if he/she would like to participate. After hearing and reading an explanation of the study and what is involved, and being given a chance to ask questions and voice concerns, your child will be asked to sign a consent form. Participation is voluntary, and anyone may withdraw from the study, including withdrawing any data collected, at any time.

You can reach me at (405) 744-8141; email me at edwarmc@okstate.edu; or write to me at Craig Edwards, Oklahoma Math-in-CTE Project Director, Oklahoma State University, Agricultural Hall Room 448, Stillwater, OK 74078.

If you have any questions or concerns regarding the study and would like to talk to someone other than the researchers, contact Dr. Carol Olson, Director, Office of the Vice President for Research, Oklahoma State University, 415 Whitehurst, Stillwater, OK 74078; telephone (405) 744-1676; or email colson@okstate.edu

Sincerely,

Dr. M. Craig Edwards
Oklahoma Math-in-CTE Project Director

APPENDIX J

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 Map

Agricultural Mechanics Problem-Solving Applications	Mathematics Content Standards	PASS 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
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
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
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
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
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
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
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 2-8b
Calculate the amount of compression/pressure to use for a given set of project specs.	Solve problems involving ratio and proportions	
Use histograms and scatterplots of safety data in making decisions	Reading and interpreting graphs	PASS Algebra I Standard 2-5b, 3-2
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 K

MATH TEACHER GUIDING QUESTIONS FOR DEBRIEFING

Guiding questions for the debriefing interview

Dear Math Teacher,

Please use the following questions to guide your debriefing interviews with your CTE teacher. After each interview, take a moment to:

- type a response
- save it to a file, and
- either send it to the NRC through the webCT site, attach it to an email to mathincte@umn.edu, or fax it to 612-624-7757.

If you email your files, please make sure to put your name and teacher ID number in the emails.

Name of Lesson: ______________________________

Date Lesson was Presented: ______________________________

1) *In general, how did it go?*

2) *How did your students respond? In your opinion, did students understand the math concepts?*

3) *What elements of the enhancement were particularly effective?*

4) *What would you like to build on or strengthen?*

5) *What elements of the lesson were challenging or difficult to teach?*

6) *Were there some elements of the lesson you did not have an opportunity to teach?*

7) *If so, why were you unable to teach some elements of the lesson? (If the teacher answers lack of time, please identify what caused the time crunch.)*

8) *What would you like to do differently next time?*

9) *What kind of support do you need to prepare for the next enhancement?*

APPENDIX L

AGENDA FOR FIRST ROUND OF PROFESSIONAL DEVELOPMENT

Math-in-CTE
Professional Development Training
Agricultural Power & Technology

November 13-15, 2003
Clarion Meridian Hotel & Convention Center
Oklahoma City, OK

Agenda

Thursday, Nov. 13

4:30 – 5:45 p.m.	Arrival, Check-in to Hotel, Pick-up Workshop Notebook & Name Tag (Salon O)
5:45 – 6:30 p.m.	Dinner: Deli Sandwich Bar (Salon O)
~6:30 p.m.	Welcome and Staff Introductions, Dr. Craig Edwards, Oklahoma State University (Salon O)
	Complete Teacher Surveys
~7:00 p.m.	Dr. Jim Stone, National Research Center for Career & Technical Education, University of Minnesota
	Overview and Purpose of the Research Study
~7:30 p.m.	Organize Curriculum Artifacts Folder & Informal Break
~7:55 p.m.	Teacher Introductions
~8:15 p.m.	"Sponge Activity" – Enhancing Math through Ag Power & Technology: *An Example Exercise*
	Dr. Harry Field & Mr. Brian Parr, Oklahoma State University
	Related Group Activity
	Group Reports
~9:15 p.m.	Questions, Comments, Ideas . . .

	Adjourn for the Evening
<u>Friday, Nov. 14</u>	
til ~8:25 a.m.	Continental Breakfast provided by the Hotel
8:30 a.m.	Day #2 of Workshop Begins/Additional Introductions (Salon D)
~8:35 a.m.	Discuss Math Concepts to be Enhanced through Ag Power & Technology: *Oklahoma PASS Skills . . .* Mrs. Christine Kokojan, Math Teacher, Drummond H.S. & Mrs. Kathleen Hoey, Math and CTE Teacher, Sand Springs H.S.
~9:05 a.m.	The Enhancement Process – Steps/Components McNally's Presentation via CD, Facilitated by Mrs. Mary Fudge, Academic Technical Coordinator
~9:30 a.m.	An Example Math-Enhanced Lesson in Ag Power & Technology: *Constructing a Gate* Mr. Paul Hoey, Agricultural Education Teacher, Sand Springs H.S. & Mrs. Kathleen Hoey Questions, Ideas, Suggestions . . .
~10:15 a.m.	Refreshment Break
~10:35 a.m.	Review Key Steps/Components for any Math Enhancement, Mrs. Mary Fudge et al. Questions . . .
~11:00 a.m.	Brainstorming/Idea Generation for Additional Lesson Activities for Identified Math Concepts, Staff
~11:25 a.m.	Teams Select Math Concept for which their Math-Enhanced Lesson will be Developed *Need Two Teams per Math Concept working on <u>different</u> Lesson Plans for that Concept*
~11:50 a.m.	Lunch/Teams "Negotiate" as needed who will Address which Concept and Develop which Activity (Salon F)

Friday, Nov. 14 (cont'd)

~12:50 p.m.	The "Heavy-lifting" Begins ☺
	Develop and "Flesh-out" Lesson Plans, Teams facilitated by Staff
~3:00 p.m.	Refreshment Break
~3:20 p.m.	Team Progress Checks: Discuss Progress, Problems Encountered, Solutions, etc.
	Continue Developing Lessons, Create Electronic Files (Save, Save, Save, . . .)
	Trade Lesson Plan with another Team for Critique and Comment, Teams facilitated by Staff
~5:00 p.m.	Questions, Comments, Tomorrow . . .
6:00 p.m.	Group Dinner and Visitin' ☺ (Salon F)
~7:00 p.m.	Adjourn for the Evening

Saturday, Nov. 15

til ~8:25 a.m.	Continental Breakfast provided by the Hotel
8:30 a.m.	Day #3 of Workshop Begins (Salon D)
	Questions, Thoughts, Ideas from Overnight, Group
~8:45 a.m.	Teams Finalize Initial Lesson Plan Drafts – Generate Hard Copies and Electronic Copies
	Make Corrections, Changes, etc. as needed
	Provide Project Team with an Electronic Copy of *Draft Lesson Plans*
	Teams Share an Overview of their Lesson with the Group – *What You Envision Doing & How . . .*
~10:15 a.m.	Refreshment Break

Saturday, Nov. 15 (cont'd.)

~10:35 a.m.	Teams Complete Lesson Plan Overviews and Sharing Questions, Comments, Critique . . .
~11:45 a.m.	Lunch (Salon F) Room Check-out
1:30 p.m.	Discuss what to do between now and the December 19-20 Professional Development . . . "Practice" Your Lesson . . . ☺ Continue to Collaborate and Improve it Discuss what we will do at the next Professional Development Workshop . . . Travel Mileage forms & information about Substitute Reimbursement Procedures Questions . . . Complete and Turn-in Workshop Evaluation form Please BE SURE to provide Project Team with an Electronic Copy of your *Draft Lesson Plan* before leaving
~3:00 p.m.	Adjourn

Thank You and have a safe trip home!!

APPENDIX M

THE SEVEN-STEP MATH-ENHANCED DELIVERY MODEL

Components of a Math-Enhanced Lesson:

1. Recognizing math with your class ("Pull & Point")
   When you come to the part of your lesson where predetermined math exists, verbally recognize the math …show students by "pulling out" and "pointing out" in the lesson, activity, project for the day.

2. Assess students' math awareness –
   Using suggested questions, evaluate how much students know about the math concept/skill being addressed.
   Questions: "What do you know about _____? Or
   "What can you tell me about _____?

3. Walk through the "pulled out" math example –
   - Walk students through the steps/processes needed to complete the example.
   - Ask students to take the lead depending on level of understanding.

4. "Enhance" the math in your lesson –
   a. Share the "generic" math principle/concepts with students. Purposely use math language and ask students to do so as well during the enhancement.
   b. The transition from CTE to math vocabulary should be gradual throughout the lesson, being sure to never completely abandon either set of vocabulary once it is introduced, e.g. use the term "slope" along with the term "pitch."

5. Reinforce the enhancement – Supply students with:
   a. similar math example(s) from a similar CTE scenario and
   b. generic math example(s) similar to those they might see in a math class or on a math test.

   (Students may work through the math principle or concept individually or in groups.)

6. Check for Understanding –Ask students the following questions:
   Q: " Can you explain the math step(s)/concept(s) that we used today"?
   Q: "How would you explain these math steps/concepts to someone else"?

7. Expand the Enhancement - Ask students to create:
   a. a math example within the CTE lesson context OR provide students another CTE scenario (which addresses the same math

principle/concept) but with an error in logic and have them correct the work.

b. a generic math example (similar to those they might see in math class or on a math test) OR provide students another generic math example (which addresses the same math principle/concept) but with an error in logic and have them correct the work.

(Students should be allowed to and even encouraged to actually solve their homemade examples.)

APPENDIX N

SAMPLE MATH-ENHANCED LESSON PLAN

Teacher Notes for
BUILDING A MATH ENHANCEMENT

Title of the Lesson: Got Paint?

1. Objective of the lesson.

Student will demonstrate a working knowledge of

- Translating word phrases and sentences into expressions and equations and vice versa. (PASS: Algebra I, Standard 1, Objective 1)
- Drawing and analyzing 2- and 3-dimensional figures. (PASS: Geometry, Standard 2, Objective 2)
- Computing length, perimeter or circumference, area, volume, and surface area of geometric figures with missing information and correctly identify the appropriate unit of measure of each. (PASS: Geometry, Standard 2, Objective 4)
- Using the formulas from measurable attributes of geometric models (perimeter, circumference, area and volume), science, and statistics to solve problems within an algebraic context. (PASS: Algebra I, Standard 2, Objective 8)

and its application in agriculture power and technology, while recognizing it in other contexts.

2. Identify the math, math terms and vocabulary and write out the description or definitions.

Prism - A solid figure whose bases or ends have the same size and shape and are parallel to one another, and each of whose sides is a parallelogram. Square tubing will be a special case of a prism since its hollow.

Area - The surface of a 2-dimensional object measured in square units.

Surface area – Describes the area of the faces of a 3-dimensional object.

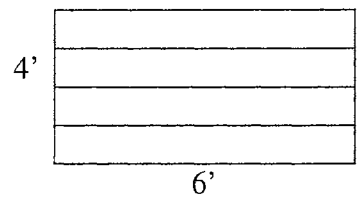
Units of measure

- sq units – measures area of a 2-D object or a face of a 3-D object
- linear ft – measures length of 2-D object or length of a face of 3-D object
- gallons – liquid measure
- quarts – liquid measure
- gallons per sq ft – liquid needed to cover 1 sq ft of surface area

3. Note the steps, rules, underlying principles of the concept or theory and summarize.

1. The surface area of a 3 dimensional object is the sum of the surface areas of its sides.
2. We can calculate the surface area of a solid by breaking it down into a set of 2 dimensional shapes.

Prior to this lesson, students have designed and built 4' x 6' gates with 5 bars.



Area = length * width
Surface Area of square tubing = 4*area of side
Linear Feet used in frame = 20'
Linear Feet used in gate = 38'
1 Sq ft = 144 sq inches

4. Develop several sample problems, moving from very specific agriculture power and technology examples to more generic problems.

Calculate the area to be painted:
- 2-Dimensional Object
  - 8' x 10' wall
- 3-Dimensional Object
  - 17" long piece of 1" diameter square tubing
  - 13 ½" long piece of 3" diameter round tubing
- 3-Dimensional Frame
- 3-Dimensional Gate (frame and crossbars)

Generic Problems:
- Paint a room in a house
- Paint the outside of house
- Spray fertilizer for lawn

5. Document references and supplies needed to demonstrate the math concept.

Resource Web Site: - (Good reference but not necessary)
Linking Length, Perimeter, Area, and Volume Part 5: Purple Prisms - http://illuminations.nctm.org/lessonplans/6-8/linking5/

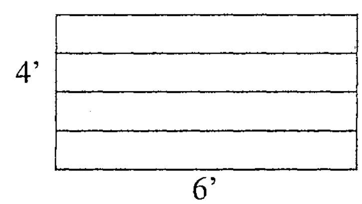
Lesson Plan Template for
TEACHING A MATH ENHANCEMENT

Title of the Lesson: Got Paint?

1. Introduction to the lesson.

It's time to paint all the panels in the shop. Due to a limited budget, we have to know exactly how much paint to buy. Think about how we might go about solving this problem. Can you think of any formulas or strategies that might work? Let's refer to your design drawings when you did your bill of materials to determine how much paint to buy. The paint we will use covers 275 sq ft with 1 gallon. There are 4 quarts per gallon.

Gate Design:



2. Assess students' math awareness by asking questions.

What can you tell me about area? How do you find area of a rectangle? When does that differ from surface area? How many rectangular faces make up a rectangular prism? Although each face of the rectangular prism is two-dimensional, together what do they make? Can you use the same formula for square tubing and round tubing? How have you used or seen this before? Why are square units used when measuring surface area? In your own words, give a definition of surface area of a rectangular prism? What strategy would you use to determine how much paint you would need for the gate? Divide the calculation in small part then add those together? Dividing a large problem into smaller steps is a good problem solving strategy.

3. Demonstrate the example problem.

Let's look at a couple of examples first. Suppose I want to paint a wall that measures 8' x 10'. What is the area of the wall?

*Remember: Area = Length * Width*

*Area = 8' * 10'*

Area = 80 sq ft (point out the unit change here)

The amount of paint needed = Area/Coverage

= 80 sq ft / 275 sq ft / gallon

= .29 gallons (point out the unit change here)

Is that more or less than a quart?

Suppose you have a 6' piece of 1" square tubing to paint. How much paint do you need?

*Surface Area = Length * width * # of sides*
*= 72" * 1" * 4*
= 288 sq in (point out the unit change here)
Area in sq ft = 288 sq in / 144 sq in
= 2 sq ft (point out the unit change here)
Paint needed = Area/ Coverage
= 2 sq ft / 275 sq ft / gallon
= .007 gallon (point out the unit change here)

Is that more or less than a quart? What might be a better unit of measure for the amount of paint needed? How would that change our calculation?

Suppose you have a 6' x 4' panel frame made of 1" square tubing to paint. How much paint do you need?

*Linear Ft of frame = Length * 2 + width* 2*
*= 72" * 2 + 48" * 2*
= 144" + 96"
= 240"
*Surface Area = Length * width * 4*
*= 240" * 1" * 4*
= 960 sq in (point out the unit change here)
Area in sq ft = 960 sq in / 144 sq in / sq ft
= 6.67 sq ft (point out the unit change here)
Paint needed = Area/ Coverage
= 6.67 sq ft / 275 sq ft / gallon
= .02 gallon (point out the unit change here)

Is that more or less that a quart? What might be a better unit of measure for the amount of paint needed? How would that change our calculation?

4. Explain the math concept or theory and show students how it applies, using the terminology of math.

Refer to #2 and #3

5. Demonstrate other examples as necessary.

If more examples are needed, use different lengths and sizes of square tubing.

6. Have students explain the solutions to the problems, or demonstrate what they did to show understanding.

Tell students to determine how much paint to order. (Give students the number of panels "that have been made".) Be able to explain your calculations. Show all your work and don't forget to keep track of units.

7. Challenge students to write and solve their own example problems and demonstrate competency in a test situation.

How much adjustment is needed to account for end-butt welds?
What if you used round tubing for the gate? What if you used rectangular tubing?

Sample Standardized Test Questions involving these concepts:

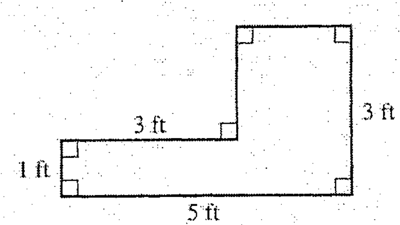
From ACT Standards for Transition Information Services:

Score Range 16 – 19:
The out-of-bounds lines around a basketball court in Central Park need to be repainted. The court is a rectangle 90 feet long and 50 feet wide. What is the perimeter, in feet?

a. *140*
b. *190*
c. *230*
d. *280*
e. *4,500*

Score Range 24-27:
How many feet long is the perimeter of the figure sketched below?

a. *12*
b. *14*
c. *15*
d. *16*
e. *18*



Student Worksheet for
TEACHING A MATH ENHANCEMENT

Title of the Lesson: Got Paint?

1. *Suppose you want to paint a wall that measures 8' x 10'. What is the area of the wall?*

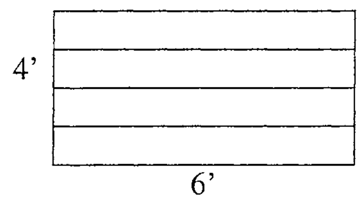
How much paint is needed?

2. *Suppose you have a 6' piece of 1" square tubing to paint. How much paint do you need? (Start by sketching a diagram.)*

3. *Suppose you have a 6' x 4' panel frame made of 1" square tubing to paint. How much paint do you need? (Start by sketching a diagram.)*

It's time to paint all the panels in the shop. Due to a limited budget, we have to know exactly how much paint to buy. Think about how we might go about solving this problem. Can you think of any formulas or strategies that might work? Let's refer to your design drawings when you did your bill of materials to determine how much paint to buy. The paint we will use covers 275 sq ft with 1 gallon. There are 4 quarts per gallon.

Gate Design:



Determine how much paint to order. There are ___________ panels to be painted. Be able to explain your calculations. Show all your work and don't forget to keep track of units.

APPENDIX O

AGENDA FOR SECOND ROUND OF PROFESSIONAL DEVELOPMENT

Math-in-CTE
Professional Development Training, Round #2
Agricultural Power & Technology

December 19 – 20, 2003
Atherton Hotel/OSU Student Union & Oklahoma CareerTech
Stillwater, OK

Agenda

Friday, Dec. 19

5:00 – 6:15 p.m. Arrival & Check-in to Hotel (Atherton Hotel Foyer)

Pick-up Workshop Folder & Name Badge

Make digital photos of teacher teams (State Room)

Verify press release information

6:30 – 7:20 p.m. Dinner (OSU Student Union, Oklahoma Room, Rm 211)

Sign Roster & Complete Additional Contact Information forms

Welcome, Dr. Craig Edwards & Dr. Jim Leising, Oklahoma State University; Mr. Eddie Smith, Program Administrator, AGED, Oklahoma CareerTech

7:30 p.m. Team Reports: "What we learned from the 'practice' lessons." – Mr. Brian Parr (Exhibit Rooms I & II, 4th Floor, Student Union)

~8:00 p.m. The Spring 2004 Semester: Dr. Craig Edwards, et al.

Role of Liaisons. . .

Delivery of Materials. . .

Testing Dates and Times. . .

Scheduled Observations. . .

Student Rewards/Incentives. . .

Questions, Comments, Concerns. . .

~9:15 p.m. Adjourn for the Evening

Saturday, Dec. 20

	Check-out of Atherton Hotel
	Day #2 of Workshop Begins
8:00 til 8:45 a.m.	Breakfast at Oklahoma CareerTech (Tuttle Seminar Center)
8:50 a.m.	A "Refresher": Important Steps in the "Enhancement Process" – Brian Parr, et al.
~9:15 a.m.	Sample Math-Enhanced Lessons in Ag Power & Technology:
	Mr. Joe Wright, Agricultural Education Teacher & Mr. Keith Lane, Math Teacher, Afton H.S.
	Mr. Arnold Bourne, Agricultural Education Teacher & Mrs. Cristy Dufur, Math Teacher, Durant H.S.
	Questions, Ideas, Suggestions. . .
~10:15 a.m.	Refreshment Break
~10:30 a.m.	Refinement/Improvement of Lesson Plans ☺
	"Flesh-out"/Modify Lesson Plans as needed; Teams facilitated by Staff
~11:50 a.m.	Lunch - CareerTech
~1:00 p.m.	Finalize Lesson Plans & Planning, Create Electronic Files (Save, Save, Save, . . .), Print Hard Copies; Teams facilitated by Staff
	Schedule Teaching of Lessons by weeks in the Semester – Mr. Brian Parr (Give us a copy of your planned schedule)
~2:30 p.m.	Refreshment Break

Saturday, Dec. 20 (cont'd.)

~2:45 p.m. Travel Mileage forms & related information

Questions & Final Charge. . .

Complete and Turn-in Workshop Evaluation form

Please BE SURE to provide Project Team with Electronic and Hard Copies of your *Final Lesson Plan* before leaving.

~3:00 p.m. Adjourn

Thank you and have a safe trip home!

Happy Holidays!!

APPENDIX P

CLASSROOM OBSERVATION INSTRUMENT

NRCCTE Math-in-CTE Project
Classroom Observation Instrument

Teacher Code:________________
Observer Name:____________________

Date:______________

Number of Students in Classroom: M_____F_____

Title/topic of math-enhanced lesson:____

IMPORTANT:

- *Please attach the lesson plan you were given in advance of the observation. (You should review and code the lesson plan before your observation.)*
- *Please attach any additional instructional materials you collect. Examples: revised lesson plan, student worksheets, written homework assignments, powerpoint notes, etc.*
- *Submit the observation form with attached materials to your site researcher. Sites will send copies to the Center.*

Please make general comments here:

1

Math Enhancement Codes

These codes do not presume a step-by-step presentation of the lesson. A teacher may choose to order the lesson as he or she wishes.

1- Teacher recognizes math with the class "points/pulls out math"--"talks out loud about math"
2- Teacher assesses students' math awareness
3- Teacher walks through the "pulled out" example
4- Teacher explains math concept(s)/principle(s), integrating math language with CTE language
5- Teacher reinforces by having students try a similar CTE and math examples
6- Teacher checks for understanding; students demonstrate understanding
7- Students create new CTE and math examples

Codes for Type of Instruction

These codes will help us learn more about how the enhanced lesson was delivered. These may be added by the observer sometime after the lesson is completed. More than one code can be used to describe an activity.

L	lecture	CL	cooperative learning activity
LD	lecture with discussion	LA	laboratory activity
Q	teacher questioning	WW	worksheet work/writing
TD	teacher demonstration	T	use of texts, reading materials
PM	teacher problem modeling	TIS	teacher interacting w individual students
SG	small group discussion/activity	A	assessment of student learning
SD	student-led discussion/activity	R	review of assignments/tests/projects
CD	class discussion	HW	assign homework
HO	hands-on; experiential activity	OC	out-of-classroom (field exp, shop, greenhouse, etc.)
IN	independent student work		
UT	use of computer, calculators, technology	O	other (please describe)

Record your observations in 5 minute intervals. Note: More than one math enhancement code may be used in each box.

Min.	*Math Code*	*Script of Lesson (script <u>what</u> was taught)* *Indicate Start Time:_______*	*Method (indicate <u>how</u> the lesson was taught; note context/location of lesson; describe artifacts that cannot be collected)*	*Instruct. Code*
0-5				
5-10				
10-15				
15-20				
20-25				
25-30				
Min.	*Math Code*	*Lesson (script <u>what</u> was taught)*	*Method (indicate <u>how</u> the lesson was taught; note context/location of lesson; describe artifacts that cannot be collected)*	*Instruct. Code*

30-35				
35-40				
40-45				
45-50				
50-55				
55-60				
Min.	*Math Code*	*Lesson (script what was taught)*	*Method (indicate how the lesson was taught; note context/location of lesson; describe artifacts that cannot be collected)*	*Instruct. Code*

60-65				
65-70				
70-75				
75-80				
80-85				
85-90				

5

#2

Brian Allen Parr

Vita

EDUCATION

A.S. Agriculture, Walters State Community College, Morristown, Tennessee

Conferred:	May, 1996
Advisor:	Roger Brooks

B.S. (*Magna Cum Laude*) – Agriculture, The University of Tennessee, Knoxville

Conferred:	May, 1998
Advisor:	John Todd, PhD

M.S. - Agricultural Education, The University of Tennessee, Knoxville

Conferred:	December, 2000
Advisor:	John Todd, PhD

Completed the requirements for the Doctor of Philosophy degree at Oklahoma State University in December, 2004.

PROFESSIONAL EXPERIENCE

Assistant Professor
School of Agriculture, Murray State University, Murray, Kentucky, August 2004-present.

Graduate Teaching Associate
Department of Agricultural Education, Communications and 4-H Youth Development, Oklahoma State University, 2002-2004.

Graduate Research Associate
Department of Agricultural Education, Communications and 4-H Youth Development, Oklahoma State University, 2003-2004.

Agricultural Education Teacher
David Crockett High School, Washington County Schools, Jonesborough, TN, 1998-2002