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EFFECTS OF EMBEDDED MATH-IN-CTE TEACHING MODEL ON AUTOMOTIVE YOUTH EDUCATION SYSTEMS (AYES) ASSESSMENT SCORES

A Thesis in
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by

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ABSTRACT

With the passage of the No Child Left Behind act of 2001(NCLB), all students need to be proficient on high-stakes standardized testing by the year 2014. However, currently, career and technical education curricula, which lack the rigorous academic standards noted in NLCB, exist in numerous CTE centers nationwide. If standardized tests touted by NCLB emphasize rigorous academic standards, and all students, including CTE students, need to pass these high-stakes tests, how is it possible to provide instruction in order that the CTE student masters both the necessary academics and skill development concurrently? Specifically, this research investigates whether mathematics taught in content areas may enhance rather than detract from skill development for CTE students.

This study uses data from the National Research Center for Career and Technical Education national study of Math in CTE. The NRC model study had 5 replications with 149 teachers and over 2000 students, and utilized The Pennsylvania State University's replication, which included 28 teachers and 550 students. Each participant of the NRC study completed the Terra Nova Basic Math Battery as a pretest, and completed 1 or more of the Automotive Youth Education System end-of-program tests as the post test. There were 849 data points distributed across the four tests.

Using the multivariate analysis, a positive relationship was found between math scores on the Terra Nova Basic Math Battery pretest and scores on the 4 AYES end-of-year tests. It may be important to note that students who scored well on the AYES end-of-year tests had taken 3 or more math classes previous to taking the AYES test; yet, teaching math concepts of the NRC Model study in the auto technology class did not

increase nor decrease scores in three out of the four AYES exit tests, the Steering and Suspension, Electrical/Electronics Systems, and Engine Performance auto tests of students participating in the NRC model and the control group and one test, the Brakes test, yielded a negative relationship for the students who participated in the NRC model study. Furthermore, a strong positive relationship was found between high scores on the math pretest and high post test scores on all four AYES exit tests.

Therefore this concludes that students wanting to enroll in the Automotive Technology curriculum be proficient in mathematics before enrolling. Young students, 15 years of age, and/or students with 0-1 math classes were the ones to do poorly. Also the Brakes test was given to younger students so this could be why the math instruction intervention did not help those students. The NRC Model study, while helping with the automotive technology students' math scores, did nothing to increase their automotive technology exit test scores. However, this intervention and the time it took to implement did not harm those AYES scores either.

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Chapter 1

INTRODUCTION

There have been a number of governmental warnings for our educational system. Included are *A Nation At Risk* (1983), *Educating Americans for the 21st Century* (1983), *Investing in People* (1989), *America's Choice: High Skills or Low Wages* (1990), the SCANS report, *What Work Requires of Schools* (1991), and *Before It's Too Late* (2000) by Sen. John Glenn (Bracey, 2001). In 2001, President George W. Bush signed into law the federal No Child Left Behind (NCLB) act to ensure all students graduate from high school prepared to be productive members of society (USDOE, 2005). Currently, a significant number of students in the career and technical education subgroup do poorly on the high stakes standardized tests that come with the NCLB accountability process (Stone, 2003b). These students do not do well in math classes because of poor prior math attainment (Stone, 2003b; Bustard, 2004).

Traditionally, Career and Technical Education (CTE) was never intended as a means to improve academic performance. CTE has been regarded as a place for students who could were faced with sometimes insurmountable academic challenges; therefore, most existing CTE courses are designed to exclude rigorous math and science rather than reinforce them (Hull, 2003). Many instructors have stated that they would show their students math "tricks" in order for the student to complete a necessary calculation, but would never explain the math concept behind that calculation. The instructors admitted that they learned the process through such "tricks" and were therefore unable to teach the math involved. As a result, many workers currently say the purpose of math escaped them in school and became clear only at work (Bracey, 2001).

However, there are many CTE programs that attempt to address this problem. Instructors in the Automotive Youth Education Systems (AYES) certified programs integrate higher levels of math and science into the curriculum and are establishing rigorous exit exams that are linked to industry-recognized credentials (Stone, 2003b). In CTE courses, math becomes contextualized and therefore, readily applicable (Stone, 2003a). In order to investigate the results of contextualized mathematics applicability in CTE, this study will examine and analyze exit exams for the AYES program to determine whether math scores can be increased by including contextualized math in the AYES programs. If career and technical education programs include additional rigorous, math-enhanced elements and instruction, will career and technical education (CTE) students perform better on the NCLB assessments? (Stone, 2005). Gene Bottoms, former executive director of Association for Career and Technical Education (ACTE) and senior vice president at Southern Regional Education Board (SREB) which oversees High Schools That Work (HSTW), stresses that the career and technical coursework needs to be as rigorous as the academics (Lozada, 1999). To accomplish such rigor, CTE teachers need to place more emphasis on math that is embedded in their program's content, but not at the expense of occupational skills attainment (Stone, 2005).

Background

While working with Career and Technical teachers for three years, this researcher has seen first-hand the importance of math in the content areas. One initial challenge became evident when CTE teachers would sometimes avoid telling students that math is related and needed in their subject areas (Bracey, 2001), despite the need for those students to be aware of just how important a role math would play in their studies. The

National Research Center for Career and Technical Education (NRCCTE) model study entitled *Math-in-CTE* was intended to emphasize the importance of math in the content areas and to strongly suggest the CTE teachers to demonstrate the importance of math to their students. The purpose of the study was "to test the possibility that enhancing the embedded mathematics in Technical Education coursework will build skills in this critical academic area without reducing technical skill development" (NRCCTE, 2004).

The Pennsylvania State University replication utilized the Automotive Technology teachers using the Automotive Youth Educational System (AYES) curriculum because it would be common to all teachers involved. The NRC model study employed Terra Nova CAT Basic Battery as a pre-test and Terra Nova, Accuplacer and Workkeys as math post tests. As the post-test for skills development for this study, the Automotive Youth Education System (AYES) automotive technical competency tests were given to the students in the Penn State replication. The study focused on the naturally occurring math already embedded in the CTE curriculum and how that embedded math could be enhanced for better understanding (Stone, 2005).

As a result of the NRC model study, participating students scored higher on the Terra Nova and Accuplacer tests than did non-participating students. When controlling for the math pretest, the participating students scored significantly higher according to the statistical data recorded (Stone, 2005; ACTE, 2005).

One crucial question of concern asked whether content skill standards would be lost as a result of the emphasis on math. This study examined that question using the pre-test given by the NRC model study and the post-test administered by AYES to analyze whether participation in one study related to scores on another.

The Problem

While the NRC Model, Math-in-CTE, has shown that math scores do increase among the CTE student population, the question remains whether the increased scores occurred at the expense of the students' learning technical skills. Is there a relationship between math attainment and technical skills? Will math-enhanced lesson plans detract from learning and teaching the content subject matter?

The Perkins Act of 1998 requires demonstration that CTE students are achieving in both technical and academic skills (Stone, 2003b). To this day, debates continue about best practices that should be implemented in order to increase academic rigor of the career technical courses (Lozada, 1999). In a SREB survey of 8000 CTE teachers in 1998, approximately 45% of the instructors surveyed admitted that they needed to update their own math skills before they could teach rigorous math content in the context of their specialties (Lozada, 1999). The NRC Model used as the basis for this research attempted to increase academic rigor while maintaining the required technical content. This study will investigate whether any part of the content area was jeopardized while enhancing the embedded mathematics.

Purpose of the Study

The purpose of the NRC Model study was "to test the possibility that enhancing the embedded mathematics (instruction) in Technical Education coursework will build skills in this critical academic area without reducing (occupational) technical skill development" (Stone, 2004). This study focused on ways in which math attainment relates to technical skill development, and investigated whether a math-enhanced technical education curriculum would have any effect on scores on the AYES exit exam if the instructors emphasize and enhance math concepts that already exist in their curriculum.

Significance of the Study

This study has great significance for the Automotive Youth Education Systems (AYES) certification program. The website, http://www.ayes.org/docs/about/index.html, notes that the goal of the AYES program is "to encourage bright students with a good mechanical aptitude to pursue careers in the ever-changing fields of automotive service technology or collision repair/refinish, and to prepare them for entry-level positions or challenging academic options." This study tested whether using the NRC Model of math-enhanced lesson and teacher professional development improved the exit tests of this AYES program.

An additional benefit of this study was that core teachers and career and tech education teachers could see how they can work together to raise the level of student academic achievement (Reese, 2003). These teachers have come to know the value of each others' discipline and how it can further the education of the student. Their courses cannot be taught in a vacuum and must complement each other. The students are the ones to benefit from the practicality of math in the workplace and that technical subject can help the mathematics be more relevant to the non-technical students as well.

Research Question

What relationship exists between automotive students' participation in the NRC Model, *Math-in-CTE* instructional class, and their performance on the end of year AYES skills test when controlling for gender, age, ethnicity, the number of math courses the student has taken, if the student is currently enrolled in a math course, previous year participation in the NRC Model and their score on the math pre-test?

Limitations

The data set used in this study was taken from the research project conducted by the National Research Center for Career and Technical Education based at the University of Minnesota. There was a one-semester pilot study followed by a full year, two-semester study. The data used in this study is from the full-year study.

Teachers were recruited by their affiliation to AYES and their close proximity to Penn State University by residing and teaching in the state of Pennsylvania and surrounding states. Teachers volunteered or were recruited by their principals or directors who encouraged them to participate.

The students that were tested were in the classes of the volunteer teachers. They had to sign consent forms for their involvement while their parents had to return a signed form only if they did not want their child to participate in the testing process.

Definitions of Terms

For the purpose of this study, the following terms are defined:

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

Applied academics – teaching concepts by using real world context (NATEF, 2005).

Contextual learning - learning that motivates students to make connections between knowledge and its applications to their lives as family members, citizens and workers as defined by US Department of Education, OVAE.

CTE – career and technical education, new name for vocational-technical education.

Experiential learning – process of "learning by doing"; retrieved from the Center for Research on Learning and Teaching (CRLT) website http://www.crlt.umich.edu/tstrategies/tsel.html

Institute of Education Science (IES) – the research arm of the US Department of Education (DOE).

Integrated coursework or academics – coordinates the teaching of occupational skills and traditional academic skills by using the former as the context for the latter (Gray, p. 181).

Professional Development - prepares and supports educators in the development of their professional lives; retrieved from the US Department of Education website on publications http://www.ed.gov/pubs/AchGoal4/mission.html.

Terra Nova CAT™ Basic Battery (CTB/McGraw-Hill, 2000) 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, 2000) – an examination employed to determine a student's level of general math aptitude following the experimental treatment.

Vo-Tech – vocational-technical education now changed to career and technical education (CTE)

Work based learning – learning that takes place as part of work either in a lab, in a classroom or on the job (Gray, p. 202).

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

Assumptions

There is an assumption that the data was collected and entered cleanly by the researchers at the NRCCTE at the University of Minnesota. The researchers had to depend on liaisons in each school to administer the standardized tests and record the scores on the AYES tests. It is assumed that the testing procedures used by the liaisons were both valid and reliable.

It is assumed that the teachers were randomly assigned into one of the study groups either the control or experimental. It is further assumed that the control group teachers did not teach more mathematics to their students due to their involvement in the study and that control group and experimental group teachers did not discuss the experiment while it was in progress.

The AYES exit exam is a computer-administered test so it is assumed that the liaisons and students have some knowledge of how to test on a computer and that computers were available to these participants. Because the students were compensated for their participation in this study it is assumed that each student performed to the best of their ability on each testing measure. It is also assumed that the students have the appropriate reading skills to read and understand the math and auto technology questions.

Theoretical Framework

The theoretical framework that guides career and technical education is based primarily on the work of David Snedden and Charles Prosser from the early 1900s (Doolittle, 1999). Constructivism focuses on the importance of students' prior knowledge and how learners construct their own meanings from previous experiences (Flick, 2004) Therefore, the focus of social constructivism is on shared experiences and the social negotiation of meaning (Doolittle, 1999).

Since constructivist theory underscores the need for students to find ways to incorporate new ideas into their already-established knowledge base, change is an inherent facet of their learning; however, much research indicates that fostering change in the classroom needs to start with teacher professional development (Cook, 1996; Edmonds, 2002). Teachers need to experience new environments as learners themselves in order to implement changes in their teaching. When such experience occurs, an instructor functioning in the role of a learner is provided with a better understanding of the learning process, and then is able to model teaching pedagogies appropriate for students working in a constructivist-oriented learning environment (Moar, 1999). However, providing teachers with this new constructivist based pedagogy and expecting them to use it immediately in their teaching is unreasonable. After participating in a professional development workshop, teachers need further support to put into practice this constructivist-oriented program (Moar, 1999) The NRCCTE study seems to suggest that teachers learn best in a constructivist learning environment because of the many learning and teaching experiences they have had (Stone, 2005).

Because the teachers experience the frustrations and joys working with any new material, they can better understand the difficulties their students may have (Maor, 1999). Maor's (1999) article suggests that "teachers who engage themselves as learners in a professional development program have greater opportunities to bring about the successful implementation of new ideas into the classroom" (p 48).

Chapter 2

REVIEW OF RELATED LITERATURE

The review of related literature includes three topics significant to the research project. To begin, background information which explains the Automotive Youth Educational System (AYES) and its end-of-program tests is presented. White papers written by AYES serve as the bases for discussion. Since math tests were used as a pretest for the NRC model study, the impact of high stakes testing in other states are discussed next. Finally, the student subjects of this research were also participants of the NRC model study; therefore, information concerning the importance of the national study and its relationship to this study is detailed.

Automotive Youth Educational System

The Automotive Youth Educational System (AYES) was started more than 10 years ago as a partnership between participating automobile manufacturers, dealers and high school/technical schools to help fill the need for qualified employees. AYES is connecting bright students and these dealerships that need qualified automotive technicians (http://www.ayes.org).

A career in automotive service technology is an opportunity that requires advanced skills but not an advanced degree. Students participating in this program are prepared to begin a full-time entry level career or to further their education. The AYES program stresses the importance of continuing education through college or advanced training (AYES, n.d., General Information). Students in this program graduate with academic skills as well as technical skills to either enter the workplace or to pursue further academic studies (AYES, n.d., Students).

Students encounter “real life” applications involving math, science and communications while attaining specified competencies with plenty of on- the- job experiences (AYES, n.d., General Information).

The AYES program allows schools to develop the next generation of productive citizens while encouraging collaboration between technical training and academic learning by focusing on students that have advanced academic and technical skill. This develops partnerships with community and businesses and enables schools to obtain state-of-the-art equipment and tools through donations. (AYES, n.d., General Information).

AYES Testing

The AYES Exit Exam System is administered entirely online and is available to secondary students in the four specific areas; steering and suspension, brakes, electrical/electronics system, and engine performance. These four tests are part of the eight (ASE) Automobile Service areas. They are designed to test the students’ knowledge of both theory and application. The student is allowed to take the test two times in any school year. For this study only the first administration was accepted. The students’ scores were provided instantly and were sent to the researcher using the student ID number given by the school liaison in the NRC model study.

The AYES teacher and his assigned proctor are the only ones that can log online and administer these tests to the appropriated students thus following a secure testing environment. Each test contains between 80 and 90 multiple choice questions and take no more than two and one half hours to complete.

These tests were created by ASE and AYES using subject matter experts that were both practitioners and educators. They identified competencies needed and then ranked them according to importance and frequency of use on the job. “The result is a test content outline with subject weights that are referred to as test specifications” (AYES, n.d., AYES Exit Exam System).These specifications are utilized for preparing the tests. All questions are subject to multiple review and validation. After development all questions are kept in an item bank and statistics are collected on each item to track performance history allowing for a more efficient test selection. “Once a test has been administered, AYES and ASE re-validate each test question based on student responses to ensure that tests continue to assess the appropriate content and level of that content” (AYES, n.d., AYES Exit Exam System, p. 2).

Career and Technical Education and High Stakes Testing in other states

The NRC model study tested students in 12 states. The Penn State replication represented 8 states; PA, MD, NJ, NY, VA, MI, OH, and DE. These states have similar issues when it comes to high stakes testing. “As a group, career and technical education students perform worse on standardized tests than their non voc-ed peers” (Anonymous, 2002). Industry depends on CTE students to learn the skills needed for the job but are being denied a diploma because they cannot pass the standardized test for graduation (Rowland, 2002).

In Massachusetts career and technical teachers say their high stakes test, MCAS, barely touches their curriculum. They believe CTE students do not learn the same as traditional high school students and should not be tested the same way (Giodano, 2001). David Cronin, executive director of the Massachusetts Association for Vocational Administrators (MAVA) states, “Our big issue is that about one-half of what they study is not being measured” (Mass Vo Ed, 2001). Many Massachusetts career and technical schools have changed their curriculum to include collaboration between academic and CTE teachers with common planning time and an opportunity for academic teachers to observe CTE classes. “The aim was to find the math and science concepts inherent in the technical subjects” says Deborah Depaolo, assistant superintendent at the Blue Hills Regional Technical School in Canton, MA (Mass Vo Ed, 2001).

Eugene Carlo, superintendent at Assabet Valley Regional Vocational Technical School in Marlborough, MA, says he supports high standards but opposes the “one-size fits all” assessment (Schworm, 2003). Michael Fitzpatrick, superintendent at Blackstone Valley Regional Vocational Technical School, Upton, MA, agrees with Mr. Carlo that it is not right to have to pass a single test in order to obtain a high school diploma (Thompson, 2002). Superintendent of schools Paul Bento of Framingham, MA says “Our goal and mission isn’t to prepare a youngster to pass a standardized test. Our goal is to teach them the skills to start a career” (Schworm, 2003). Given the fact science and math instruction tends to be strong in theory but weak in practice while technology education just the reverse (Lankard, 1993), state officials in Massachusetts believe that students can learn a trade and also achieve academic success (Abelson, 2003).

Researchers at Johns Hopkins University report that “students from schools that have blended CTE into their whole-school reform efforts are producing better math achievement, persistence in high school attendance and progress toward graduation at similar or better rates that students from their respective control schools" (Lewis, 2003). "Once students see academics as a means to an end in an area in which they have an interest, their motivation increases and their performance on state tests improves markedly" (Daggett, 2005).

But today's reformers want all students to take college-preparatory courses and to meet rigorous standards (Ravitch, 2005). This course of action may increase dropout rates. Many dropouts get discouraged in 9th grade because they have trouble keeping up with their more traditional classmates. (Ravitch, 2005). When student graduate they should have both trade and technology knowledge and a college-preparatory classes so they can make some choices, Abigail L. Hughes says (Archer, 2004). "In an age when more students are attending college and pursuing advanced training, the need for career and technical schools to combine high standards with practical learning experiences is more important than ever." (Roberts, 1999).

Education officials in the states of New Hampshire, Vermont and especially Massachusetts are annoyed with federal reformers. Director Bob Bickford, River Valley Technical Center in Springfield, NH said the Federal No Child Left Behind Act of 2001 was not developed with technical education in mind (Anonymous, 2001). Teachers believe that if more time is need to teach the math then less time will be spent on technical skills (Bustard, 2004). The National Research Center for Career and Technical Education embarked on a study to determine just that. The researchers tested whether teaching a math-enhanced CTE curriculum could increase scores on the math test without compromising the technical content.

National Research Center for Career and Technical Education, Math-in-CTE Model

From September 2003 to July 2005, The National Research Center for Career and Technical Education (NRCCTE) conducted a research study entitled Math-in-CTE funded by the Office of Vocational and Adult Education. The purpose of this study was "to test the possibility that enhancing the embedded mathematics in Technical Education coursework will build skills in this critical academic area without reducing technical skill development" (NRCCTE, 2004).

The NRC Model, Math-in-CTE, as this study is now called, was the first random assignment, experimental design funded by the Office of Vocational and Adult Education with the US Department of Education. This model followed the experimental design having two groups both control and experimental. The pilot study held during the spring semester 2004 had six replications, 240 teachers and nearly 4000 students. The Pennsylvania State University replication recruited 44 CTE teachers to be assigned into two groups—control and experimental. This replication utilized the Automotive Technology teachers using the Automotive Youth Educational System (AYES) curriculum. During the second year the study had 5 replications, 149 teachers and over 2000 students.

The study employed four testing measures of math skills as well as a content skills test. As a pre-test the NRCCTE center researchers chose Terra Nova CAT Basic Battery. As the post test the four different measures used were; (1) a shortened version of the Terra Nova test (Terra Nova CAT Survey Edition; (2) WorkKeys Applied Mathematics Assessment (ACT); (3) the Accuplacer Elementary Algebra test (The College Board); (4) and, a skills test appropriate to the field of study. The Automotive

Youth Education System (AYES), automotive technical competency tests were given to the students in the Penn State replication.

The teacher participants were recruited because of their affiliation to a particular group. The Pennsylvania replication chose the teachers using the Automotive Youth Education Systems (AYES) curriculum because it would be common to all teachers involved. Instructors in the AYES certified programs integrate higher levels of math and science into the curriculum and established rigorous exit exams that are linked to industry recognized credentials (Stone, 2003b; AYES, n.d.).

There were four other state replications involved in the national study. When each replication had its desired number of teacher participants they were divided randomly into the two groups. Those teachers chosen for the control group needed to do nothing different. They had to teach their CTE lessons from the standard curriculum. The experimental group of teachers would be involved in extensive professional development and had to choose a math teacher that they would partner with through the entire study. The tested subjects of this study were the students in the classes of these teachers.

Focus of the entire study was on the naturally occurring math that is embedded in the CTE curriculum and how it could be enhanced for better understanding (Stone, 2005). The enhancement process was based on a seven-element template used for lesson plan development. The professional development of the experimental teachers consisted of writing, teaching and reflecting on these lessons.

As a result the students in the experimental group scored higher on the Terra Nova and Accuplacer tests than did the control classroom students. When controlling for the pretest, the experimental group of students scored significantly higher (Stone, 2005; ACTE, 2005).

The Procedure

The researchers and an advisory board developed the procedure for this study. This panel met on several occasions to finalize the process. The following sections describe the procedure that was developed.

Teacher Teams. The experimental approach of this design requires the preparation of CTE teachers to implement a math-enhanced curriculum (Stone, 2005). The CTE teachers were required to identify math teacher “partners” to help them identify points of intersection of mathematics in their specific CTE courses and how to highlight the embedded mathematics principles. Partnering high school math teachers with CTE teachers encourages them to function as a team, each learning how the others’ expertise can enhance his/her own teaching (NRCCTE, 2004).

A two-part professional development workshop was conducted in the fall of 2003 to prepare the teacher teams to function collaboratively. This was before the implementation of the experiments in January 2004. The amount of contact time between the math teacher and CTE teacher during the semester varied, but the teams were asked to communicate before and after the implementation of each lesson enhancement. The math teacher provided support for the CTE teacher in planning the lessons, answering questions, helping to problem-solve, and offering encouragement. Then, following the enhancement, the math teacher followed a structured debriefing protocol with the CTE teacher and sent reflections to the National Research Center (NRCCTE, 2004). The same teacher teams continued into year 2.

Professional Development. Experimental CTE-teacher and math partners attended a two-part local professional development workshop in fall, 2003 and winter 2004 to learn the steps for enhancing mathematics within the CTE curriculum and work on developing specific lessons. The agenda for the professional development workshops included strategies for effective team building and guidance on how to work together to create lessons that identify the mathematics embedded in the CTE curriculum. Teacher teams were provided with curriculum maps that aligned math competencies (e.g., algebra, geometry, trigonometry) onto existing high school CTE curricula. For example, the use of proportions and ratios is critical to the compression of the automobile engine. The accumulated points of intersection created a "map" that was then used by the CTE and math teacher teams to develop an initial scope and sequence and subsequent lesson plans (NRCCTE, 2004).

During the professional development workshops each math-CTE teacher team used the maps to create a math-enhanced AYES curriculum. Teams were given examples of contextualized math lessons that were gathered from various sources around the country, including one developed by Dr. Mary Kisner and Dr. Kathleen McNally for this purpose. Teacher teams were presented with a model of an enhanced CTE lesson, including seven critical components: (1) "pull out" the mathematics found in the lesson, (2) assess students' math understanding, (3) work through the pulled-out example, (4) identify the underlying math concept, using math vocabulary, (5) work through similar examples and generic examples, (6) check for understanding, (7) have students create other examples, both from CTE and generic math (NRCCTE, 2004). During the second year NRCCTE researchers and advisory board reviewed and refined the professional development and these seven elements, as they are now called, to include (1) introduce the CTE lesson by “pulling out” the math, (2) assess students’ math awareness, (3) work through the math example embedded in the CTE lesson, (4) work through related, contextual math in CTE examples, (5) work through traditional math examples, (6) students demonstrate their understanding and (7) formal assessment. An example of these lessons, the piston displacement lesson, can be found in the appendix. Teacher teams were expected to include the seven steps in their constructed lesson plans, further develop the lessons during and following the workshops, and refine them as they continued working together. The goals of the workshops were to ensure that teacher teams were able to work together, that all teachers understood and were able to do the enhancements, and that an adequate number of enhanced lessons was created so that the group would walk away with 8 or so new lesson plans to implement during the Spring 2004 semester (NRCCTE, 2004). For the second year these lessons were divided and additional lessons were added to the original 8 to make 15 lessons.

To ensure that all experimental teachers in the entire NRCCTE study received the same professional development workshop, facilitators from all replication sites met in late summer 2003 to jointly plan the workshop agendas. All trainers were given a trainer packet with all of the training instructions and relevant materials. All experimental CTE and math teachers in the workshops also received a packet of materials, including information about the study, curriculum maps for their area. Copies of the lessons they and their colleagues had created during the workshops was also distributed when they were completed (NRCCTE, 2004).

For the second year of this study the professional development time has been increased and continued math support meetings have been scheduled three times during the school year. Over time this group of experimental teachers both CTE and math developed a tight bond which was later to be identified as a "community of practice" (Stone, 2005).

This researcher had the opportunity to work with AYES and math instructors in the experimental group. All had indicted that they were better prepared to teach their subject matter after participating in the NRC Model study. Because all AYES instructors were using the same AYES curriculum and teaching the same lessons they understood more fully the importance of this NRC model study instructional intervention. They experienced first hand the importance mathematics play in their lessons by discussing that importance with their math teacher partner. They had to identify the math that existed in their curriculum and work very closely with their math partner to clarify these concepts. They also understood the implications for their high school students of not passing the math proficiency test at their respective schools. Some students were pulled out of their technical classes to attend remedial math classes if they were not proficient in math at their home schools. The purpose of the AYES high school curriculum is to insure that graduating students become productive workers at their chosen auto technology profession. However, they also must pass the high stakes tests accompanying this curriculum in order to receive employment credentialing. The purpose of this study was then to see if teaching both mathematics and auto technology can be done efficiently as to not interfere but rather complement each other.

Chapter 3

METHODOLOGY

This study focused on how math attainment relates to technical skill development. The purpose was to investigate what effect a math-enhanced technical education curriculum will have on scores on the AYES exit exam if the instructors emphasize and enhance the math concepts that already exist in their curriculum.

The Problem

While the NRC Model, Math-in-CTE, has proven to increase math scores among the CTE student population, the question remains whether this was at the expense of the technical skills. Is there a relationship between math attainment and technical skills? Will math-enhanced lesson plans detract from learning and teaching the content subject matter?

Research Question

What relationship exists between automotive students' participation in the NRC Model, Math-in-CTE instructional class, and their performance on the end of year AYES skills test when controlling for gender, age, ethnicity, the number of math courses the student has taken, if the student is currently enrolled in a math course, and previous year participation in the NRC Model and their score on the math pre-test?

Measurement

Subjects. The subjects for this study are the high school students of CTE certified instructors in the AYES program. The CTE teachers were contacted by the state representative of AYES and most of their school directors encouraged them to volunteer to participate in this study. They came from Pennsylvania and the surrounding states, New Jersey, New York, Delaware, Virginia, Maryland, Ohio and Michigan. These states were chosen because of their location and proximity to The Pennsylvania State University. This convenience sample was then randomly assigned to two groups. The advantage of a random assignment is if there was a statistically significant difference between the two groups it can be said that it was the intervention or experiment that caused it. (Cook, 2002; NRCCTE, 2004, Stone, 2005). Each group started with 22 teachers and approximately 950 students total. These two groups of 11th or 12th grade high school students were identified for this study as follows:

> Group 1. (control) CTE students participating in a traditional CTE class with teachers using the traditional curriculum with no professional development program.
>
> Group 2. (experimental) CTE students participating in a math-enhanced CTE class with teachers who were part of a very extensive professional development program.

Student math achievement was measured on four assessments: (1) a traditional measure of math performance (Terra Nova); (2) a problem-based measure of math performance (WorkKeys); (3) a widely used college math placement exam (Accuplacer); and (4) a technical skills test (AYES). For the purpose of this study only the AYES exit exam scores was evaluated.

Both groups of teachers were sent letters by NRC informing them of their selection. The control group was asked to implement their traditional curriculum and do nothing else. During the second full year the control group had to maintain the same curriculum. The experimental teacher was asked to pair with a math teacher partner in their school or school near by. They were told they would implement a math-enhanced CTE curriculum during the spring of 2004. They would help to develop this curriculum with their math teacher partners at professional development workshops in fall 2003. During the second year these teachers were asked to continue with this professional development during the 2004-2005 school year and to write twice as many lesson plans as before. Because of the extended commitment 11 of the original 22 experimental teachers chose not to continue. Five of the control group teachers also decided not to continue in the study. As a result the number of participating students was reduced to 550 total.

Instruments: Terra Nova Basic Battery. The students in both control and experimental groups were given the same math pre-test and the same assigned math post-test. The Terra Nova Basic Battery was administered to ensure comparability between groups at pretest, and if they were not comparable, to be able to use as a control when statistically analyzing group differences on the post-tests. Because this is an experimental study with random assignment to groups, the researchers assumed that any variability in student “test-taking ability” is randomly distributed between experimental and control groups (NRCCTE, 2004; Stone, 2005)

Instruments: AYES Exit Exam. An occupational skills test appropriate to the field of study was used to ensure that the experimental group did not sacrifice such skills in order to learn mathematics (Stone, 2005). Automotive Youth Education System (AYES), automotive technical competency tests were given to the group in the Penn State replication. This assessment consisted of four parts; steering and suspension, brakes, electrical systems and engine performance. The student subjects took one or more of these tests depending on their area of study.

The Automotive Youth Educational System is based on “technical, academic, and general employability skill standards that can be synthesized into an ‘integrated curriculum standard’ (ICS)… to be used as a guide in developing an assessment instrument by which student progress is monitored” (AYES, Changing, p. 12). Each time a testing period is completed “AYES and ASE re-validate each test question based on student responses to ensure” validity. (AYES, Exit Exam, p. 7)

Confidentiality. To maintain the confidentiality of the participants a number was assigning to each teacher in both groups and a corresponding random number to each student. All reference to these numbers was destroyed after all data had been collected.

Liaisons were used at each school to facilitate communication between the researchers and the teachers. Liaisons were responsible for assigning ID numbers to students and keeping all teacher and student data anonymous and confidential. The liaisons were also responsible for scheduling test dates and arranging data collection. They explained the study to students and distributed and collected consent forms in the classrooms.

Students were required to sign consent forms before taking the surveys and pre-tests. They were required to return their parents’ signed consent form to the liaison only if the parent did not want their child to participate in the testing process. The classroom environment would not change if they decided not to participate.

All students taking a pre-test and post-test (in both experimental and control groups) were paid for each test administration. The pretest administration took 2 days, 1 for the student survey and 1 for the Terra Nova math test. The post-test administration took 3 days, 1 for the survey, 1 for the math test, and 1 for the AYES skills test.

Variables

Dependent variables. The dependent variable in the study is student scores on the four AYES exit exams. These exams include steering and suspension, brakes, electrical systems, and engine performance. These variables are interval scaled measurement.

Independent variables. The independent variable used is the participation in the NRC Model, Math-in-CTE, as defined. The treatment is defined as a series of math-enhanced lesson plans created by teams of two teachers, one math teacher and one CTE teacher during extensive professional development sessions and the teaching of those lessons throughout the school year.

Moderating variables. The moderating variables are gender, age, ethnicity, the number of math courses the student has taken, if the student is currently enrolled in a math course, previous participation in this NRC Model and their score on the math pre-test.

Experimental Design

As stated by Cresswell (1994), "an experiment tests cause and effect relationships in which researcher randomly assigns subjects to groups. The researcher manipulates one or more independent variable to determine whether these manipulations cause an outcome." (p. 117). The design of the NRC Model, Math-in-CTE study chosen by the researchers at the NRCCTE at the University of Minnesota is an example of a "true experimental design" called a "pretest-posttest control group design" (Cresswell, 1994, p. 133). The random assignment, experimental approach follows The Institute of Education Sciences (IES) guidelines. The entire group of volunteer CTE teachers was randomly assigned to either a control group or an experimental group. Students in both groups took a pretest and posttest but only the experimental group received the treatment. The pretest given to the all students of the study was the Terra Nova Basic Battery. In this design the pretest is used only to determine equality among the entire group and that randomization was achieved (Cresswell, 1994).

Control --- Pretest [No treatment] Posttest

Experimental – Pretest [Treatment] Posttest

The two groups were also compared against each other using the posttest. In this study the posttest was one or more of four AYES skills exit exams. The relationship between pre-test and post-test gain scores cannot be determined because the pre-test and post-test are two different tests.

Statistical Analysis

With experimental design involving groups "univariate analysis of variance (ANOVA), will be used to determine statistical significance of mean score differences among treatment (and control) groups" (Cresswell, 1994, p. 136). Multiple linear regression analysis was used to examine to what extent AYES exit exam scores are influenced by the following factors: (a) gender, (b) age, (c) ethnicity, (d) the number of math courses the student has taken, (e) if the student is currently enrolled in a math course, (f) previous participation in the NRC model study, and (g) scores on the math pre-test. Before the actual regression analysis was run, basic correlation was used to identify the bivariate relationship between each independent variable and the dependent variable. The researcher examined for linearity of the relationship and normality of the data. Multiple regression enabled the researcher to examine the relationship between the primary variable of interest (control or experimental condition) and the dependent variable score when controlling for the influence of the moderating variables included in the regression equation (Cresswell, 1994).

The regression equations used for this study are:

$$Y_{1i} = \beta_{10} + \beta_{11}(x_1) + \beta_{12}(x_2) + \beta_{13}(x_3) + \beta_{14}(x_4) + \beta_{15}(x_5) + \beta_{16}(x_6) + \beta_{17}(x_7) + r_{1i}$$
$$Y_{2i} = \beta_{20} + \beta_{21}(x_1) + \beta_{22}(x_2) + \beta_{23}(x_3) + \beta_{24}(x_4) + \beta_{25}(x_5) + \beta_{26}(x_6) + \beta_{27}(x_7) + r_{2i}$$
$$Y_{3i} = \beta_{30} + \beta_{31}(x_1) + \beta_{32}(x_2) + \beta_{33}(x_3) + \beta_{34}(x_4) + \beta_{35}(x_5) + \beta_{36}(x_6) + \beta_{37}(x_7) + r_{3i}$$
$$Y_{4i} = \beta_{40} + \beta_{41}(x_1) + \beta_{42}(x_2) + \beta_{43}(x_3) + \beta_{44}(x_4) + \beta_{45}(x_5) + \beta_{46}(x_6) + \beta_{47}(x_7) + r_{4i}$$

where

Y_{1i} = the outcome on AYES Steering and Suspension exit test;
Y_{2i} = the outcome on AYES Brakes exit test;
Y_{3i} = the outcome on AYES Electrical/Electronic systems exit test;
Y_{4i} = the outcome on AYES Engine Performance exit test;
$\beta_{10} to \beta_{40}$ = the y-intercept of the regression line;
$\beta_{11} to \beta_{47}$ = slope coefficients representing the relationship between predictor and outcomes;
x_1 = NRC model participation
x_2 = age
x_3 = ethnicity
x_4 = number of math classes taken
x_5 = currently enrolled in math class
x_6 = previous participation in NRC model study
x_7 = math pretest score
r_{1i} *to* r_{4i} = the residual error term. This residual is assumed to be normally distributed between 0 and a variance σ^2.

Chapter 4

FINDINGS

The purpose of the study was to investigate what effect a math-enhanced technical education curriculum had on scores on the Automotive Youth Education System exit exams if the instructors emphasize and enhance the math concepts that already exist in their curriculum.

The research question asked what relationship exists between automotive students' participation in the NRC model instructional class and their performance on the end-of-year AYES skills tests when controls for age, ethnicity, the number of math courses taken, current enrollment in a math course, previous year participation in this NRC Model, and score on the math pre-test are considered.

Despite using only one research question, four AYES exit exams exist; therefore the research question was tested four times, one for each subtest. The first part of this chapter includes the descriptive statistics needed to explain the findings found in part two. Part two includes the regression analysis results for each of the AYES exit tests.

Descriptive Statistics

Each participant in the NRC model was asked demographic questions regarding gender, age, ethnicity, the number of math courses taken, whether s/he is currently enrolled in a math course, and number of years of participation in the study. Even though gender was not considered in the analysis it is included here for informational purposes only. Table 4.1 summarizes this data. In the NRC model study students were placed into two groups, experimental and control. These two groups of 11^{th} or 12^{th} grade high school students were identified for this study:

Group 1. (control) CTE students participating in a traditional CTE class with teachers using the traditional curriculum with no professional development program.

Group 2. (experimental) CTE students participating in a math-enhanced CTE class with teachers who were part of a very extensive professional development program.

The number of students in the experimental group (n = 351) was somewhat equal to those chosen as a control group (n = 366). The NRC researchers tried to maintain equal numbers in these groups.

Table 4.2 and 4.3 displays the mean and standard deviation for the dependent variables by the independent variables for pretest scores and the four AYES post tests scores respectively.

In table 4.2 the range of mean scores on the pretest for all variables falls between $\bar{x} = \mathbf{9.70}$ and $\bar{x} = \mathbf{12.12}$. Results showed that, in general, students who have taken three math classes scored highest, with Asian or Caucasian students' scores next highest ($\bar{x} = \mathbf{12.09}$). The lowest mean score reflected students enrolled in 0-1 math classes. Students aged 15 years old scored second lowest ($\bar{x} = \mathbf{10.08}$).

Results indicated that females ($\bar{x} = \mathbf{10.62}$) scored lower than males($\bar{x} = \mathbf{11.32}$), but comparison is not significant given low ratio (females, n = 34; males, n = 646). The mean pre-test score for participants (experimental group) in the NRC model study ($\bar{x} = \mathbf{10.88}$) was lower than for those who did not participate (control group) ($\bar{x} = \mathbf{11.67}$). Sixteen-year-olds scored slightly higher ($\bar{x} = \mathbf{11.68}$) than 15-, 17- and 18-year-old and older students ($\bar{x} = \mathbf{10.08}, \bar{x} = \mathbf{11.49}, \bar{x} = \mathbf{11.46}$, respectively). Mean scores

Table 4.1

Number of participants by gender, member of NRC model Math-in CTE group, age, section number, ethnicity, number of math classes taken, currently enrolled in a math class, part of the study last year (n = 717).

Variable		*n*	*Valid %*
GENDER			
	Male	666	95.0
	Female	35	5.0
	No response	16	
MEMBER OF NRC MODEL Math-in-CTE GROUP			
	Yes	351	49.0
	No	366	51.0
AGE			
	15	145	20.6
	16	265	37.6
	17	215	30.5
	18 and older	79	11.2
	No response	13	
ETHNICITY			
	Asian or Caucasian	370	53.4
	Others	323	46.6
	No response	24	
NUMBER OF MATH CLASSES TAKEN			
	0-1	104	14.9
	2	207	29.7
	3	261	37.5
	4 or more	124	17.8
	No response	21	
CURRENTLY ENROLLED IN A MATH CLASS			
	Yes	475	68.9
	No	214	31.1
	No response	28	
PART OF STUDY LAST YEAR			
	Yes	122	17.4
	No	580	82.6
	No response	15	

Note: Not all students taking the survey took the pretest.

Table 4.2

Mean Scores and Standard Deviations for Math Pre Tests by the Independent Variables

Variables		*n*	*M*	*SD*
Gender				
	Male	646	11.32	4.74
	Female	34	10.62	3.99
NRC Model Participant				
	Experimental	330	10.88	4.51
	Control	356	11.67	4.85
Age	15	140	10.08	4.01
	16	258	11.68	5.04
	17	209	11.49	4.51
	18 and older	74	11.46	4.83
Ethnicity				
	Asian or Caucasian	356	12.09	4.80
	All Other	314	10.33	4.44
Number of math classes taken				
	0-1	99	9.70	3.56
	2	201	10.78	4.20
	3	250	12.12	5.07
	4 or more	123	11.74	5.12
Currently taking a math class				
	Yes	463	11.13	4.67
	No	203	11.81	4.81
Part of study last year				
	Yes	118	10.63	4.74
	No	561	11.44	4.68

Note: Not all students taking the survey took the pretest.

increased with the number of math classes taken with the exception of 4 or more ($\bar{x} = \mathbf{11.74}$) increasing from $\bar{x} = \mathbf{9.70}$ for 0-1 math classes taken to $\bar{x} = \mathbf{12.12}$ for 3 math classes taken. Students currently enrolled in a math class scored slightly lower ($\bar{x} = \mathbf{11.81}$) than those not currently enrolled ($\bar{x} = \mathbf{11.13}$). Those that were part of the study last year ($\bar{x} = \mathbf{10.63}$) scored lower than those in the study for the current year ($\bar{x} = \mathbf{11.44}$).

Table 4.3 shows the post test scores on all four AYES tests; Steering and Suspension, Brakes, Electrical/Electronic Systems, and Engine Performance by the independent variables. This table shows the range in mean scores on all the post tests for all variables falls between $\bar{x} = \mathbf{32.40}$ and $\bar{x} = \mathbf{48.82}$. Maximum score is 65.

Students taking 0-1 math classes scored lowest on all four post tests compared to students who had taken more math classes. Highest score results occurred on the Electrical/Electronic Systems test, with students who had completed 4 or more math classes. Those students not currently enrolled in a math class scored higher than those currently enrolled across all four tests.

Males out scored females in all tests, but again ratios were very low to do the comparisons. Students in the experimental group who participated in the NRC model study had means scores higher on the Steering and Suspension test but lower on the other three auto tests. Generally the lowest AYES exit test scores came from 15 year old students. Results indicate that scores increased with an increase in age. The exception seems to be in Electrical/Electronic Systems test, where the 15 year olds (n = 6) scored higher than those older. Asian or Caucasian students mean scores were better than the other ethnic group. As the number of math classes taken increased, so did the mean scores on all four exit tests, except for those stating that they had taken more that four math classes. Those students not currently enrolled in a math class had mean scores higher than those currently enrolled. The students that answered as being part of the study for two years had mean scores that were higher in two of the four tests (Steering and Suspension and Electrical/Electronic Systems) and lower in the other two tests (Brakes and Engine Performance).

Evaluation of individual test indicates that the lowest mean score on the Steering and Suspension test occurred when students had completed 0-1 math classes. The highest mean score reflected those students aged 18 and older. On the Brakes test, the lowest mean score occurred when students had completed 0-1 math classes. The highest mean score reflected students who were not currently taking a math class. The lowest mean score on the Electrical/Electronic Systems test reflected students taking 0-1 math classes. As the number of math classes taken increased so did the mean scores on the Electrical/Electronic Systems test. The highest mean score reflected students previously completing 4 or more math classes. Similarly in the Engine Performance test, the lowest mean score was indicated for students enrolled in 0-1 math classes, while the highest mean score reflected students who were part of the study previously.

Table 4.3

Mean Numbers and Standard Deviations for All Four AYES Post Tests by Independent Variables

		Steering and Suspension			Brakes			Electrical/Electronic Systems			Engine Performance	
Variables	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
Gender												
Male	148	42.07	11.15	263	45.95	10.75	179	46.06	13.52	149	43.10	11.15
Female	7	40.14	11.68	12	42.33	10.83	9	42.67	11.52	7	36.71	4.42
NRC Model Participant												
Experimental	47	43.32	11.85	115	44.40	12.04	131	44.76	13.10	64	40.95	10.26
Control	115	41.96	10.94	170	46.85	9.74	67	46.57	13.42	101	45.89	11.10
Age 15	19	40.57	11.91	60	44.07	11.42	6	46.17	12.45	16	35.94	10.34
16	48	41.02	11.26	98	45.91	11.18	61	44.95	11.94	38	42.08	10.02
17	62	42.50	10.84	85	46.82	10.05	85	45.69	13.76	70	44.93	11.39
18 and older	27	44.44	12.00	32	46.56	10.27	38	48.29	15.17	34	43.09	10.62
Ethnicity												
Asian or Caucasian	96	43.31	10.34	155	46.88	11.62	99	46.88	14.60	82	43.79	11.00
Other	57	40.39	12.41	117	44.55	9.53	86	45.50	11.63	71	42.20	11.07
Number of Math classes taken												
0-1	14	34.14	11.02	39	43.85	10.25	6	33.17	6.94	15	32.40	6.13
2	44	42.84	9.47	75	45.33	10.16	46	40.09	11.89	40	38.90	9.50
3	64	43.33	11.02	117	46.55	10.77	88	48.40	13.11	70	46.17	10.67
4 or more	31	43.42	13.03	43	46.74	12.43	49	48.82	13.66	32	45.22	10.71
Currently taking a math class												
Yes	97	42.04	10.50	197	44.72	10.71	99	44.18	13.58	93	41.35	10.66
No	56	42.64	12.54	76	48.76	10.55	89	47.90	13.16	62	45.68	10.63
Part of study last year												
Yes	48	43.60	11.50	69	45.62	11.60	59	46.12	13.91	47	47.68	10.71
No	107	41.53	11.20	206	45.92	10.54	130	46.08	13.17	110	41.01	10.58

Note: Not all students took all four tests. Students took one, two, three or four tests.

Regression Analysis

The research question asked to what extent AYES exam scores are related to the following predicting factors: (a) participation in the NRC Math-in-CTE model, (b) age, (c) ethnicity, (d) the number of math courses the student has taken, (e) current enrollment in a math course, (f) part of NRC model study in the previous year and (g) score on the math pre-test. To answer the research question multiple linear regression analysis was used. Before the actual regression analysis was run, basic correlation was used to identify the bivariate relationship between each independent variable and the dependent variable. The researcher also examined linearity of the relationship and normality of the data. Multiple regressions enabled the researcher to examine the relationship between the primary variable of interest (participation in the NRC model in the control or experimental groups) and the dependent variable score (scores of the four AYES exit tests) when controlling for the influence of the moderating variables included in the regression equation.

Correlations were found between the number of correct responses on the Math pretest and the number correct responses on each of the four AYES exit tests. Regression equations were run to determine to what extent the independent variables would predict the outcome of the AYES exit tests.

Tables 4.4 to 4.7 show the regression analysis summaries. The major relationship on the four AYES exit test was with the scores on the math pretest.

Table 4.4 is a summary of the regression analysis for Auto Steering and Suspension Test. This analysis found no relationship between students who a participated in the NRC model study and scores on this test at the $p<.05$ level. The math pretest score was the only variable significantly related to this test score, therefore, the higher the math pretest scores, the higher the Auto Steering and Suspension test scores.

No relationship was found between the Auto Steering and Suspension test and the other variables (age, section, ethnicity, number of math courses taken previous participation).

Table 4.4

Summary of Multiple Regression Analysis for Variables Predicting Scores on the Auto Steering and Suspension Test (n = 162)

	B	*SE B*	*β*	*p*
(Constant)	39.421	8.885		<0.001
NRC Model Participant	5.334	3.646	0.220	0.146
Age	1.182	1.468	0.096	0.422
Ethnicity	1.611	1.944	0.071	0.409
Number of math courses taken	0.611	0.818	0.076	0.457
Currently in math class	-0.420	2.194	-0.018	0.848
Previously in study	-2.147	2.566	-0.089	0.404
Math pretest	0.531	0.208	0.221	0.012

Note. $R^2 = .104$

Table 4.5 shows a summary of the regression analysis for the Brakes Test. A negative relationship exists between participation in the NRC model and scores on the Brakes test ($p<.05$). Scores on the Brakes test were higher for students not participating in the NRC model. Those students not currently enrolled in a math class scored higher on the Brakes test. And finally, as in the Steering and Suspension test, the math pretest score was significantly related to the Brakes test score.

No relationship was found between the Brakes test score and age, ethnicity, number of math classes taken, or previous participation in the NRC model study.

Table 4.5

Summary of Multiple Regression Analysis for Variables Predicting Scores on the Brakes Test (n = 285)

	B	*SE B*	*β*	*p*
(Constant)	32.170	4.936		<0.001
NRC Model Participant	-3.245	1.553	-0.149	0.037
Age	-0.789	0.873	-0.069	0.367
Ethnicity	0.438	1.291	0.020	0.735
Number of Math courses taken	-0.154	0.485	-0.020	0.752
Currently in math class	3.344	1.553	0.140	0.032
Previously in study	-0.725	1.666	-0.029	0.664
Math Pretest	0.843	0.138	0.373	<0.001

Note. $R^2 = .190$

Table 4.6 is a summary of the regression analysis for Electrical/Electronic Systems Test. No relationship exists between participation in the NRC model study and these test scores ($p<.05$). As the number of math classes taken increased so did the score on the Electrical/Electronic Systems Test. And finally, as in the previous two tables, the math pretest has a significant relationship to the Auto Electrical/Electronic Systems Test.

There is no relationship between the Electrical/Electronic Systems Test and age, ethnicity, current enrollment in math class, or previous participation in NRC model study.

Table 4.6

Summary of Multiple Regression Analysis for Variables Predicting Scores on the Auto Electrical/Electronic Systems Test (n = 198)

	B	*SE B*	*β*	*p*
(Constant)	25.817	6.721		<0.001
NRC Model Participant	0.000	2.133	0.000	1.000
Age	0.951	1.257	0.056	0.450
Ethnicity	0.223	1.901	0.008	0.907
Number of Math courses taken	1.786	0.682	0.186	0.010
Currently in math class	1.946	2.021	0.073	0.337
Previously in study	-0.813	2.117	-0.028	0.702
Math Pretest	1.164	0.199	0.414	<0.001

Note. $R^2 = .259$

In table 4.7 those in the NRC model study for one year showed no relationship to scores on the Engine Performance test at the $p<.05$ level. However, participation in the NRC model study for more than one year showed a significantly relationship on scores. Those in the study for more than one year scored higher on the Engine Performance. This analysis also found that students not currently in a math class scored significantly higher on the Engine Performance test than students taking a math class. As in the previous three tables math pretest scores has the highest relationship of scores on this Engine Performance Test.

There is no relationship between Engine Performance exit test score and age, ethnicity, or number of courses taken.

Table 4.7

Summary of Multiple Regression Analysis for Variables Predicting Scores on the Engine Performance Test (n = 165)

	B	*SE B*	*β*	*p*
(Constant)	35.647	5.622		<0.001
NRC Model Participant	-2.391	2.190	-0.108	0.277
Age	-0.471	1.061	-0.040	0.658
Ethnicity	2.864	1.725	0.133	0.099
Number of Math courses taken	0.803	0.624	0.108	0.200
Currently in math class	3.841	1.790	0.174	0.034
Previously in study	-5.560	1.863	-0.237	0.003
Math Pretest	0.819	0.171	0.367	<0.001

Note. $R^2 = .336$

In summary, participation in the NRC model study was significantly related negatively to scores only on the Brakes test. The other three AYES exit tests showed no relationship with participation in the NRC model study. Age and ethnicity had no relationship to scores on any of the four exit tests. The number of math classes taken had a positive relationship with Electrical/Electronic Systems test scores. Engine Performance test scores had a positive relationship with being previously in the study and not being currently enrolled in a math class. The math pretest outcome was the only variable to have a positive relationship with scores on all four AYES exit test.

Chapter 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of the NRC Model study was "to test the possibility that enhancing the embedded mathematics (instruction) in Technical Education coursework will build skills in this critical academic area without reducing (occupational) technical skill development" (Stone, 2004). This present study focused on the relationship between math attainment and technical skill development. What effect will a math-enhanced technical education curriculum have on scores on the AYES exit exam if the instructors emphasize and enhance the math concepts that already exist in their curriculum?

Multiple linear regression analysis was used to examine to what extent AYES exit test scores are influenced by the following factors: (a) gender, (b) age, (c) ethnicity, (d) the number of math courses the student has taken, (e) if the student is currently enrolled in a math course, (h) previous participation in the NRC model study, and (g) scores on the math pre-test.

This study investigated whether any part of the automotive technology content area was jeopardized while enhancing the embedded mathematics. With the exception of the AYES auto brakes test there was no significant difference on the other three AYES exit tests between the control and experimental groups. This suggests that emphasizing math concepts did not hinder the development of skills needed in the auto technology classroom. Results indicated that, in general, students who have taken three or more math classes had highest mean scores on all four AYES exit tests. The lowest mean score on all four AYES exit tests reflected students enrolled in 0-1 math classes. The highest mean score results occurred on the Electrical/Electronic Systems test, with students who had completed 4 or more math classes. Those students not currently enrolled in a math class had mean scores higher than those currently enrolled across all four tests.

Conclusions

The research question tested the relationship between automotive students' participation in the NRC Model, Math-in-CTE instructional class, and their performance on the end of year AYES skills test when controlling for gender, age, ethnicity, the number of math courses the student has taken, if the student is currently enrolled in a math course, previous year participation in the NRC Model and their score on the math pre-test.

Although participating in the NRC model had no relationship to the three of the four AYES exit test scores (Steering and Suspension, Electrical/ Electronic Systems, Engine Performance), and a negative relationship to one exit test score (Brakes) having a higher score on the Terra Nova pretest did. It seemed that the more math knowledge a student had before enrolling in the AYES program the better the chance the student scored higher on the auto exit tests. Students who had taken three math classes scored highest. A student currently enrolled in a math class as well as the Brakes or Engine Performance auto class but not fully prepared in math at the start of the AYES program could not gain enough knowledge while enrolled in these programs to score better on these exit tests. It seems prior math knowledge was what made the difference.

The results of the research question as it apply to the four exit tests follows.

Steering and Suspension Auto test – There was no relationship between participating in the NRC model study and the score on the Steering and Suspension exit test. In other words, participation in the NRC model study did not have any influence on the Steering and Suspension test. The only moderating variable to have a relationship with the AYES Steering and Suspension auto test scores was the scores on the math pretest. Students with prior math knowledge were the ones to get the higher scores.

Brakes test – There was a negative relationship between participation in the NRC model study and the Brakes test score. Students participating in the NRC model study did poorer on the AYES brakes test than did non-participants indicating that participation may have been detrimental. There was a positive relationship between Brakes test and the math pretest scores.

The Brakes test score was the only AYES exit test score having a negative relationship to participating in the NRC model study. The number of students participating in the AYES Brakes program (n = 275) was 46% more than the number of students taking the Electrical/Electronics System exit test (n = 188) and 77% and 76% more than the number of students in both the Steering and Suspension (n = 155) and the Engine Performance (n = 156) programs, respectively. This might suggest that if student numbers were increased in the other three tests the same negative results may occur in those other three areas. More investigation might turn up other conclusions. The students taking the Brakes test may need more time on task to complete the brakes curriculum and math may have been a distraction. Those participating in the study could have been younger and had not had the opportunity to complete the required mathematics needed to comprehend the brakes curriculum to score successfully on the exit test.

Electrical/Electronics Systems test – There was no relationship between participating in the NRC model study and the scores on the Electrical/Electronics Systems exit test. Therefore, participation in the NRC model study was not detrimental to the scores on the AYES electrical/electronics systems test. The moderating variables which indicate a positive relationship were found between the number of math classes taken, the math pretest and the Electrical/Electronics Systems test. Again, students with a better grasp of mathematics before enrolling in Electrical/Electronics Systems curriculum were had the better scores. Taking a math class at the same time as their technical studies did not help with exit scores.

Engine Performance test – There was no relationship between participating in the NRC model study and the scores on the Engine Performance exit test. Therefore, participating in the NRC model study for one year had no ill effect on the scores on the AYES Engine performance test; however, there was a positive relationship with being a participant in the study for more than one year. This suggests that participating in the NRC model study may have a better effect on AYES exit test scores if the students were exposed to the program for more that the one year. If this Math-in-CTE program, as outlined in the NRC model study, was to be implemented for successive years the scores may be higher. As in the other three exit tests the moderating variable which shows a positive relationship was the math pretest score.

Recommendations

Math is an essential workplace skill (Stone, 2003b). According to this research math is a strong predictor of AYES exit test scores. This suggests that it is essential to have prior math knowledge before undertaking a career as an Auto Technician. It is recommended that students be tested for their math ability before being admitted into the AYES program. Maturity and the age of the student may also play a role in the test scores. Student that scored highest in these exit tests were older, therefore enrolling in these automotive technology class should be deferred until students are older so they could receive the much needed mathematics background.

Reading ability was not assessed at this time. There may be a correlation between reading scores and auto technology scores. Students read the problems from a computer screen and answer accordingly. If they have difficulty reading and/or working with a computer this may have an impact on their test score. More research is needed to see if there is a relationship between reading levels and these exit test scores.

A similar replication of this study can be done using the NRC model study with other included CTE groups such as health occupations, information technology, agriculture mechanics, and business and marketing,

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APPENDIX

The following is an example of the Math-In-CTE lesson plan developed by an automotive teacher with the help of his math teacher partner.

Math-in-CTE Lesson Plan

Lesson Title: Piston Displacement	**Lesson Number: 07**

Occupational Area: Automotive Technology
CTE Concept(s): Piston Displacement
Math Concept(s): Formula for finding the volume of a cylinder; computation.

Lesson Objective:	Students will demonstrate a working knowledge of solving problems involving formulas with specified symbols (math concept) and its application in Automotive Technology: Engine Repair (technical field), while recognizing it in other contexts.
Supplies Needed:	AYES Curriculum Guide of math concepts: Applied Academic & Workplace Skills for Automobile Technicians Have various cylinders and old pistons from many different sizes of engines available.

THE "7 ELEMENTS"	**TEACHER NOTES (and answer key)**
1. Introduce the CTE lesson.	
Today we're going to talk about how to modify an engine to make the car go faster. What ideas do you have about how to make a car go faster?	The students will probably mention things like: change the headers, carburetion, and cam shaft, raise the compression, stroke the engine…
Ask: What does "stroking" an engine mean?	Stroking the engine (ha, ha) means to change the crank shaft from short to long, therefore changing the cu. in. displacement of the engine.
Ask: What do you think the numbers on the sides of cars mean? Like a 426 Hemi Chrysler or a 427 on a Classic Chevy?	The answer is that the numbers 427 stand for the cubic inch displacement of the engine. (427 cu. in.)
Ask: Why would you want to be able to figure out the	When you buy a car that needs to be rebuilt or restored and want to use it for

cu in displacement of an engine? *Ask: So, how do you figure out the cubic inch displacement of an engine block? What engine dimensions or specifications determine the cubic inch displacement (CID)?*	drag racing, there is a size limit of 440 cu in. If you win and it's contested, your car can be taken apart and measured. If you are over 440 cu in, your car goes to the person contesting the race! You would need to know the bore, which is the diameter of each cylinder, the stroke, which is the distance the piston travels from bottom dead center (BDC) to top dead center (TDC), and the number of cylinders in the engine block. The volume that the piston "sweeps" through is the cubic inch displacement of the engine. This volume can be represented as the volume of a right circular cylinder.
2. Assess students' math awareness as it relates to the CTE lesson. Bring out many examples of cylinders and pistons, from diesel engines to minibikes. *Ask: What are the differences among all these cylinders?* Ask: 1. What do we call the diameter of the cylinder? 2. What do we call the travel of the piston in the cylinder? 3. How do we determine piston displacement? 4. What would be a mathematical name for	Don't forget the rule: NRA…never refuse anything! Begin collecting different sizes of pistons for demonstration purposes. Students may say: they are small and big; they burn different fuels… You can judge the size of an engine by the size of the cylinder. Listen to student discussion to see if they are familiar with vocabulary: Bore (diameter), stroke (height), cu in displacement, etc. Answer (4): Total volume of the cylinders in the engine block

cylinder displacement? 5. How do we determine volume of a cylinder? (same as #4)	Engine displacement can be expressed in different units of measure (ie: cubic inches to liters to cubic centimeters) • Define bore or diameter as the largest part across the cylinder • $V = \pi r^2 h \approx 3.14 r^2 h$ (volume of a cylinder) $r = \frac{1}{2}d = \frac{d}{2}$ (relationship between radius and diameter) $r^2 = \left(\frac{1}{2}d\right)^2 = \frac{d^2}{4}$ • Formula for piston displacement is based on the volume of a cylinder. $PD = \frac{\pi d^2 SN}{4} \approx \frac{3.14 d^2 SN}{4} \approx 0.7854 d^2 SN$, where d is the cylinder bore; S is the stroke; and N is the number of cylinders. • Bore – diameter of cylinder • Stroke – height of cylinder • PD – piston displacement • Volume of a cylinder: $V = \pi r^2 h \approx 3.14 r^2 h \approx \frac{3.14 d^2 h}{4} \approx 0.7854 d^2 h$, where r = radius, d = diameter, and h = height of the cylinder $(Bore)^2 * (Stroke) * 0.7854 * (Number\ of\ Cylinders)$ ***NOTE: refer to conversion sheets and charts (Lesson #1)*** 1 liter = 1000 cubic centimeters cc

	1 cubic inch = 16.39 cc cubic inch to cc ci X 16.39 cc cc to cubic inch cc X .061 ci
3. Work through the math example *embedded* in the CTE lesson. *Let's say we had a bore of 4 inches, a stroke of 3 inches…what would be the size of one cylinder? What if you had a V8 engine? Multiply times 8. So, if Mr. Ford needs a marketing strategy…what's he going to put on the side of his car:* *301.59 or 302?* *And in the 1960's, a 302 was really cool!* *What if we convert it to metric? 302 becomes 5.0. Which would you rather have on your car? 302 or 5.0?* *Let's do some other examples:* *Using a bore of 4.25 inches and a stroke of 3.76 inches in an 8-cylinder engine block should produce a volume or cubic inch displacement of approximately 427 cubic inches.* *Another problem:* *What is the cubic inch displacement of an 8-cylinder engine having a bore of 4.094 inches and a stroke of 3.76 inches? The result should be approximately 396 cubic inches, which is the CID of engine blocks used for Chevy Chevelles back in the middle to late 1960's.*	$(Bore)^2 * (Stroke) * \frac{\pi}{4}$ 4 x 4 x 3 x .785 = 37.68 cu in (In one cylinder…) V8 = 37.68 x 8 = 301.59 Use conversion of cu inch to liters… PD = $0.7854(4.25)^2(3.76)(8)$ PD = 426.7 ≈ 427 ≈ means approx. equal to $piston\ displacement = \frac{\pi\,(bore)^2\,(stroke)(number\ of\ cylinders)}{4} = .7854\,d^2SN$ where: d = bore

The number 396 is also located on the side front fenders of these cars.	S = stroke N = number of cylinders π = Pi (3.1416…)
4. Work through *related, contextual* math-in-CTE examples. 1. Find the piston displacement for a 4-cylinder engine with a 3 3/4" bore and a 3 1/2" stroke. 2. Find the increase in PD if a 8-cylinder engine with a 3.5" bore and a 3.75"crankshaft stroke is increased to a 3.55" bore.	1. PD = .7854 $(3.75)^2(3.5)(4)$ PD = 154.6 ≈ 155 2. PD_1 = .7854 $(3.5)^2(3.75)(8)$ = 288.6 PD_2 = .7854 $(3.55)^2(3.75)(8)$ = 296.9 Increase difference = 8.3 Have students actually measure a bore and a stroke and figure out cubic inch displacement convert to cc and liters.
5. Work through *traditional math* examples. 3. Find the volume of a soup can with the diameter of 2 7/8" and the height of 4 3/8". 4. Find the height of a cylinder with a volume of 27 cubic inches and a radius of 2 inches.	3. $V = \frac{\pi (2\ 7/8)^2(4\ 3/8)}{4} = 28.4$ 4. $27 = \pi (2)^2 h$ 27 = 12.57h h = 2.15
6. Students demonstrate their understanding. *Ask: So what advice would you give the student that has to restore/rebuild the 427 engine to compete in a drag race.*	Begin with a class discussion of advice to give the student. Continue by asking students to write out a list of steps the student should follow to rebuild the engine.

	Students could also choose a different example engine and describe to the class how they would make the engine drag race ready. Students could use the attached worksheet for homework, to be filed in student portfolio.
7. Formal assessment. Possible Test Questions 1. Find the piston displacement for a 4-cylinder engine with a 3” bore and a 2 1/2” stroke. 2. Find the volume of a cylinder with a radius of 10 inches and a height of 20 inches.	1. PD = .7854 $(3)^2(2.5)(4) = 70.69 \approx 71$ 2. $V = \pi r^2 h$ $V = 3.14\ (10)^2\ (20)$ V = 6283.19 cu in

Practice with Piston Displacement

1. Find the piston displacement for a 6-cylinder engine with a 8.56 cm bore and a 6.9 cm stroke.

2. Find the piston displacement for an 8-cylinder engine with a 4.13” bore and a 4” stroke.

3. Find the volume of water in an above ground, circular swimming pool that is 3 feet high and 15 feet across.

4. What is the radius of the pool mentioned in problem 3?

5. What is the volume of the pool if the radius is 5 feet and the height is 5 feet?

6. Find the height of the silo if the volume is 14,322 square feet and the diameter is 20 feet.

7. Find the volume of a cylinder with a diameter of 36 cubic inches and a height of 6 inches.

8. Find the height of a cylinder with a volume of 28 cubic inches and a radius of 2.5 inches.

Answers:

1. $PD = .7854(8.56)^2(6.9)(6)$
   $PD = 2382.53$

2. $PD = .7854(4.13)^2(4)(8)$
   $PD = 428.69$

3. $V = \pi r^2 h$
   $V = \pi\ (15/2)^2(3)$
   $V = 70.69$

4. $r = 7.5$

5. $V = \pi r^2(h)$
   $V = \pi\ (5)^2\ (5)$
   $V = 392.7$

6. $14322 = \pi(20/2)^2 h$
   $14322 = 3.14\ (10)^2\ h$
   $14322 = 314.16h$
   $14322/314.6 = h$
   $h = 45.52$

7. $V = \pi\ r^2 h$
   $V = 3.14\ (36/2)^2\ 6$
   $V = 6107.3$

8. $28 = \pi\ (2.5)^2 h$
   $28 = 3.14\ (6.25)\ h$
   $28 = 19.63h$
   $28/19.63 = h$
   $h = 1.49$

VITAE

Education

- Bachelors Degree in Elementary Education from Bloomsburg University, Bloomsburg, PA, 1972
- Masters of Science in Mathematics Education from Marywood University, Scranton, PA, 1991
- PhD in Workforce Education and Development from Penn State University, University Park, PA. 2006
- Completed coursework for the Supervisor's Certification in Vocational Education at Penn State University, 2006

Certification

- PA Instructional I certification in elementary education
- PA Instructional I certification in secondary mathematics

Employment

2003-2006	Instructor in the Professional Personnel Development Center Workforce Education and Development Department Pennsylvania State University, University Park, PA
2002-2003	Mathematics Teacher 8th grade Northeast Intermediate School Scranton School District, Scranton, PA
1988-2002	Adjunct mathematics instructor Allied Health and Environmental Technology Division Keystone College, LaPlume, PA

Projects (2003-2006)

- Worked extensively with Career and Technology teachers as they work toward their state teaching certification
- Delivered Act 48 services to both in-service and pre-service Career and Technical Education teachers
- Coordinated the Governor's Institute for the CTE teachers on two occasions
- Program chairperson for the PA Career and Technical Education Conference (PA*CTEC) held in June 2006
- Worked on the Math-in-CTE research project with the researchers at the National Research Center for Career and Technical Education at the University of Minnesota
- Participated in Phase I of the CareerLink study conducting interviews for qualitative research
- Taught mathematics courses from Pre-Algebra up to and including Pre-Calculus