THE EFFICACY OF DEVELOPING CRITICAL THINKING AND PROBLEM SOLVING SKILLS THROUGH TECHNOLOGY EDUCATION TO EIGHTH GRADE STUDENTS

By

GARY STEVEN MAHONEY

Bachelor of Science
Berea College
Berea, Kentucky
1982

Master of Science
Murray State University
Murray, Kentucky
1983

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF EDUCATION
May, 1993

OKLAHOMA STATE UNIVERSITY

THE EFFICACY OF DEVELOPING CRITICAL THINKING AND PROBLEM SOLVING SKILLS THROUGH TECHNOLOGY EDUCATION TO EIGHTH GRADE STUDENTS

Thesis Approved:

Gary R. Bice
Thesis Adviser

Gary Oakley

Ray E. Sanders

James P. Key

Thomas C. Collins
Dean of the Graduate College

ACKNOWLEDGMENTS

I wish to express sincere appreciation and gratitude to the individuals that assisted me in this project. Dr. Garry Bice for his patients, guidance, and direction, as the chairperson for my committee and dissertation. His contributions as a mentor and a friend were infinite. I am also grateful for the valuable assistance and guidance given to me by committee members, Dr. James Key, Dr. Gary Oakley, and Dr. Ray Sanders, they contributed not only as committee members but as friends.

Additionally, thanks is extended to Berea College and in particular the people of the Department of Technology and Industrial Arts for their support and encouragement. I would like to thank the Kentucky Department of Education and the teachers, students, and schools that participated in this study.

Most of all, I would like to thank my wonderful family who made this whole undertaking possible. First, to my parents, Gayle and Vivian who taught me that anything is possible if you really

apply yourself. Then to my son Donald who served as an inspiration and sacrificed much time away from his dad. And finally, to my wife Cathy, her sacrifices are too great to list. Without her support and encouragement this project would not have been possible.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure | Page

CHAPTER I

INTRODUCTION

Nature of the Problem

Over the past few decades public criticism of the educational system has been rampant. Reports and studies have placed the blame on everyone from teachers to administrators to governmental leaders (Howe, 1983). That has forced educators to reexamine educational methods. Naisbitt and Aburdene (1985) identify that a profound mismatch exists between workplace needs and what the schools are providing. That is based primarily on the lack of schools to respond to the passing of the industrial era and the advancement of technology. In this new age, the information age, it is no longer possible to predict the base of knowledge required to be a productive citizen (Naisbitt, 1984; Costa,1989). Furthermore, it is impossible to "cover" all the information needed in the lifetime of a human being. Therefore, the teaching of thinking processes and skills need to be emphasized. Costa (1985) stated that it is imperative that all citizens learn to solve problems and think critically. Helmstadter (1985) encouraged the careful appraisal of critical thinking. He identified that as our world becomes increasingly complex and technical the need for critical thinking, and more importantly research into how to promote critical thinking, is needed.

Critical thinking and problem solving have been identified as key components of education in recent years. They are not separate subjects, but skills that should be developed and used across the curriculum. Sellwood (1989) attributed our inability to compete in world markets to our lack of problem solving skills. He indicated that education should emphasize creative and critical thinking, of which problem solving is an important element. Sellwood (1989) and Nickerson (1984) identified that critical thinking and problem solving skills must be exercised by students to develop and mature. They indicated that technology education provides the practical and "doing" environment conducive to developing such skills.

Critical thinking and problem solving are identified as key components of technology education. When reviewing the literature, in technology education, the terms critical thinking and problem solving are encountered frequently. Journal articles even describe how to teach critical thinking and problem solving through technology education. However, a closer review fails to reveal the empirical data upon which those statements are based. Stern (1991) stated "... there is very little if any data on the impact of technology education on outcome measures such as ... the ability to reason and solve problems" (p. 4). The few attempts at substantiating the teaching of critical thinking and problem solving were conducted by survey research. They were comprised of questions such as: Does this exercise promote problem solving skills?, and Does this exercise require problem solving, etc. (Seymour, 1990)?

If technology education can be empirically linked to the promotion or the development of critical thinking and problem solving skills, then a stronger argument can be made about the importance of technology education's place in the general education curriculum. If technology education can not be associated with the teaching of problem solving then technology education must explore what is required to teach critical thinking and problem solving or decide if that should be one of technology education's main objectives.

Problem Statement

Nationwide, major efforts are being focused on revamping technology education curricula. Efforts target curriculum content, retraining of teachers, retooling laboratories and changing images, with the hope that the program will improve student problem solving and critical thinking abilities. However, there is no empirical evidence to support the contention that technology education improves or enhances critical thinking and problem solving skills of students.

Purpose of the Research

The purpose of the study was to collect empirical data to determine whether technology education promotes or facilitates critical thinking and problem solving skills of eighth grade students.

Research Questions

Two primary research questions guided the conduct of the study:

(1) Will eighth grade students enrolled in technology education score significantly higher on critical thinking tests than eighth

grade students not enrolled in technology education?

(2) Will eighth grade students enrolled in technology education and math or algebra or pre-algebra or science score significantly higher on critical thinking tests than eighth grade students not enrolled in technology education?

Scope and Limitations

1. The treatment group was comprised of a purposive cluster sample.
2. Inferences made from such a population are limited.
3. The study was limited to 10 schools in the State of Kentucky.
4. Instruction was limited to 12 weeks of the new modular strategy for teaching technology education.
5. The technology education programs in the schools included in the study were in their first or second year.

Definition of Terms

The following definitions were used in the conduct of the study:

Technology Education:

Technology education is a program offered at the middle and high school levels that provides students an opportunity to learn about technological systems as these impact societal wants and needs. Technology education derives its content from curriculum organizers identified as communications, production, transportation and bio-related topics. Technology education is an integral part of any school's comprehensive program (KCITE, 1992, p. 1).

Problem Solving is defined as:

... using basic thinking processes to resolve a known or defined difficulty; assemble facts about the difficulty and determine additional information needed; infer or suggest alternate solutions and test them for appropriateness; potentially reduce to simpler levels of explanation and eliminate discrepancies; provide solution checks for generalizable value. (Presseisen, 1985, p. 45)

Critical Thinking: For purposes of this study a working definition of critical thinking was developed from the commonalities of definitions given by Paul (1984), Presseisen (1985), and KCITE (1992)and as measured by the Cornell Critical Thinking Test. Critical thinking is using thinking processes to actively and skillfully conceptualize, apply, analyze (including understanding assumptions and biases underlying particular positions), synthesize or evaluate information gathered from, or generated by, observation, experience, reflection, reasoning (both inductively and deductively), or communication, to reach factual or judgmental conclusions based on sound inferences drawn from unambiguous statements of knowledge or belief.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Costa (1989), in his foreword for "Toward the Thinking Curriculum", identified scholars such as Hirsch, Cheney, Ravitch, Finn, and Bennett as having argued that disciplinary knowledge and cultural literacy are the major curriculum components for achieving an educated citizenry. With that principle as a basis, knowledge - oriented standards as an assessment for literacy levels have impacted the schools dramatically. It follows that the primary purpose of the school is to impart knowledge. Thus, an effective school, and in turn teacher, covers more material faster, therefore "coverage" is the measure of good teaching (Costa,1989).

In contrast to that view, Costa (1989) and other educators, (Resnick & Klopfer, 1989), and (McTighe & Schollenberger, 1985), believe that knowledge in and of itself is of little use. They identify that the teaching of thinking processes and skills need to be emphasized (Costa, 1989). That belief is based primarily on the passing of the industrial era. It is no longer possible to predict the base of knowledge required to be a productive citizen in the new information age (Naisbitt, 1984; Costa, 1989). Furthermore, it is impossible to "cover" all the information needed in the lifetime of a human being. Thus, it is imperative that all citizens learn to solve problems and think critically (Costa, 1989). Helmstadter (1985) encourages the careful appraisal of critical thinking. He indicated that as our world becomes increasingly complex and technical, the need for critical thinking and, more importantly, research into how to promote critical thinking is needed.

Critical Thinking

Paul (1984) indicated that most persons knowledgeable of critical thinking skills agree that school systems and teachers are not well prepared for the teaching of critical thinking. McMillen (1986) supports that by noting that faculty members at a growing number of colleges and universities find it necessary to formally teach students "how to read with a questionable attitude, how to analyze and criticize subject matter carefully, and how to construct their own convincing argument" (p. 23). In lieu of quick fixes, Paul (1984) advocates a short-term and a long-term strategy, based on where the school systems and teachers currently are and where they hope to be, in order to better prepare both school systems and teachers.

The short term strategy presented by Paul (1984) facilitates the understanding and the teaching of micro-logical, analytic critical thinking skills within established subject areas. Central to that short term approach is the development of an elementary critical / analytic vocabulary. Students would develop a working knowledge of such terms as

> ... premise, reason, conclusion, inference, assumption, relevant / irrelevant, consistent / contradictory, credible / doubtful, evidence, fact, interpretation, question-at-issue, problem, and so on (Paul, 1984, p. 6).

Nationally normed tests, such as the Watson-Glaser and the Cornell Critical Thinking Tests, already available to teachers are designed to test for knowledge and understanding of critical thinking (Paul, 1984), and are appropriate to assess the short term progress of critical thinking.

Paul (1984) described a long-term strategy for critical thinking as containing two major components:

> ... an explication of obstacles to the development of strong-sense critical thinking skills, and an increasing recognition of the distinctive nature and importance of dialectical issues and the manner in which they can be brought into the traditional school curriculum (p. 7).

Paul (1984) indicated that it is not enough to recognize that all human thought is embedded in human activity and all human activity is embedded in human thought. He states that it is important to recognize that much of human thought is subconscious, automated, and irrational. He identifies that we live in two very different noetic worlds. One world, the technical, is clear and ordered and the other, the personal social, is full of disorder and confusion. The literature reveals that we are concerned with solving problems in the ordered, technical domain and ignore, to the detriment of, problem solving in the personal social domain.

In technical critical thinking and problem solving there is a specific objective developed from one frame of reference to one standpoint. With the dialectic approach, questions are raised that each have a variety of alternative systems or competing viewpoints that generate conflicting lines of reasoning and answers. Thus, dialectical reasoning is described as thinking critically and reciprocally within opposing points of views (Goldman, 1984). Paul (1984) indicates that "this ability to move up and back between contradictory lines of reasoning, using each to critically cross-examine the other, is not characteristic of the technical mind" (p. 10).

Falkof and Moss (1984) support the teaching of dialogical reasoning, but indicated that asking questions is not enough. Current research suggests that 80 to 85 percent of all questions asked by teachers are on a factual level. To teach students to think requires that not only factual questions be posed but also higher order questions. Falkof and Moss (1984) indicate that the type of question asked determines the level of thinking and the quality of response given. They identify four types of questions, factual, interpretive, creative, and evaluative, and compare them to Bloom's Taxonomy of Educational Objectives and Guilford's Structure of the Intellect (see Figure 1).

Paul (1984) concludes, that when one reaches a decision based on hearing different sides of the argument, reading many reports, is prepared to argue and explore various interpretations . . . one is reasoning dialectically. Application of dialectical reasoning would

Four Types of Questions		
Type of Question	Bloom's Taxonomy	Guilford's Structure of the Intellect
Factual	Knowledge/Comprehension	Cognition/Memory
Interpretive	Application/Analysis	Convergent Thinking
Creative	Synthesis	Divergent Thinking
Evaluative	Evaluation	Affective, Convergent Thinking

Figure I. Four Types of Questions

include reaching a verdict in a trial, deciding on which candidate to vote for, developing a position on nuclear proliferation, and determining a marriage partner. Ultimately, all of these decisions are critical for a free society, and are in fact the bases of such (Paul, 1984). The dialectic method of teaching can prompt thinking and reasoning skills in students. Fedje and Irvine (1982) indicate that through the dialectic method of critical thinking, students have a better understanding of the content, longer retention and less reliance on rote learning.

Problem Solving

Introduction to Problem Solving

Education from every level and every philosophical persuasion identifies that it is important to teach students to think. To some, the teaching of problem solving is synonymous with the teaching of thinking. Through the teaching of problem solving, critical thinking is developed (Greenfield, 1985). Further, problem solving is described by Rowe (1985, p. 3) as "a central prerequisite for human survival." While the process is essential, the mechanics of it are still a puzzle. Cyert (1980) indicated that problem solving skills are essential to education. He stated that if the mechanics of problem solving can be identified then students would be able to learn better and more quickly. Larkin and Reif (1976) conducted experiments to explore the teaching of problem solving skills. They concluded that current teaching methods are both slow and inefficient and that cognitive skills, such as problem solving, should be taught. As a result of developing cognitive skills, the students develop skills that are applicable to other courses and in their future life experiences.

A review of the literature revealed many different attempts at describing problem solving. Rowe (1985) wrote that many models have been developed since the 1960's. She suggested that studying the models themselves to try to identify a "well-developed area of empirical knowledge which is founded upon accepted basic concepts," (p. 38) would be misleading. Instead she identified the interpretative frameworks upon which the models are based. As a result, four distinct frameworks or models for problem solving were identified. The four interpretative frameworks are labeled as the gestalt model, the behaviorist model, the psychometric model, and the information processing model. Greenfield (1987) identified similar methods or frameworks developed by educators, psychologists, philosophers, and others to describe, define or analyze problem solving. The five methods identified by Greenfield (1987) are behaviorism, psychological types and cognitive styles, computer simulation and information processing, rational analysis, and analysis of the problem solving process. Those methods are consistent with the four frameworks identified by Rowe (1985). Greenfield (1987) further stated that the methods used to teach problem solving skills are determined by the teacher's definition of problem solving.

The gestalt model is the major non-behavioral model. It is based on philosophy and validates itself through introspection and insight. "A gestalt was defined as a whole which is greater than the sum of it's parts" (Rowe, 1985). With gestalt, it is therefore fundamental to examine the total process of problem solving and any attempt to break it down into smaller elements would be contradictory. The gestalt psychologist investigates how "organisms organize," therefore the gestalt model is concerned with the problem solving process and not the outcome.

The behaviorist model applies the interpretative framework of learning theory to problem solving. That framework utilizes the stimulus-response approach to problem solving. It is concerned with the "determinants of the problem solver's response" (Rowe, 1985). In teaching, the student is given a set of stimuli, by which they can form associations, of varying probability of occurrence and strength, with sets of responses and mediating variables.

> The probability and strength of each association are determined by basic learning principles, which postulate that the responses which are most frequently reinforced are most strongly associated with the stimuli and are therefore most likely to be elicited (Rowe, 1985, p. 47).

Problem solving of that framework is thus denoted by trial and error, habit family hierarchies, operant conditioning, chains of association and transfer of learning (Rowe, 1985). Most of the studies conducted by behaviorist to substantiate behaviorism utilized animals and young children. Kohler's classic studies with apes and Piaget's observations and interviews with children are two of the more notable examples (Greenfield, 1987). Skinner influenced the development of teaching machines and programmed learning based on the behaviorist laws of effect and of association. Behaviorists also developed the concepts of "practice, transfer, incentives, reinforcement, discrimination, motivation, mental habits and drills" (Greenfield, 1987, p. 7).

The psychometric model is based on factor analysis and owes much of its impetus to the testing movement (Rowe, 1985). That model finds most of its support in applied psychology and education. The focus of the psychometric model is on the product not the process of problem solving. The popularity of that model is based on its expediency in providing information about groups of individuals (Rowe, 1985), and it measures overt and quantifiable aspects of behavior. Greenfield (1987) stated that theorists have developed rating forms, cognitive style maps, and inventories to determine an individuals learning style. The Myers - Briggs Type Indicators, for example, denotes the way an individual becomes aware (sencing / intuition), comes to conclusions (thinking / feeling), takes in information and undertakes action (judgement / perception), and the way the individual views the world (extravertion / intravertion). Greenfield (1987) further states that researchers are exploring the advantages of matching teaching styles to learning styles on the premise that it will increase both learning and problem solving ability. Finally, Greenfield (1987) suggests that early research showed a relationship between matching teaching styles to learning styles, but warns of the dangers of over simplification.

The information processing framework is based on detailed task analysis, it is task oriented. It relies strongly on verbal reports to identify cognitive processes. That information is used to identify operations and protocol used to problem solve. The major thrust of the framework was to provide descriptive models and graphic representations of the steps and sequence of problem solving (Rowe, 1985). Greenfield (1987) noted that there were many similarities between computers and people. Both can store, retrieve, and transform information. Similarly, computer simulation models have served to ask questions about long term and short term memory, how knowledge is organized and accessed, and what kind of control system determines the sequence of operations (Greenfield, 1987).

Rowe (1985), concluded that the four models or interpretative frameworks, the gestalt model, the behaviorist model, the psychometric model, and the information processing model, are not competitive models but complementary. Each model has contributed to the theoretical and empirical knowledge relating to problem solving. Each framework has a different focus. The psychometric and behavioral approaches stress the product or results of performance, while, the gestalt and information processing frameworks emphasize the process that takes place in the individual, while working on a problem.

Relationship of Problem Solving to Critical Thinking

In the literature, the terms critical thinking and problem solving are used in a variety of ways. There is no single widely accepted definition of critical thinking (Landis and Michael, 1981). Problem solving is sometimes used to refer to simply answering questions or solving problems on a problem sheet. It is also used interchangeably with critical or creative thinking. It is therefore essential to establish working definitions of key terms when examining problem solving.

Presseisen (1985), described critical thinking as --

> using basic thinking processes to analyze arguments and generate insights into particular meanings and interpretations; develop cohesive, logical reasoning patterns and understand assumptions and biases underlying particular positions; attain a credible, concise, and convincing style of presentation (p. 45).

California State University uses the following description for its graduation requirement in critical thinking:

> ...an understanding of the relationship of language to logic, leading to the ability to analyze, criticize, and advocate ideas, to reason inductively and deductively, and to reach factual or judgmental conclusions based on sound inferences drawn from inambiguous statements of knowledge or belief (Paul, 1984, p. 5).

Presseisen (1985) further defined problem solving as

> ... using basic thinking processes to resolve a known or defined difficulty; assemble facts about the difficulty and determine additional information needed; infer or suggest alternate solutions and test them for

> appropriateness; potentially reduce to simpler levels of explanation and eliminate discrepancies; provide solution checks for generalizable value (p. 45).

Greenfield (1987) used a definition of problem solving by Brownell (1942):

> problem solving refers (a) only to perceptual and conceptual tasks (b) the nature of which the subject, by reasons of original nature, of previous learning, or of organization of the task, is able to understand and but (c) for which at the time he knows no direct means of satisfaction. (d) The subject experiences perplexity in the problem situation, but he does not experience utter confusion. From this he is saved by the condition described above under (b). Then, problem solving becomes the process by which the subject extricates himself from his problem (p. 416).

Presseisen's (1985) definition of creative thinking is:

> using basic thinking processes to develop or invent novel, aesthetic, constructive ideas or products, related to precepts as well as concepts, and stressing the intuitive aspects of thinking as much as the rational. Emphasis is on using known information or material to generate the possible, as well as to elaborate on the thinker's original perspective (p. 45).

Technology Education

Introduction

The National Science Board Commission on Pre-College Education in Mathematics, Science, and Technology (1983) agreed with popular opinion that there was a need to return to the basics. However the basics promoted by them were not the traditional three R's but a new set for the 21st century. Problem-solving and critical thinking skills are listed as important basics. Naisbitt and Aburdene (1985) note that there is a profound mismatch between the skills that the workplace needs and those that the schools are providing. Lauda (1988) indicated that, a critical survival skill for students in a complex, changing world is that they be able "to detect problems and determine appropriate solutions" (p. 11). The need for students to become more effective thinkers is fundamental according to the Commission (The National Science Board Commission on Pre-College Education in Mathematics, Science, and Technology, 1983).

Technology education has seen extensive modification as its programs move through transition from industrial arts. The traditional offerings in the pre-occupational topics of woodworking, metalworking, and drafting are being replaced by the broader coursework present within technology education (Wright & Sterry, 1983). In technology education, students are challenged to think and reason, practice problem solving, analyze complex topics and issues, and apply mathematical and scientific principles in typical situations (Jones & Wright, 1986; Stern, 1991b). Technology education is an integrative program that can address this critical list of skills in an applied environment (Baker & Dugger, 1986; Jones & Wright, 1986; Johnson, 1989; Stern, 1991b).

Problem solving is not considered to be a separate subject, but a skill that should be developed and utilized across the curriculum. Sellwood (1989) attributed the United States' inability to compete in world markets to its lack of problem solving skills. He indicated that education should emphasize creative and critical thinking, of which he considered problem solving to be an important element. He stated that thinking and problem solving skills must be exercised by students in order to develop and mature. Sellwood (1989) stated that technology education provides the practical and "doing" environment conducive to developing such skills.

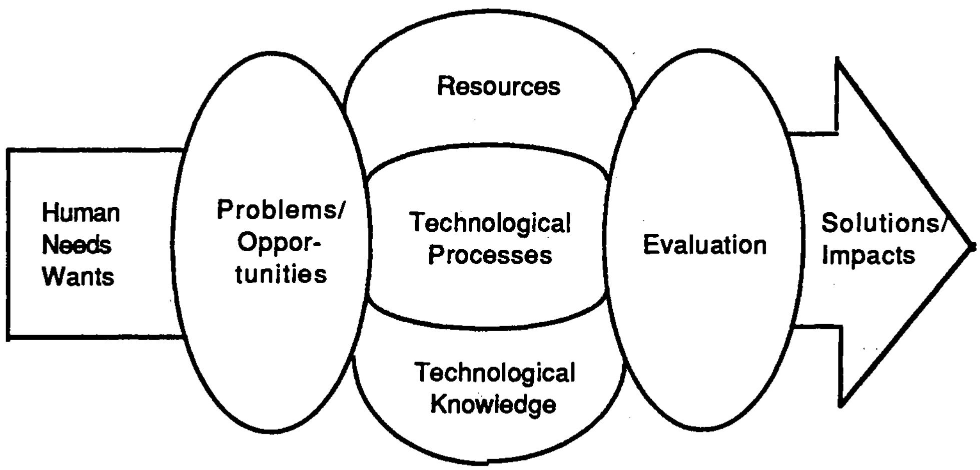
Current Technology Education Programs

Savage and Sterry (1990) developed a conceptual framework for technology education through a grant from the Technical Foundation of America and in conjunction with the International Technology Education Association (ITEA), the American Vocational

Association (AVA), and the Council on Technology Teacher Education (CTTE). A three stage Delphi process was used to identify leaders who could contribute to the process. That group of 25 met and developed a document outlining a conceptual framework for technology education. The first stage produced two parts. Part one described the Technological Method (see Figure 2) and part two addressed the content model for technology education (Savage and Sterry, 1990).

The technological process is summarized by the statement that "Human needs and wants lead to the identification of problems and opportunities as addressed by resources and technological knowledge through technological processes to reach evaluable solutions that have impacts" (Savage and Sterry, p. 6). That provides a process or model that identifies human needs and wants as the focal point. From the human needs and or wants, the problem or opportunity is identified. The next phase of the model is to identify the resources, technological processes, and the technological knowledge that are available. Resources include personnel,

TECHNOLOGICAL METHOD



Humans:
- Needs
- Wants

Technology Knowledge:
- Bio-related Technology
- Communication Technology
- Production-Technology
- Transportation Technology

Tasks:
- Problems
- Opportunities

Resources:
- Personnel
- Tools/Machines
- Data
- Materials
- Energy
- Capital
- Time

Evaluation:
- Satisfactory
- Exceptional
- Unacceptable

Technological Processes:
- Analyzing
- Realizing
- Testing

Accomplishments:
- Solutions
- Impacts

Figure 2. Technological Method

Source: Savage, E. & Sterry, L. (1990). A conceptual framework for technology education. The Technology Teacher, 50 (2), p. 7.

tools/machines, data, materials, energy, capital and time. Technological knowledge is based upon content that is unique to the human-made world. Technological knowledge is classified as bio-related technology, communication technology, production technology, and transportation technology (Savage and Sterry, 1990). Technological processes are systematized approaches to provide an interface between resources and technological knowledge. Technological processes provide the ability to analyze, realize, and test. The next phase of the model is evaluation. The evaluation phase determines if the solution when compared to the original problem, is satisfactory, exceptional, or if it is unacceptable in part or total (Savage and Sterry, 1990). The final phase, solutions and impacts, considers areas such as values, ethics, norms, psychological, and physical influences.

Changes in Teaching Methods

Recent advances in technology have made a major impact on both industry and education. Workplace demands have changed from specific skill base, to the need for workers that have higher reading skills, thinking skills, are able to learn, and are problem solvers

(Naisbitt & Aburdene, 1985). Johnson and Thomas (1992) described a shift from behaviorism to constructivism as a recent change in technology education that addresses the needs of the workplace.

Traditional technology education programs (industrial arts) utilize behaviorism. Under that theory, learning is viewed as a change in behavior. That method utilized lectures and requires students to memorize information. Skills are taught by breaking them down into small tasks and are mastered through practice (Johnson & Thomas, 1992).

Constructivism learning theory views learning as the adding of new information onto what is already known (Johnson & Thomas, 1992). Students thus learn by constructing their own understanding based on what they already know. Thus, the student learns based on understanding and examining and reexamining instead of memorizing. The expectations of the teacher have also changed (Costa, 1989). Instead of throwing out facts, the teacher facilitates the learning process. That is accomplished through developing a "stimulating learning environment in which the students are active participants in the planning, delivery, and evaluation of the instruction" (Johnson & Thomas, 1992).

Through the application of constructivism (Johnson & Thomas, 1992), five major principles were identified for technology education. The first principle was to help students organize their knowledge. Expert problem solvers are able to process large amounts of information through organization and the use of external memory. The use of concept maps and the steps used in problem solving provide direction and guidance to thinking. The second principle was to build on what the student already knows. Acquiring and using new knowledge is based on prior or existing knowledge of the student (Johnson & Thomas, 1992). If the student enters the class without prerequisite knowledge they will have difficulty in interpreting and understanding new information. The teacher must ensure the student possesses prerequisite knowledge. The third principle was to facilitate information processing. The way something is learned will influence the use of that knowledge (Johnson & Thomas, 1992). Through providing a real life context for the acquisition of knowledge, the learner is provided an index of obtained knowledge. The fourth principle was to facilitate deep thinking. Through problem solving the student is required to understand the information and make decisions based on it (Johnson

& Thomas, 1992). The fifth principle was making the thinking processes explicit. Through metacognition the student develops strategies that include self-monitoring, advance planning, self-checking, questioning, summarizing, predicting, generating and evaluating alternatives, and evaluating learning (Johnson & Thomas, 1992).

In summary, Thode (1989) states that technology education needs to keep the hands-on approach to learning but include activities that challenge students to apply higher level thinking skills with minds-on activities. As a result, the students will be better prepared to cope with whatever the future holds.

Technology Education in the State of Kentucky

In June, 1989, the public school system in the State of Kentucky was ruled unconstitutional by the Kentucky Supreme Court (Miller, Noland, & Schaaf, 1990). That led the way for massive, across the board, educational reforms. One of the groups working with the reform of technology education was the Kentucky Council for Industrial Teacher Educators, KCITE. The KCITE position paper

(1992) on technology education identified, in the philosophy section, that technology education should be available to all students and should assist in developing and applying creative problem solving techniques and critical thinking skills.

The council provided the following definition of technology education:

> Technology education is a program offered at the middle and high school levels that provides students an opportunity to learn about technological systems as these impact societal wants and needs. Technology education derives its content from curriculum organizers identified as communications, production, transportation and bio-related topics. Technology education is an integral part of any school's comprehensive program (KCITE, 1992, p. 1).

The council further described the mission of technology education as to develop critical thinking abilities through a problem solving curriculum, and identifies two of its seven goals as: 1) utilization of academic and technological skills to solve real life problems, 2) and, utilization of critical thinking and problem solving skills to identify and solve problems in situations throughout life. The KCITE position paper (1992) identifies one of the teacher's objectives as to create situations for skill development in critical thinking and problem solving. The KCITE council identified critical thinking as:

> ... the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action (KCITE, 1992, p. 1).

The New Technology Education Programs in Kentucky

Technology education in Kentucky is comprised of two components, Level I and Level II. Level I technology education, middle school, is an orientation course and Level II, high school, is an exploration course.

In Technology Education in the 21st Century, Stanley (1991) provided a description of the new technology education program supported by the Kentucky State Department of Education. The program is comprised of self-directed study modules lasting for a period of two weeks per module for Level I students. Level II students will allow four weeks per module. Level I students are in technology education programs for nine, twelve, or eighteen weeks, depending on the rotation of the particular school system. This results in each student studying four, five, or seven modules respectfully.

Students study the modules in groups of two. The self-directed study includes the use of computer software, videotapes, filmstrips, text books, and hands on activities. Upon the completion of the module, two weeks, the student moves on to another chosen module.

The modules that are recommended by the State Department of Education are listed and described by Stanley (1991, p. 19-24), and are included in Appendix A. Each technology education program is comprised of a minimum of 14 modules and each program is encouraged to incorporate 16 modules if the space is available.

Problem Solving Through Technology Education

Introduction

Johnson and Thomas (1992) have attributed advances in technology as having impacted both educational and industrial institutions. Technological advances have produced sophisticated equipment and processes that have changed the skills and knowledge levels needed by workers (Costa, 1989; Naisbitt & Aburdene, 1985). The single classification worker is being replaced by multiple classification workers that are required to work in teams and problem solve (Johnson & Thomas, 1992). That has placed a demand on the schools to produce a student that is a good thinker and problem solver (Johnson & Thomas, 1992; Naisbitt & Aburdene, 1985).

Problem Solving Models

Baker and Dugger (1986) stated that technology education considers that problem solving is one of its major thrusts. In order to teach problem solving a model must be used to facilitate that emphasis (Baker and Dugger, 1986). One model used by technology education for problem solving is similar to the scientific method. That five step method is:

1) Set a goal that the student can attain including considerations for age, motivational aspects, the physical ability of the typical student in the level and so on.

2) Define a task that is to be done in such a manner so that the student must incorporate new actions, make decisions, and consider new ideas.

3) Provide a structure in which the student investigates the various actions, looks at alternatives and considers primary and secondary effects of these alternatives.

4) Force the student to choose between several alternatives. The student must decide which is best for that individual situation, then plan and execute these decision(sic) within the limits established by the teacher.

5) Make the student evaluate the activities and conclude if the idea worked or failed, and make decisions as to what factors aided or hindered, and what could have been improved (Baker & Dugger, 1986, p. 11).

In addition to that model the technology educator must be knowledgeable of two different types of problem solving; proactive problem solving and reactive problem solving (Baker and Dugger, 1986). Through proactive problem solving the teacher uses questions or situations to guide the student instead of expelling facts to be memorized or giving step by step directions, thus making the student a worker not a learner. Reactive problem solving is "a reaction to a situation that is not working properly" (Baker and Dugger, 1986). It is important that the student be allowed to analyze and identify the problem and then problem solve to develop a solution.

Baker and Dugger (1986), identify four considerations in teaching problem solving. The first consideration is "guided discovery." The teacher provides a structure that guides the student to solving the problem. Initially the stage is very structured, however as the students develop proficiencies in problem solving the structure is reduced. The second consideration is "simple to complex." Simple highly structured problem solving activities will be used initially, as students become more proficient at problem solving less structured, more difficult problems will be identified. The third consideration is "success oriented." The teacher must establish that the goal is attainable for the specific students involved. The final consideration is "repetition and drill." Baker and Dugger (1986) further describe problem solving as a skill. It is developed like any other skill, through practice.

Evaluation of Critical Thinking and Problem Solving

Introduction

The assessment of thinking skills requires the educator to undergo a paradigm shift. The standard methods used to assess behaviors can not be used to assess thinking skills. Costa (1985) stated that "While behaviors are overt, thinking is covert." He goes on to identify that the development of thinking skills takes time. He notes that many research studies indicate that a change in thinking skills can occur only after a two year period of carefully designed curriculum with quality instruction (Costa, 1985).

Methods Used To Evaluate Critical Thinking and Problem Solving

The two tests used most frequently to assess critical thinking skills are the Watson-Glaser Critical Thinking Appraisal and the Cornell Critical Thinking Tests (McPeck,1981) and (Paul, 1984). The Watson-Glaser Critical Thinking Appraisal is intended for grades nine through sixteen and adults. It provides for scores from five subtests; inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments (Mitchell, 1985). The Cornell Critical Thinking Tests assess general critical thinking abilities including; induction, deduction, evaluation, observation, credibility, assumption identification, and meaning. The CCTT was first published in 1961 and revised in 1985 (Kramer and Conoley, 1992). There are four sections of the CCTT. The first section, questions 3 through 25, was designed to assess one's ability to judge whether a simple generalization was warranted, a hypothesis was justified, or a reason was relevant. The second section, questions 27 through 47 and 49, was designed to represent one's ability to judge whether an alleged authority of an observation is reliable. The third section, questions 52 through 65, was designed to assess deductive logic, one's ability to judge whether a statement follows from premises. The forth section, questions 67 through 76, was designed to identify assumptions and to determine whether reason is relevant for a given deduction (Landis and Michael, 1981). Malcolm (1992) states that the Cornell Critical Thinking Tests "holds good potential" as a tool for examining the teaching of critical thinking. She does note, as identified by the authors of the

CCTT, that additional exploration into reliability and validity is needed.

Methods Used in Technology Education to Evaluate Problem Solving

The evaluation of critical thinking and problem solving in technology education has been limited (Stern, 1991). Stern (1991) indicated that there is little if any emperical evidence to implicate technology education with the teaching of critical thinking and problem solving. The few attempts at substantiating the teaching of critical thinking and problem solving were conducted by survey research or involve designing course specific evaluation instruments. Seymour (1990) attempted to associate technology education with problem solving by surveying experts in the field. He asked questions such as: Does this exercise promote problem solving skills, and does this exercise require problem solving, etc.? Greenan and McCabe (1989) developed an instrument to measure generalizable reasoning skills for a specific secondary vocational school.

Summary and Implications for the Study

In summary, critical thinking and problem solving skills are identified as being critical for students to possess in this new information age. The research shows that teachers are not well prepared to teach critical thinking and problem solving. Furthermore, changing school systems and preparing teachers to obtain that goal will not be accomplished quickly, with the actual teaching / learning process being a lengthy one. This coupled with the variety of definitions and discipline specific concerns makes for a formidable but achievable task.

Technology Education with its broader coursework (Wright & Sterry, 1983) challenges students to think and reason, practice problem solving, analyze complex topics and issues, and apply mathematical and scientific principles in typical situations (Jones & Wright, 1986). Technology education as an integrative program can address this critical list of skills in an applied environment (Baker & Dugger, 1986; Jones & Wright, 1986; Johnson, 1989).

If technology education can be empirically linked to the promotion or the development of problem solving skills, then a stronger argument can be made about the importance of technology education's place in the secondary education curriculum. If technology education can not be associated with the teaching of problem solving then technology education must explore what is required to teach problem solving or decide if this should be one of their main objectives.

CHAPTER III

PROCEDURES

Problem Statement

Nationwide, major efforts are being focused on revamping technology education curricula. Efforts target curriculum content, retraining of teachers, retooling laboratories and changing images with the hope that the program will improve student problem solving and critical thinking abilities. However, there is no empirical evidence to support the contention that technology education improves or enhances critical thinking and problem solving skills of students.

Purpose of the Research

The purpose of the study was to collect empirical data to determine whether technology education promotes or facilitates critical thinking and problem solving skills of eighth grade students.

Research Questions

Two primary research questions guided the conduct of the study:

(1) Will eighth grade students enrolled in technology education score significantly higher on critical thinking tests than eighth grade students not enrolled in technology education?

(2) Will eighth grade students enrolled in technology education and math or algebra or pre-algebra or science score significantly higher on critical thinking tests than eighth grade students not enrolled in technology education?

Design

The research design for the study was a post-test only control group design, and according to Campbell and Stanley (1966) is shown schematically as:

R	X	O
R		O

The treatment group was comprised of eighth grade intact technology education classes participating in the new technology education program. The control group consisted of eighth grade classes from school systems that do not offer technology education courses.

Population

The population for the study was eighth grade classes enrolled in schools in the State of Kentucky. The treatment group was comprised of students enrolled in intact courses in eleven fully implemented technology education programs. Students attending those schools were required to take a technology education course during their eighth grade year. The control group was comprised of eighth grade students enrolled in schools not offering technology education courses.

Sampling Procedures

The treatment group was identified by the State Supervisor of Technology Education. The 11 programs were pilot programs representing the type of program supported by the State Department. The teachers in the programs were contacted to establish the grade levels and make-up of courses offered during the Fall term 1992. Additional information such as: enrollment, composition, and time was obtained through telephone conversations and / or on site visits. The schools offering courses required of all eighth grade students were randomly selected to obtain five intact classes of eighth graders.

The control group was identified by obtaining a listing of all schools in the State of Kentucky. The list was cross referenced with the list provided by the State Department of Education to identify those schools not offering technology education or industrial arts programs at the eighth grade level. That group of 50 schools was randomly selected to produce a number of intact eighth grade classes equal to the number in the treatment group and comprised of similar geographic and demographic characteristics. Five schools were selected to participate in the study. A sample size of five schools was used to obtain cell sizes of 15.

Independent Variable

The treatment for this study is the Kentucky Department of Education supported technology education program. This program used a modular approach to teaching. Each program is comprised of a minumin of 14 modules and is encouraged to incorporate 16 if the space is available. Students work in groups of two. They select the module they want to study, and then follow the directions of that particular module. The modules are self-directed and include the use of computer software, videotapes, filmstrips, text books, and hands on activities. Upon the completion of the module, two weeks, the student moves on to another chosen module.

Instrument Description

The Cornell Critical Thinking Test, level X, was used to measure critical thinking skills. The CCTT has two levels, level X is for populations comprised of grades 4-14, and level Z is for populations comprised of advanced and gifted high school and college students and adults. The CCTT was first published in 1961 and revised in 1985 (Kramer and Conoley, 1992). It is comprised of four sections and contains 71 multiple choice questions. The CCTT is intended to be administered within a fifty minute period, but can be taken in two or more sessions.

The test asks students to think critically about problems in a science fiction story. The CCTT assess general critical thinking abilities including; induction, deduction, evaluation, observation, credibility, assumption identification, and meaning. Sections include induction, credibility, deduction, and identification of assumptions (Ennis, Millman & Tomko, 1985).

The first section, questions 3 through 25, was designed to assess one's ability to judge whether a simple generalization was warranted, a hypothesis was justified, or a reason was relevant. The second section, questions 27 through 47 and 49, was designed to represent one's ability to judge whether an alleged authority of an observation is reliable. The third section, questions 52 through 65, was designed to assess deductive logic, one's ability to judge whether a statement follows from premises. The fourth section, questions 67 through 76, was designed to identify assumptions and to determine whether reason is relevant for a given deduction (Landis, and Michael, 1981).

The reliability and internal consistency estimates range from .67 to .90 on the level X test. Validity is more difficult to establish in that there is not an established criterion for critical thinking ability. The IRB clearance form is included as appendix C.

Data Gathering Procedures

The researcher telephoned the technology education teachers to describe the project and solicit their participation. Some teachers required the researcher to visit the school, some required a copy of the instrument, some required a meeting with the principal and / or guidance counselor, while some agreed immediately over the phone. To obtain permission from the control group schools, the researcher contacted the principal and/or guidance counselor, and was then directed to a lead eighth grade classroom teacher. The teachers were asked to identify a class that would represent the general population of the school.

Following the treatment, the posttest was administered by the researcher to both the treatment group and the control group during Fall Term 1992, during the period of November 5th through December 4th. The testing dates were determined by the completion of specific school's 12 week rotation. Peppenhorst (1987) indicated that students taking critical thinking tests score significantly higher in the morning. Therefore, all tests were administered in the morning.

Scores were collected by the use of the researcher designed answer sheet. In addition to providing spaces to respond to the 76 multiple choice questions of the CCTT, spaces were provided for students to indicate gender, whether or not they had taken a technology education course before (and how many), and if they were currently enrolled in math, pre-algebra, algebra, and / or science.

Data Analysis Techniques, Statistics

Single Factor Analysis of Variance was used to determine if differences exist at the .05 level of probability. Tests were conducted to determine if differences exists on total scores for the CCTT, on section scores (induction, credibility, deduction, and identification of assumptions), between genders, and between students enrolled in math, pre-algebra, algebra, and science.

CHAPTER IV

FINDINGS

Problem Statement

Nationwide, major efforts are being focused on revamping technology education curriculum. Efforts target curriculum content, retraining of teachers, retooling laboratories and changing images with the hope that the program will improve student problem solving and critical thinking abilities. However, there is no empirical evidence to support the contention that technology education improves or enhances critical thinking and problem solving skills of students.

Purpose of the Research

The purpose of the study was to collect empirical data to determine whether technology education promotes or facilitates critical thinking and problem solving skills of eighth grade students.

Research Questions

Two primary research questions guided the conduct of the study:

(1) Will eighth grade students enrolled in technology education score significantly higher on critical thinking tests than eighth grade students not enrolled in technology education?

(2) Will eighth grade students enrolled in technology education and math or algebra or pre-algebra or science score significantly higher on critical thinking tests than eighth grade students not enrolled in technology education?

Description of Experimental and Control Groups

The population for the study was eighth grade students enrolled in schools in the State of Kentucky. The treatment group was comprised of students enrolled in intact courses in eleven new technology education programs. Students attending those schools were required to take a technology education course during their eighth grade year. The control group was comprised of eighth grade students enrolled in schools not offering technology education courses.

The population was comprised of ten middle schools, five control and five treatment classes. The classes representing control one and two (C1 & C2) and treatment one and two (T1 & T2) were best described as urban large city schools. The classes representing control four and five (C4 & C5) and treatment three and four (T3 & T4) were best described as rural county schools. The classes representing control three (C3) and treatment five (T5) were best described as rural small county schools.

The five control classes were comprised of 109 students, 52 males and 57 females. The treatment classes were comprised of 99 students, 63 males and 36 females. Data are recorded in Table I. Students in the study were asked to identify specific courses (math, pre-algebra, algebra, and science) in which they were currently enrolled. Ninety-eight students indicated they were in math. Of the 98, 53 were in the control group and 45 were in the treatment group. Of the 53 in the control group 31 were males and 22 were females. The treatment group was comprised of 28 males and 17 females. Seventy-seven students indicated they were in pre-algebra. Of the 77, 50 were in the control group and 27 were in the treatment

TABLE I

NUMBER OF STUDENTS BY TREATMENT BY SCHOOL BY SEX

GROUPS (n=208)							
Treatment (n=99)				Control (n=109)			
School	males	females	total	School	males	females	total
T1	20	6	26	C1	13	12	25
T2	16	6	22	C2	12	8	20
T3	8	12	20	C3	11	13	24
T4	8	8	16	C4	10	12	22
T5	11	4	15	C5	6	12	18
Totals	63	36	99		52	57	109

Females = 93
Males = 115

group. Of the 50 in the control group 20 were males and 30 were females. The treatment group was comprised of 14 males and 13 females. Thirty-eight students indicated they were in algebra. Of the 38, five were in the control group and 33 were in the treatment group. Of the five in the control group three were males and two were females. The treatment group was comprised of 27 males and six females. One hundred ninety-five students indicated they were in science. Of the 195, 107 were in the control group and 88 were in the treatment group. Data are recorded in Table II.

TABLE II

NUMBER OF STUDENTS BY TREATMENT
BY COURSES BY SEX

GROUPS (n=208)						
	Treatment (n=99)			Control (n=109)		
Course	males	females	total	males	females	total
Math	28	17	45	31	22	53
Pre-Alg	14	13	27	20	30	50
Algebra	27	6	33	3	2	5
Science	-	-	88	-	-	107

Findings Related to Research Questions

The total score and the four sectional scores, induction, credibility, deduction, and identification of assumptions, were tabulated and compared for differences, between the treatment and control groups. Single Factor Between Subjects Analysis of

Variance tests were run using the SYSTAT: The System for Statistics software package. Two different units of analysis were used, school and student. Student as a unit of analysis was used when the number of subjects per cell in the groups fell below 15. Mean score data by class by group by subtest is represented in Figure 3, and mean score data by group by subtest is represented in Figure 4. Specific mean scores for all ANOVA tests are included in Appendix B.

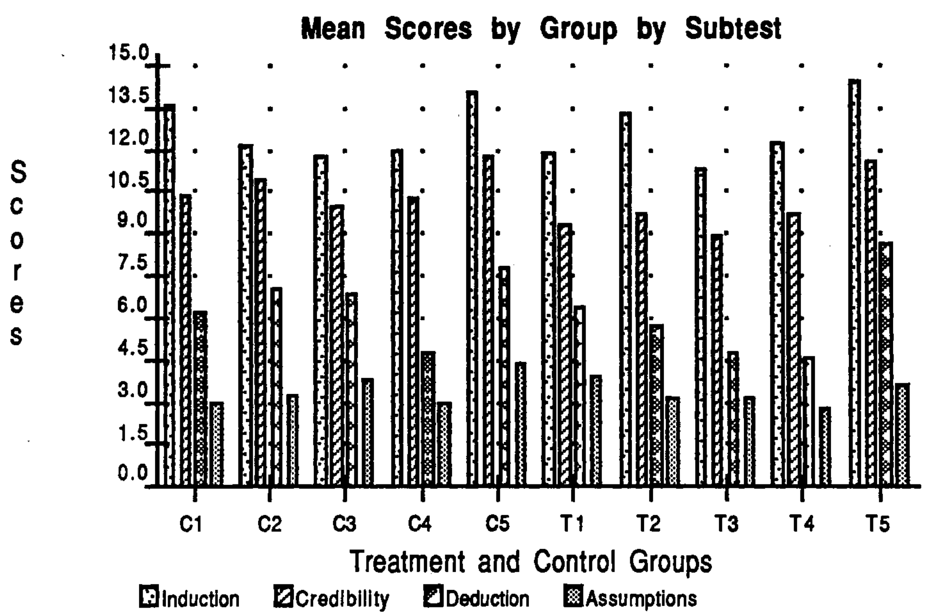


Figure 3. Mean Scores by Class by Group by Subtest on CCTT

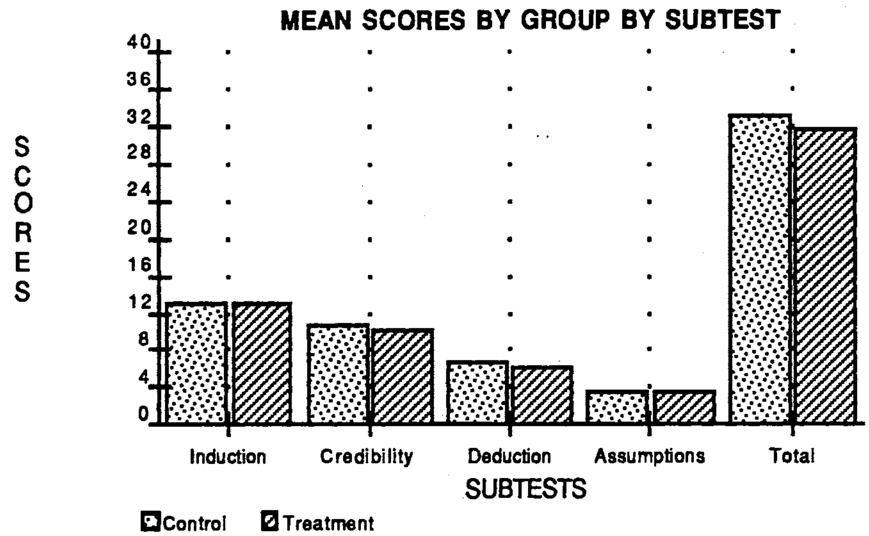


Figure 4. Mean Scores by Group by Subtest on CCTT

<u>Research Question #1</u>

(1) Will eighth grade students enrolled in technology education score significantly higher on critical thinking tests than eighth grade students not enrolled in technology education?

Using school as the unit of analysis, five separate Single Factor Between Subjects Analysis of Variance tests were run. The five tests were comprised of a comparison of groups (treatment and control) to the total score and four sectional scores of the CCTT (dependent variables). There were no significant differences.

Tables III through VII record the results of ANOVA calculations.

TABLE III

ANOVA SUMMARY TABLE FOR DIFFERENCES BETWEEN EXPERIMENTAL AND CONTROL GROUP ON OVERALL SCORE ON CCTT

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	5.685	1	5.685	0.471	0.512
ERROR	96.608	8	12.076		

TABLE IV

ANOVA SUMMARY TABLE FOR DIFFERENCES BETWEEN EXPERIMENTAL AND CONTROL GROUP ON INDUCTION SUBSCORE ON CCTT

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	0.007	1	0.007	0.005	0.945
ERROR	10.579	8	1.322		

TABLE V

ANOVA SUMMARY TABLE FOR DIFFERENCES BETWEEN EXPERIMENTAL AND CONTROL GROUPS ON CREDIBILITY SUBSCORE ON CCTT

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	1.573	1	1.573	1.990	0.196
ERROR	6.327	8	0.791		

TABLE VI

ANOVA SUMMARY TABLE FOR DIFFERENCES BETWEEN EXPERIMENTAL AND CONTROL GROUPS ON DEDUCTION SUBSCORE ON CCTT

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	0.610	1	0.610	0.300	0.599
ERROR	16.249	8	2.031		

TABLE VII

ANOVA SUMMARY TABLE FOR DIFFERENCES BETWEEN EXPERIMENTAL AND CONTROL GROUPS ON IDENTIFICATION OF ASSUMPTIONS SUBSCORE ON CCTT

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	0.075	1	0.075	0.285	0.608
ERROR	2.107	8	0.263		

For comparing differences between the treatment and control group crossed with gender to the total score and the four sectional scores of the CCTT, student was used as the unit of analysis. This was because n was less than fifteen when examining gender in the control or treatment groups at the level of school.

Five separate Between Subjects Analysis of Variance tests were run. The five tests were comprised of a comparison of groups (treatment and control) and gender (male and female) to the total score and four sectional scores of the CCTT (dependent variables). There were no significant differences on the interaction between group and gender. There was a significant difference (p=0.046) with the main effect gender and the dependent variable induction subscore of the CCTT. Data are recorded in Table VIII. There was a significant difference (p=0.050) with the main effect group and the dependent variable credibility subscore of the CCTT. Data are recorded in Table VIII.

TABLE VIII

EXPERIMENTAL AND CONTROL DIFFERENCES BY GENDER BY SUBSECTIONS OF CCTT

P Values			
Student Level Data Gender			
Source	Dep. Var	F-Ratio	P
Group	Total	3.120	0.079
Gender	Total	3.253	0.073
Group X Gender	Total	0.183	0.669
Group	Induction	0.305	0.582
Gender	Induction	4.027	0.046*
Group X Gender	Induction	0.023	0.880
Group	Credibility	3.872	0.050*
Gender	Credibility	0.008	0.927
Group X Gender	Credibility	0.010	0.921
Group	Deduction	1.959	0.163
Gender	Deduction	1.253	0.264
Group X Gender	Deduction	0.851	0.357
Group	Assumptions	0.266	0.607
Gender	Assumptions	0.961	0.328
Group X Gender	Assumptions	0.002	0.967

* Indicates significant difference

Research Question #2

(2) Will eighth grade students enrolled in technology education and math or algebra or pre-algebra or science score significantly higher on critical thinking tests than eighth grade students not enrolled in technology education?

Using student as the unit of analysis, due to cell size, five separate Between Subjects Analysis of Variance tests were run per course (math, pre-algebra, algebra, and science) for a total of twenty ANOVAs. The five tests were comprised of a comparison of groups (treatment and control) crossed with course (either math, pre-algebra, algebra, or science), to the total score and four sectional scores of the CCTT (dependent variables). Even at the student level of analysis, cell size was below 15 in both algebra (five control students in algebra) and science (two control students not in science and eleven treatment students not in science). There was one significant difference on the interaction between group and class. It occurred at group crossed with pre-algebra with identification of assumptions subscore as the dependent variable ($p=0.049$). Results are recorded in Table X. There was a significant difference with the main effect math at the dependent variables overall score (p=0.000), induction subscore (p=0.000), credibility subscore (p=0.027), and deduction subscore (p=0.000) of the CCTT. Results are recorded in table IX. There was a significant difference (p=0.045) with the main effect pre-algebra and the dependent variable credibility subscore of the CCTT. Results are recorded in Table X.

TABLE IX

EXPERIMENTAL AND CONTROL DIFFERENCES
BY MATH BY SUBSECTIONS OF CCTT

	P Value		
Student Level Data Math			
Source	Dep. Var	F-Ratio	P
Group	Total	2.989	0.085
Math	Total	28.280	0.000*
Group X Math	Total	0.089	0.766
Group	Induction	0.207	0.650
Math	Induction	20.310	0.000*
Group X Math	Induction	1.978	0.161
Group	Credibility	4.371	0.038*
Math	Credibility	4.952	0.027*
Group X Math	Credibility	0.010	0.920
Group	Deduction	1.713	0.192
Math	Deduction	19.093	0.000*
Group X Math	Deduction	0.061	0.805
Group	Assumptions	0.102	0.749
Math	Assumptions	0.493	0.483
Group X Math	Assumptions	1.191	0.276

* Indicates significant difference

TABLE X

EXPERIMENTAL AND CONTROL DIFFERENCES BY PRE-ALGEBRA BY SUBSECTIONS OF CCTT

	P Value		
Student Level Data			
Pre-Algebra			
Source	Dep. Var	F-Ratio	P
Group	Total	2.162	0.143
Pre-Alg	Total	3.755	0.054
Group X Pre-Alg	Total	2.782	0.097
Group	Induction	0.179	0.673
Pre-Alg	Induction	1.363	0.244
Group X Pre-Alg	Induction	2.611	0.108
Group	Credibility	2.111	0.148
Pre-Alg	Credibility	4.086	0.045*
Group X Pre-Alg	Credibility	0.066	0.797
Group	Deduction	1.367	0.244
Pre-Alg	Deduction	0.655	0.419
Group X Pre-Alg	Deduction	0.880	0.349
Group	Assumptions	0.545	0.461
Pre-Alg	Assumptions	0.545	0.461
Group X Pre-Alg	Assumptions	3.927	0.049*

* Indicates significant difference

Summary

There were no significant differences in the five Single Factor Between Subjects Analysis of Variance tests which compared groups (treatment and control) to the total score and four sectional scores of the CCTT (dependent variables).

Five separate Between Subjects Analysis of Variance tests were used to compare groups (treatment and control) and gender (male and female) to the total score and four sectional scores of the CCTT (dependent variables). There were no significant differences on the interaction between group and gender. There was a significant difference (p=0.046) with the main effect gender and the dependent variable induction subscore of the CCTT. There was a significant difference (p=0.050) with the main effect group and the dependent variable credibility subscore of the CCTT.

Five separate Between Subjects Analysis of Variance tests were run per course (math, pre-algebra, algebra, and science) for a total of twenty ANOVAs. The five tests were comprised of a comparison of groups (treatment and control) crossed with course (either math, pre-algebra, algebra, or science), to the total score and four sectional scores of the CCTT (dependent variables). There was one significant difference on the interaction between group and class. It occurred at group crossed with pre-algebra with identification of assumptions subscore as the dependent variable (p=0.049). The was a significant difference with the main effect math at the dependent variables overall score (p=0.000), induction subscore (p=0.000), credibility subscore (p=0.027), and deduction subscore (p=0.000) of the CCTT. There was a significant difference (p=0.045) with the main effect pre-algebra and the dependent variable credibility subscore of the CCTT.

CHAPTER V

RECOMMENDATIONS AND CONCLUSIONS

Problem Statement

Nationwide, major efforts are being focused on revamping technology education curriculum. Efforts target curriculum content, retraining of teachers, retooling laboratories and changing images with the hope that the program will improve student problem solving and critical thinking abilities. However, there is no empirical evidence to support the contention that technology education improves or enhances critical thinking and problem solving skills of students.

Purpose of the Research

The purpose of the study was to collect empirical data to determine whether technology education promotes or facilitates critical thinking and problem solving skills of eighth grade students.

Research Questions

Two primary research questions guided the conduct of the study:

(1) Will eighth grade students enrolled in technology education score significantly higher on critical thinking tests than eighth grade students not enrolled in technology education?

(2) Will eighth grade students enrolled in technology education and math or algebra or pre-algebra or science score significantly higher on critical thinking tests than eighth grade students not enrolled in technology education?

Conclusions

Conclusion #1

The findings from this study reveal no difference between experimental and control groups on overall CCTT scores over a 12 week period. It is therefore concluded that this study fails to empirically link technology education with the promotion or development of critical thinking and problem solving skills over a 12 week period. This conclusion supports the review of literature. Costa (1985) stated that research indicates that a change in thinking skills can occur only after a two year period of carefully designed curriculum with quality instruction.

Conclusion #2

Based upon the finding that there is no difference in CCTT test scores between genders, it is concluded that special gender specific instruction is not warranted. This conclusion supports the review of literature. Differences in gender were not identified as being factors in the development of critical thinking and problem skills.

Conclusion #3

Based upon the finding that there is no difference in CCTT test scores with students taking technology education in combination with math, pre-algebra, algebra, or science, it is concluded that technology education does not promote or develop critical thinking and problem solving skills in a 12 week period of time. Although a significant difference was not revealed, the review of literature indicated that the practical (Sellwood, 1989; and Nickerson,1984) and doing aspect present in technology education is an important component in the promotion or development of critical thinking and problem solving. Thode (1989), in describing the future of technology education, stated that technology education should keep the hands-on approach to learning, but include activities that involve higher level thinking skills with minds-on activities. Thus, the literature indicates that technology education has the potential to contribute to the promotion and development of critical thinking and problem solving skills.

Implications for Teacher Education

Costa (1989), Resnick and Klopfer (1989), McTighe and Schollenberger (1985), Larkin and Reif (1976), Lauda (1988), and Johnson and Thomas (1992) all indicate that education must shift from an emphasis on knowledge based or behaviorism to a more cognitive emphasis, including critical thinking and problem solving. Naisbitt (1984) and Costa (1989) stated that it is no longer possible to predict or teach the knowledge required to be a productive citizen. Thus it is imperative that students learn to think critically and problem solve. Paul (1984) indicated that most persons knowledgeable of critical thinking skills agree that school systems and teachers are not well prepared for the teaching of critical thinking. Based on the review of literature, it is recommended that teacher education address the cognitive emphasis and include critical thinking and problem solving as an integral part of teacher education programs.

Recommendations for Further Study

The significant difference found on the main effect gender, between males and females at the dependent variable, induction, does not warrant major concern. However it should be explored in future studies. This section of the CCTT was designed to assess one's ability to judge whether a simple generalization was warranted, a hypothesis was justified, or a reason was relevant. There was nothing found in the review of literature to support this finding.

The significant difference found on the main effect group at the dependent variable, credibility, does not warrant major concern but should be followed up in future studies. This section of the test was designed to represent one's ability to judge whether an alleged authority of an observation is reliable. On this ANOVA test the control group scored significantly higher than the treatment group.

If this finding were to be substantiated in future studies it might infer that technology education relies too much on the sequential, (step one, step two, step three), methods to find the one correct answer, and does not promote the careful evaluation necessary in critical thinking. This finding is not supported in the literature. The literature indicates that it takes much longer to change a student's thinking skills.

The significant difference found on the interaction, group crossed with pre-algebra at the dependent variable, identification of assumptions, does not warrant major concern but should be followed up in future studies. This section of the CCTT was designed to identify assumptions and determine whether reason is relevant for a given deduction. On this ANOVA test the control group scored significantly higher than the treatment group. If this finding were to be substantiated in future studies it might infer that analysis and evaluation need to be addressed more in the technology education curriculum.

The significant difference found on the main effect math at the dependent variables, total, induction, credibility, and deduction, and the main effect pre-algebra at the dependent variable credibility, indicate a definite pattern. Those students in math scored significantly lower than those in pre-algebra and algebra. This can be interpreted that pre-algebra and algebra promotes the development of critical thinking skills. Another interpretation, and a more likely one in the opinion of the researcher, is that only the better students (academically) are placed in pre-algebra and algebra. Therefore this significant difference is expected. Follow up studies, to determine if pre-algebra or algebra can increase critical thinking skills and if pre-algebra and algebra are equally effective on low, medium, and high ability students, are needed.

Recommendations

The researcher recommends that technology education should become an integral component of general education. Technology education is an integrative program that can provide relevance and application to concepts learned in other academic areas. This is essential in a technologically advancing world.

The researcher recommends that studies be conducted to determine if two years or more of a well developed technology education curriculum can promote the development of critical thinking and problem solving skills. Additional studies should be conducted to determine how technology education can contribute to a school wide curriculum aimed at promoting and developing critical thinking and problem solving skills.

BIBLIOGRAPHY

Baker, G. E. & Dugger, J. C., III. (1986). Helping students develop problem solving skills. The Technology Teacher, 45 (4), 10-13.

Brownell, W. A. (1942). Problem solving. In N.B. Henry (ed), The psychology of learning. 41st Yearbook of the National Society for the Study of Education. Chicago: National Society for the Study of Education

Campbell, D. T. & Stanley, J. C. (1966). Experimental and Quasi-experimental designs for research. Chicago: Rand McNally

Costa, A. L. (1985). Developing minds: a resource book for teaching thinking. Alexandria, VA: ASCD.

Costa, A. L. (1989). Foreword. In L.B. Resnick & L.E. Klopfer (Eds.), Toward the thinking curriculum: current cognative research (pp. vi-viii). Alexandria, VA: ASCD.

Cyert, R. M. (1980). Problem solving and educational policy. In Tuma, D. T. & Reif, F. (Eds.), Problem Solving and Education: Issues in Teaching and Research (pp. 3-8). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Ennis, R. H., Millman, J. & Tomko, T. N. (1985). Cornell critical thinking tests, level X & level Z manual. Pacific Grove, CA: Midwest Publications.

Falkof, L. & Moss, J. (1984). When teachers tackle thinking skills. Educational Leadership , 42, 4-9.

Fedje, C. G. & Irvine, A. (1982). Questions to promote thinking. VocEd, 57, 27-29.

Greenan, J. P. & McCabe, C. C. (1989, Spring). Development and validation of generalizable reasoning skills assessment strategies and procedures. JITE, 26 (3), 38-50.

Greenfield, L.B. (1987). Teaching thinking through problem solving. In J. E. Stice (ed), Developing critical thinking and problem-solving abilities (pp. 5-22). San Francisco, CA: Jossey-Bass.

Goldman, L. (1984, September). Warning: the Socratic Method can be dangerous. Educational Leadership, 42, 57-65.

Helmstadter, G. C. (1985). Review of Watson-Glaser Critical Thinking Appraisal. In Mitchell, J.V. (Ed) The Ninth Mental Measurement Yearbook (1693-1694), Volume II. Lincoln, Nebraska: The University of Nebraska Press.

Howe, H.,II. (1983). Education moves to center stage: An overview of recent studies. Phi Delta Kappan, 65 (3), 167-172.

Johnson, J. R. (1989). Technology: Report of the project 2061 phase I technology panel. Washington, D. C.: American Assiciation for the Advancement of Science.

Johnson, S.D. & Thomas, R. (1992). Technology education and the cognative revolution. The Technology Teacher, 51 (4), pp. 7-12.

Jones, R. E. & Wright, J. R. (Eds). (1986). Implementing technology education (35th yearbook, American council on industrial arts teacher education). Encino, CA: Glencoe.

KCITE, (1992, February). Position paper on technology education. Position paper from Kentucky Council for Industrial Education.

Kramer, J. J. and Conoley, J. C. (1992). The eleventh mental measurements yearbook. Lincoln, Nebraska: The University of Nebraska Press.

Landis, R.E. and Michael, W.B. (1981). The factorial validity of three measures of critical thinking within the context of Guilford's Structure-of-Intellect Model for a sampling of ninth grade students. Educational and Psychological Measurments. 41, 1147-1166.

Larkin, J. & Reif, F. (1976). Analysis and teaching of a general skill for studying scientific text, Journal of educational psychology. 68 (4), 431-440.

Lauda, D. P. (1988). Technology education. In Kemp, W. H. & Schwaller, A. E. (Eds), Instructional strategies for technology education. Mission Hills, CA: Glencoe.

Malcolm, K. K. (1992). Review of the Cornell Critical Thinking Tests. In Kramer, J. J. and Conoley, J. C. (1992). The eleventh mental measurements yearbook (243-244), Lincoln, Nebraska: The University of Nebraska Press.

McMillen, L. (1986, March 5). Many professors now start at the beginning by teaching their students how to think. The Chronicle of Higher Education, 32, (1), 23-25.

McTighe,J. & Schollenberger, J. (1985). Why teach thinking: a statement of rationale. In A. L. Costa (Ed.), Developing minds: a resource book for teaching thinking (pp. 3-6), Alexandria, VA: ASCD.

Miller, M. H.; Noland, K. & Schaaf, J. (1990). A guide to the Kentucky education reform act of 1990. Frankfort, KY: Legislative Research Commission.

Mitchell, J.V. (1985). The ninth mental measurement yearbook, Volume II. Lincoln, Nebraska: The University of Nebraska Press.

Naisbitt, J. (1984). Megatrends: ten new directions transforming our lives. New York, NY: Warner Books.

Naisbitt, J. & Aburdene, P. (1985). Re-inventing the corporation. New York: Megatrends Ltd. (Warner Books).

National Science Board Commission on Pre-College Education in Mathematics, Science, & Technology. (1983). Educating Americans for the 21st century. Washington, D.C.

Nickerson, R. S. (1984). Kinds of thinking taught in current programs. Educational Leadership, 42, 26-36.

Peppenhorst, S. N. (1987). The effects of time of day and cerebral dominance on the critical thinking ability of high school seniors. Unpublished doctoral dissertation, Memphis State University, Memphis.

Presseisen, B. Z. (1985). Thinking skills: meanings and models. In A. L. Costa (Ed.), Developing minds: a resource book for teaching thinking (pp. 43-48), Alexandria, VA: ASCD.

Paul, R. W. (1984, September). Critical thinking: fundamental to education for a free society. Educational Leadership, 42, 4-14.

Resnick, L.B. & Klopfer, L.E. (1989). Toward the thinking curriculum: an overview. In L.B. Resnick & L.E. Klopfer (Eds.), Toward the thinking curriculum: current cognative research (pp. 1-18), Alexandria, VA: ASCD.

Rowe, H. A. H. (1985). Problem solving and intelligence. Hillsdale, New Jersey.

Savage, E. & Sterry, L. (1990, Sept./ Oct.). A conceptual framework for technology education. The Technology Teacher, 50 (1), 6-11.

Savage, E. & Sterry, L. (1990,November). A conceptual framework for technology education part 2. The Technology Teacher, 50 (2), 7- 11.

Sellwood, P. (1989, December). The role of problem solving in developing thinking skills. The Technology Teacher, 49 (3), 3-10.

Seymour, R. D. (1990). The degree to which classroom and laboratory activities in the Indiana industrial technology education curriculum contribute to student creative problem solving abilities as evaluated by Indiana technology educators. Unpublished doctoral dissertation, West Virginia University, Morgantown.

Stanley, R. (1991). Technology Education in the 21st Century. Frankfort, Kentucky: Industrial Education Unit, Kentucky Department of Education.

Stern, B. E. (1991, January). Technology education as a component of fundamental education. The Technology Teacher, 50 (4), 3-7.

Stern, B. E. (1991, March). Technology education as a component of fundamental education part two. The Technology Teacher, 50 (5), 9-12.

Thode, B. (1989, November). Applying higher level thinking skills. The Technology Teacher, 49 (2), 6-13.

Wright, R. T. & Sterry, L. (1983). Industry & Technology education: A guide for curriculum designers, implementors, and teachers. Lansing, IL: Technical Foundation of America.

APPENDIXES

APPENDIX A

TECHNOLOGY EDUCATION

MODULES

MODULE DESCRIPTIONS

The following modules are supported by the State Department of Education and are described on pages 19 through 24 in:

Stanley, R. (1991). Technology Education in the 21st Century. Frankfort, Kentucky: Industrial Education Unit, Kentucky Department of Education.

Aerospace

The past, present, and future of air and space flight are introduced to the student through this module. The student will use video tapes, books, computer programs and activities of building a plane and or rocket. The level I student will use prepared kits to build the flying craft. The level II student will build the flying craft using basic materials.

Alternate Energy Systems

Fossil fuels have been used to satisfy our energy needs for more generations. Problems with supply and pollution have resulted in the need to explore energy alternatives. The Alternate Energy Systems module is designed to introduce the student to energy sources that can be used to replace fossil fuels.

Applied Physics

The student studying this module will discover the uses and principles of basic mechanisms, hydraulics and pneumatics. Physical principles of leverage, gear ratios, pressure in cylinders are some of the topics that will be covered.

Audio-Video

The Audio-Video module will involve the student in the technology of audio-video production. The level I student will produce an audio tape using a variety of input choices. Level II will have the student producing an audio tape and a videotape using cameras and editors much like the equipment used to produce the videotapes viewed in these modules.

Biotechnology

Biotechnology is a rapidly growing industry, it is the merging of several technologys into one. It uses principals of the medical field and the agricultural industry. In this module the students will be studying hydrophonics, genetic engineering, DNA, and fermentation.

Careers

Career choices are not easy for anyone to make, especially young adults. This module will provide some explorations into different career areas so that they can start making some decisions.

Computer Aided Drafting

Technological advances start with in idea put into a drawing for others to understand. This module takes the student through the basic concepts of drafting and leads the student to the computer technology known as CAD. Students will have the opportunity to advance to a level that uses AutoSketch or AutoCAD.

Computer Graphics

Computer generated graphics are used today in TV, movies, newspapers, technical publications and many other areas. This module will allow the student to create graphics on the computer with graphics programs, and BASIC programing. The student will be able to combine the graphics into an animated computer display.

Computer Numerical Control/Computer Assisted Manufacturing

Modern manufacturing relies on the technology of CNC/CAM systems. The student working on this module will discover the technology that allows a computer to control the operation of machine tools. This technology is a basic requirement of robotic manufacturing systems and automated industries. Level I will introduce basic milling operations and will result in the student programming a milling system to engrave nameplates, or plaques. The level II student will produce a machine part by programming the milling system to make cuts in three dimensions.

Desktop Publishing

The printed word is still one of the best ways to communicate. The technology introduced in this module allows the student to apply computer technology in the production of printed materials. Desktop publishing systems are used in the publishing of cards, books, newspapers, advertising flyers, and other items where the best way to spread a message is with ink and paper.

Electricity/Electronics

The electricity/electronics module will allow the student to explore basic theories and applications of electronic circuits. Electricity is the most versatile form of energy that is available to technological world. Electronics uses this energy source for computers and other "high technology" applications. This module directs the student in the construction, testing, and analyzing of basic electronic circuits.

Engineering Structures

The building and testing of model bridges introduces the student to the world of civil engineering. This module provides the student with the opportunity to test a bridge the student has designed and built. The student may select a standard engineering design or experiment with a design that is developed from the student's own ideas and imagination. Students will also construct a geodesic dome structure.

Environmental Impacts

The environment is rapidly changing, and in some cases something must be done to preserve it. This module will introduce the student to global warming it's causes and affects. The student will also study pollution, recycling, waste reduction and ozone layer depletion.

Home Maintenance

The need to understand and repair the personal home is becoming a necessity for many people. In this module the student will explore the technologies at work in the home. The student will learn maintenance and repair methods that can save a home owner many dollars. The plumbing, electrical, and structural systems in the home will be covered in this module.

Laser/Fiber Optic Technology

This module will allow the student to use Helium-Neon lasers to explore the basic principles, and applications of lasers. Some of the experiments use fiber optic cable to acquaint the student with the cable's ability to transmit the laser light. Level II students will be able to further explore fiber optic technology with the fiber optic course materials.

Mass Production

In this module the student will study techniques developed by Henry Ford. Ford's idea for mass production has to be ranked as one of the most significant advances ever made in the manufacturing industry. Mass production techniques remain the corner stone of modern manufacturing processes.

Photography

Photography is a technology that is over 150 years old. Today the use of photography is vital to research work, manufacturing of integrated circuits, and other areas of technology. This is in addition to the traditional uses of recording daily events for news publications and family memories. The level I and level II student will construct and use a pinhole camera to learn the basic principles of photography. The student will develop photographs and make a photogram while learning basic darkroom techniques. The level II student will go on to using a single-lens-reflex camera to further explore photographic techniques.

Plastics

Plastics play a major role in today's society, from the automobiles we drive to the containers for our food. There are many different types of plastics and there are several ways plastics can be formed. The student will study injection molding, vacuum forming, fiberglass application, resin cast and polystyrene expansion.

Problem Solving

This module will allow the student to use different approaches in problem solving. The student will also use the module to discover alternative solutions and how to use problem solving to make decisions on various problems.

Production

This module will instruct the student in basic woodworking and plastics technology. The level I student will produce a letter holder using wood and acrylic plastic. The level II student will produce a CD holder using the same materials. Safety is emphasized in this module. Safety glasses will be required any time the student is working with power tools. Visitors (instructor) should also have safety glasses when power tools are in use.

Research and Design

The Research and Design module will allow the level I student to use critical thinking and creative design to produce a magnetic levitation vehicle. The student will design and manufacture a MagLev Racer. The MagLev Racer is a vehicle that floats on a magnetic field. The level II student will design, produce and race a CO_2 powered dragster. These vehicles will be tested and raced to see if the student's research and design are efforts are sound. [SAFETY NOTE: INSTRUCTORS MUST DISABLE THE CO_2 RACER BY PERMANENTLY FILLING THE CARTRIDGE HOLE WITH A DOWEL OR SPENT CO_2 CARTRIDGE BEFORE THE STUDENT CAN BE ALLOWED TO TAKE THE RACER HOME.]

Robotics

The use of robots advancement in the manufacturing industries since Henry Ford developed the concept of the assembly line. Robot technology has been a benefit by allowing a machine to replace humans in jobs that are dangerous or monotonous. However, in replacing humans in some jobs many more jobs have been developed for people to design and maintain the robotic systems. This module will introduce the student to the basics of robot design, control, and applications.

Transportation

The transportation of people, goods, materials, and supplies is an area of major importance. The internal combustion engine that runs on fossil fuel is becoming an endangered species in many large cities. The need for non-polluting transportation systems to move people and materials from place to place is becoming a necessity. This module allows the student to explore present and future transportation methods.

Modules Under Development

COMPUTER INTEGRATED MANUFACTURING
ELECTRICAL SYSTEMS
MEDIA TECHNOLOGY
TEAM PROBLEM SOLVING

APPENDIX B

SYSTAT PRINTOUT
SHEETS

Total School
Group (control and treatment)
at Total and Subtest of
CCTT

TOTAL Test #1

LEVELS ENCOUNTERED DURING PROCESSING ARE:
GROUP
0.000 1.000

DEP VAR: TOTAL N: 10 MULTIPLE R: 0.236 SQUARED MULTIPLE R: 0.056
ESTIMATES OF EFFECTS B= (X'X)-1 X'Y

		TOTAL
CONSTANT		32.228
GROUP	0.000	0.754

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	5.685	1	5.685	0.471	0.512
ERROR	96.608	8	12.076		

LEAST SQUARES MEANS

			LS MEAN	SE	N
GROUP	=	0.000	32.982	1.554	5
GROUP	=	1.000	31.474	1.554	5

INDUCTION Test #2

LEVELS ENCOUNTERED DURING PROCESSING ARE:
GROUP
0.000 1.000

DEP VAR: C326 N: 110 MULTIPLE R: 0.025 SQUARED MULTIPLE R: 0.001
ESTIMATES OF EFFECTS B = (X 'X) -1 X'Y

		C326
CONSTANT		12.588
GROUP	0.000	0.026

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	O.007	1	0.007	0.005	0.945
ERROR	10.579	8	1.322		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	12.614	0.514	5
GROUP	=	1.000	12.563	0.514	5

CREDIBILITY Test #3

LEVELS ENCOUNTERED DURING PROCESSING ARE:
GROUP
0.000 1.000

DEP VAR: C2751 N: 10 MULTIPLE R: 0.446 SQUARED MULTIPLE R: 0.199
ESTIMATES OF EFFECTS B = (X'X)-1 X'Y

		C2751
CONSTANT		10.149
GROUP	0.000	0.397

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	1.573	1	1.573	1.990	0.196
ERROR	6.327	8	0.791		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	10.546	0.398	5
GROUP	=	1.000	9.753	0.398	5

DEDUCTION Test #4

LEVELS ENCOUNTERED DURING PROCESSING ARE:
GROUP
0.000 1.000

DEP VAR: C52N: 10 MULTIPLE R: 0.19O SQUARED MULTIPLE R: 0.036
ESTIMATES OF EFFECTS B = (X'X)-1 X'Y

		C52
CONSTANT		6.171
GROUP	0.000	0.247

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	0.610	1	0.610	0.300	0.599
ERROR	16.249	8	2.031		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	6.418	0.637	5
GROUP	=	1.000	5.924	0.637	5

ASSUMPTIONS Test #5

LEVELS ENCOUNTERED DURING PROCESSING ARE:
GROUP
0.000 1.000

DEP VAR: C67 N: 10 MULTIPLE R: 0.186 SQUARED MULTPLE R: 0.034
ESTIMATES OF EFFECTS B = (X'X)-1 X'Y

		C67
CONSTANT		3.321
GROUP	0.000	0.087

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	0.075	1	0.075	0.285	0.608
ERROR	2.107	8	0.263		

LEAST SQUARES MEANS.

			LS MEAN	SE	N
GROUP	=	0.000	3.408	0.229	5
GROUP	=	1.000	3.235	0.229	5

TOTAL STUDENT
Group (control and treatment)
crossed with Math at
Total and Subtest of
CCTT

TOTAL Test #1

LEVELS ENCOUNTERED DURING PROCESSING ARE:

GROUP		
	0.000	1.000
MATH		
	0.000	1.000

DEP VAR: TOTAL N: 208 MULTIPLE R: 0.362 SQUARED MULTIPLE R: 0.131
ESTIMATES OF EFFECTS B = (X ' X)-1 X'Y

		TOTAL
CONSTANT		31.841
GROUP	0.000	0.878
MATH	0.000	2.700
GROUP	0.000	
MATH	0.000	-0.151

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARES	F-RATIO	P
GROUP	159.197	1	159.197	2.989	0.085
MATH	1506.184	1	1506.184	28.280	0.000
GROUP*MATH	4.735	1	4.735	0.089	0.766
ERROR	10865.046	204	53.260		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	32.719	0.699	109
GROUP	=	1.000	30.963	0.737	99
MATH	=	0.000	34.541	0.696	110
MATH	=	1.000	29.140	0.740	98
GROUP	=	0.000			
MATH	=	0.000	35.268	0.975	56
GROUP	=	0.000			
MATH	=	1.000	30.170	1.002	53
GROUP	=	1.000			
MATH	=	0.000	33.815	0.993	54
GROUP	=	1.000			
MATH	=	1.000	28.111	1.088	45

INDUCTION Test #2

LEVELS ENCOUNTERED DURING PROCESSING ARE:

GROUP		
	0.000	1.000
MATH		
	0.000	1.000

DEP VAR: C326 N: 208 MULTIPLE R: 0.310 SQUARED MULTIPLE R: 0.096

ESTIMATES OF EFFECTS B = (X'X)-1 X'Y

		C326
CONSTANT		12.432
GROUP	0.000	0.123
MATH	0.000	1.218
GROUP MATH	0.000 0.000	-0.380

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	3.116	1	3.116	0.207	0.650
MATH	306.433	1	306.433	20.310	0.000
GROUP*MATH	29.841	1	29.841	1.978	0.161
ERROR	3077.893	204	15.088		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	12.555	0.372	109
GROUP	=	1.000	12.309	0.392	99
MATH	=	0.000	13.650	0.370	110
MATH	=	1.000	11.214	0.394	98
GROUP MATH	= =	0.000 0.000	13.393	0.519	56

GROUP	=	0.000			
MATH	=	1.000	11.717	0.534	53
GROUP	=	1.000			
MATH	=	0.000	13.907	0.529	54
GROUP	=	1.000			
MATH	=	1.000	10.711	0.579	45

CREDIBILITY Test #3

LEVELS ENCOUNTERED DURING PROCESSING ARE:

GROUP

0.000 1.000

MATH

0.000 1.000

DEP VAR: C2751 N: 208 MULTIPLE R: 0.207 SQUARED MULTIPLE R: 0.043

ESTIMATES OF EFFECTS B = (X'X) -1 X'Y

		C2751
CONSTANT		10.030
GROUP	0.000	0.434
MATH	0.000	0.462
GROUP MATH	0.000 0.000	0.021

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN SQUARES	F-RATIO	P
GROUP	38.857	1	38.857	4.371	0.038
MATH	44.027	1	44.027	4.952	0.027
GROUP*MATH	0.091	1	0.091	0.010	0.920
ERROR	1813.657	204	8.890		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	10.464	0.286	109
GROUP	=	1.000	9.596	0.301	99

MATH	=	0.000	10.492	0.284	110
MATH	=	1.000	9.568	0.302	98
GROUP	=	0.000			
MATH	=	0.000	10.946	0.398	56
GROUP	=	0.000			
MATH	=	1.000	9.981	0.410	53
GROUP	=	1.000			
MATH	=	0.000	10.037	0.406	54
GROUP	=	1.000			
MATH	=	1.000	9.156	0.444	45

DEDUCTION Test #4

LEVELS ENCOUNTERED DURING PROCESSING ARE:

GROUP		
	0.000	1.000
MATH		
	0.000	1.000

DEP VAR: C5266 N: 208 MULTIPLE R: 0.304 SQUARED MULTIPLE R: 0.092

ESTIMATES OF EFFECTS B = (X'X) -1 X'Y

		C5266
CONSTANT		6.055
GROUP	0.000	0.276
MATH	0.000	0.921
GROUP	0.000	
MATH	0.000	0.052

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	15.699	1	15.699	1.713	0.192
MATH	175.019	1	175.019	19.093	0.000
GROUP*MATH	0.559	1	0.559	0.061	0.805
ERROR	1869	204	9.167		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	6.331	0.290	109
GROUP	=	1.000	5.780	0.306	99
MATH	=	0.000	6.976	0.289	110
MATH	=	1.000	5.135	0.307	98
GROUP MATH	= =	0.000 0.000	7.304	0.405	56
GROUP MATH	= =	0.000 1.000	5.358	0.416	53
GROUP MATH	= =	1.000 0.000	6.648	0.412	54
GROUP MATH	= =	1.000 1.000	4.911	0.451	45

ASSUMPTIONS Test #5

LEVELS ENCOUNTERED DURING PROCESSING ARE:

GROUP		
	0.000	1.000
MATH		
	0.000	1.000

DEP VAR: C6776 N: 208 MULTIPLE R: 0.096 SQUARED MULTIPLE R: 0.009

ESTIMATES OF EFFECTS B = (X'X) -1 X'Y

		C6776
CONSTANT		3.323
GROUP	0.000	0.046
MATH	0.000	0.100
GROUP MATH	0.000 0.000	0.156

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	0.431	1	0.431	0.102	0.749
MATH	2.072	1	2.072	0.493	0.483
GROUP*MATH	5.009	1	5.009	1.191	0.276
ERROR	857.779	204	4.205		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	3.369	0.196	109
GROUP	=	1.000	3.278	0.207	99
MATH	=	0.000	3.424	0.196	110
MATH	=	1.000	3.223	0.208	98
GROUP	=	0.000			
MATH	=	0.000	3.625	0.274	56
GROUP	=	0.000			
MATH	=	1.000	3.113	0.282	53
GROUP	=	1.000			
MATH	=	0.000	3.222	0.279	54
GROUP	=	1.000			
MATH	=	1.000	3.333	0.306	45

TOTAL STUDENT
Group (control and treatment)
crossed with Pre-algebra at
Total and Subtest of
CCTT

TOTAL Test #1

LEVELS ENCOUNTERED DURING PROCESSING ARE:

GROUP		
	0.000	1.000
PREALGEB		
	0.000	1.000

DEP VAR: TOTAL N: 208 MULTIPLE R: 0.216 SQUARED MULTIPLE R: 0.046

ESTIMATES OF EFFECTS B = (X'X)-1 X'Y

		TOTAL
CONSTANT		32.125
GROUP	0.000	0.833
PREALGEB	0.000	-1.098
GROUP PREALGEB	0.000 0.000	-0.945

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	126.335	1	126.335	2.162	0.143
PREALGEB	219.343	1	219.343	3.755	0.054
GROUP*PREALGEB	162.529	1	162.529	2.782	0.097
ERROR	11917.854	204	58.421		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	32.958	0.735	109
GROUP	=	1.000	31.292	0.862	99

PREALGEB	=	0.000	31.027	0.671	131
PREALGEB	=	1.000	33.222	0.913	77
GROUP	=	0.000			
PREALGEB	=	0.000	30.915	0.995	59
GROUP	=	0.000	35.000	1.081	50
PREALGEB	=	1.000	31.139	0.901	72
GROUP	=	1.000			
PREALGEB	=	1.000	31.444	1.471	27

INDUCTION Test #2

LEVELS ENCOUNTERED DURING PROCESSSING ARE:

GROUP		
	0.000	1.000
MATH		
	0.000	1.000

DEP VAR : C326 N: 208 MULTIPLE R: 0.151 SQUARED MULTIPLE R: 0.023

ESTIMATES OF EFFECTS B = (X'X)-1 X'Y

		C326
CONSTANT		12.520
GROUP	0.000	0.127
PREALGEB	0.000	-0.349
GROUP	0.000	
PREALGAB	0.000	-0.484

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	2.920	1	2.920	0.179	0.673
PREALGEB	22.238	1	22.238	1.363	0.244
GROUP*PREALGEB	42.607	1	42.607	2.611	0.108
ERROR	3328.559	204	16.316		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	12.647	0.388	109
GROUP	=	1.000	12.394	0.456	99
PREALGEB	=	0.000	12.171	0.355	131
PREALGEB	=	1.000	12.870	0.482	77
GROUP PREALGEB	= =	0.000 0.000	11.814	0.526	59
GROUP PREALGEB	= =	0.000 1.000	13.480	0.571	50
GROUP PREALGEB	= =	1.000 0.000	12.528	0.476	72
GROUP PREALGEB	= =	1.000 1.000	12.259	0.777	27

CREDIBILITY Test #3

LEVELS ENCOUNTERED DURING PROCESSING ARE:

GROUP		
	0.000	1.000
PREALGEB		
	0.000	1.000

DEP VAR: C2751 N: 208 MULTIPLE R: 0.197 SQUARED MULTIPLE R: 0.039

ESTIMATES OF EFFECTS B = (X'X)-1 X'Y

		C2751
CONSTANT		10.188
GROUP	0.000	0.322
PREALGEB	0.000	-0.448
GROUP PREALGEB	0.000 0.000	0.057

ANALYSIS OF VARIANCE

SOURCE	SOURCE-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	18.854	1	18.854	2.111	0.148
PREALGEB	36.487	1	36.487	4.086	0.045
GROUP*PREALGEB	0.591	1	0.591	0.066	0.797
ERROR	1821.577	204	8.929		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	10.509	0.287	109
GROUP	=	1.000	9.866	0.337	99
PREALGEB	=	0.000	9.740	0.262	131
PREALGEB	=	1.000	10.635	0.357	77
GROUP	=	0.000			
PREALGEB	=	0.000	10.119	0.389	59
GROUP	=	0.000			
PREALGEB	=	1.000	10.900	0.423	50
GROUP	=	1.000			
PREALGEB	=	0.000	9.361	0.352	72
GROUP	=	1.000			
PREALGEB	=	1.000	10.370	0.575	27

DEDUCTION Test #4

LEVELS ENCOUNTERED DURING PROCESSING ARE:

GROUP

0.000 1.000

PREALGEB

0.000 1.000

DEP VAR: C5266 N: 208 MULTIPLE R: 0.123 SQUARED MULTIPLE R: 0.015

ESTIMATES OF EFFECTS B = (X'X)-1 X'Y

		C5266
CONSTANT		6.118
GROUP	0.000	0.273
PREALGEB	0.000	-0.189
GROUP	0.000	
PREALGEB	0.000	-0.219

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	13.601	1	13.601	1.367	0.244
PREALGEB	6.517	1	6.517	0.655	0.419
GROUP*PREALGEB	8.755	1	8.755	0.880	0.349
ERROR	2028.932	204	9.946		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	6.932	0.303	109
GROUP	=	1.000	5.845	0.356	99
PREALGEB	=	0.000	5.929	0.277	131
PREALGEB	=	1.000	6.307	0.377	77
GROUP	=	0.000			
PREALGEB	=	0.000	5.983	0.411	59
GROUP	=	0.000			
PREALGEB	=	1.000	6.800	0.446	50
GROUP	=	1.000			
PREALGEB	=	0.000	5.875	0.372	72
GROUP	=	1.000			
PREALGEB	=	1.000	5.815	0.607	27

ASSUMPTIONS Test #5

LEVELS ENCOUNTERED DURING PROCESSING ARE:

GROUP		
	0.000	1.000
PREALGEB		
	0.000	1.000

DEP VAR: C6776 N: 208 MULTIPLE R: 0.158 SQUARED MULTIPLE R: 0.025

ESTIMATES OF EFFECTS B = (X'X)-1 X'Y

		C6776
CONSTANT		3.299
GROUP	0.000	0.111
PREALGEB	0.000	-0.111
GROUP PREALGEB	0.000 0.000	-0.299

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	2.253	1	2.253	0.545	0.461
PREALGEB	2.253	1	2.253	0.545	0.461
GROUP*PREALGEB	16.251	1	16.251	3.927	0.049
ERROR	844.255	204	4.139		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	3.410	0.196	109
GROUP	=	1.000	3.188	0.230	99
PREALGEB	=	0.000	3.188	0.179	131
PREALGEB	=	1.000	3.410	0.243	77
GROUP PREALGEB	= =	0.000 0.000	3.000	0.265	59
GROUP PREALGEB	= =	0.000 1.000	3.820	0.288	50

GROUP	=	1.000			
PREALGEB	=	0.000	3.375	0.240	72
GROUP	=	1.000			
PREALGEB	=	1.000	3.000	0.392	27

TOTAL STUDENT
Group (control and treatment)
crossed with Gender at
Total and Subtest of
CCTT

TOTAL Test #1

LEVELS ENCOUTERED DURING PROCESSING ARE:
GROUP
0.000 1.000
SEX
0.000 1.000

DEP VAR: TOTAL N: 208 MULTIPLE R: 0.161 SQUARED MULTIPLE R: 0.026

ESTIMATES OF EFFECTS B = (X'X)-1 X'Y

		TOTAL
CONSTANT		31.856
GROUP	0.000	0.967
SEX	0.000	0.988
GROUP	0.000	
SEX	0.000	-0.234

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	186.156	1	186.156	3.120	0.079
SEX	194.117	1	194.117	3.253	0.073
GROUP*SEX	10.933	1	10.933	0.183	0.669
ERROR	12172.634	204	59.670		

LEAST SQUARE MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	32.824	0.741	109
GROUP	=	1.000	30.889	0.807	99
SEX	=	0.000	32.844	0.724	115

SEX	=	1.000	30.868	0.822	93
GROUP	=	0.000			
SEX	=	0.000	33.577	1.071	52
GROUP	=	0.000			
SEX	=	1.000	32.070	1.023	57
GROUP	=	1.000			
SEX	=	0.000	32.111	0.973	63
GROUP	=	1.000			
SEX	=	1.000	29.667	1.287	36

INDUCTION Test #2

LEVELS ENCOUNTERED DURING PROCESSING ARE:
GROUP
0.000 1.000
SEX
0.000 1.000

DEP VAR: C326 N: 208 MULTIPLE R: 0.140 SQUARED MULTIPLE R: 0.020

ESTIMATES OF EFFECTS B = (X'X)-1 X'Y

		C326
CONSTANT		12.444
GROUP	0.000	0.158
SEX	0.000	0.576
GROUP	0.000	
SEX	0.000	-0.043

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	4.988	1	4.988	0.305	0.582
SEX	65.920	1	65.920	4.027	0.046
GROUP*SEX	0.375	1	0.375	0.023	0.880
ERROR	3339.206	204	16.369		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	12.602	0.388	109
GROUP	=	1.000	12.286	0.423	99
SEX	=	0.000	13.020	0.379	115
SEX	=	1.000	11.868	0.431	93
GROUP	=	0.000			
SEX	=	0.000	13.135	0.561	52
GROUP	=	0.000			
SEX	=	1.000	12.070	0.536	57
GROUP	=	1.000			
SEX	=	0.000	12.905	0.510	63
GROUP	=	1.000			
SEX	=	1.000	11.667	0.674	36

CREDIBILITY Test #3

LEVELS ENCOUNTERED DURING PROCESSING ARE:

GROUP

0.000 1.000

SEX

0.000 1.000

DEP VAR: C2751 N: 208 MULTIPLE R: 0.139 SQUARED MULTIPLE R: 0.019

ESTIMATES OF EFFECTS B = (X'X)-1 X'Y

		C2751
CONSTANT		10.058
GROUP	0.000	0.421
SEX	0.000	0.019
GROUP	0.000	
SEX	0.000	0.021

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	35.261	1	35.261	3.872	0.050
SEX	0.073	1	0.073	0.008	0.929
GROUP*SEX	0.089	1	0.089	0.010	0.921
ERROR	1857.925	204	9.107		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	10.479	0.289	109
GROUP	=	1.000	9.637	0.315	99
SEX	=	0.000	10.077	0.283	115
SEX	=	1.000	10.039	0.321	93
GROUP	=	0.000			
SEX	=	0.000	10.519	0.419	52
GROUP	=	0.000			
SEX	=	1.000	10.439	0.400	57
GROUP	=	1.000			
SEX	=	0.000	9.635	0.380	63
GROUP	=	1.000			
SEX	=	1.000	9.639	0.503	36

DEDUCTION Test #4

LEVELS ENCOUNTERED DURING PROCESSING ARE:

GROUP

0.000 1.000

SEX

0.000 1.000

DEP VAR: C5266 N: 208 MUTLIPLE R: 0.125 SQUARED MULTIPLE R: 0.016

ESTIMATES OF EFFECTS B = (X'X)-1 X'Y

		C5266
CONSTANT		6.047
GROUP	0.000	0.313
SEX	0.000	0.250
GROUP SEX	0.000 0.000	-0.206

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	19.471	1	19.471	1.959	0.163
SEX	12.453	1	12.453	1.253	0.264
GROUP*SEX	8.455	1	8.455	0.851	0.357
ERROR	2027.772	204	9.940		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	6.360	0.302	109
GROUP	=	1.000	5.734	0.329	99
SEX	=	0.000	6.297	0.295	115
SEX	=	1.000	5.797	0.336	93
GROUP SEX	= =	0.000 0.000	6.404	0.437	52
GROUP SEX	= =	0.000 1.000	6.316	0.418	57
GROUP SEX	= =	1.000 0.000	6.190	0.397	63
GROUP SEX	= =	1.000 1.000	5.278	0.525	36

ASSUMPTIONS Test #5

LEVELS ENCOUNTERED DURING PROCESSING ARE:

GROUP		
	0.000	1.000
SEX		
	0.000	1.000

DEP VAR: C6776 N: 208 MULTIPLE R: 0.073 SQUARED MULTIPLE R: 0.005

ESTIMATES OF EFFECTS B = (X'X)-1 X'Y

		C6776
CONSTANT		3.307
GROUP	0.000	0.075
SEX	0.000	0.143
GROUP SEX	0.000 0.000	-0.006

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
GROUP	1.123	1	1.123	0.266	0.607
SEX	4.057	1	4.057	0.961	0.328
GROUP*SEX	0.007	1	0.007	0.002	0.967
ERROR	861.149	204	4.221		

LEAST SQUARES MEANS=

			LS MEAN	SE	N
GROUP	=	0.000	3.382	0.197	109
GROUP	=	1.000	3.232	0.215	99
SEX	=	0.000	3.450	0.192	115
SEX	=	1.000	3.164	0.219	93
GROUP SEX	= =	0.000 0.000	3.519	0.285	52
GROUP SEX	= =	0.000 1.000	3.246	0.272	57

GROUP	=	1.000			
SEX	=	0.000	3.381	0.259	63
GROUP	=	1.000			
SEX	=	1.000	3.083	0.342	36

APPENDIX C

IRB INFORMATION

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
FOR HUMAN SUBJECTS RESEARCH

Proposal Title: THE EFFICACY OF TEACHING PROBLEM SOLVING SKILLS THROUGH TECHNOLOGY EDUCATION TO NINTH GRADE STUDENTS

Principal Investigator: GARRY BICE / GARY MAHONEY

Date: 8-31-92 IRB # ED-93-015

This application has been reviewed by the IRB and

Processed as: Exempt [XX] Expedite [ ] Full Board Review [ ]

Renewal or Continuation [ ]

Approval Status Recommended by Reviewer(s):

Approved [XX] Deferred for Revision [ ]

Approved with Provision [ ] Disapproved [ ]

Approval status subject to review by full Institutional Review Board at next meeting, 2nd and 4th Thursday of each month.

Comments, Modifications/Conditions for Approval or Reason for Deferral or Disapproval:

Comments:

The information sheet which explains the study and its voluntary nature to the ninth graders should be written in less technical language.

Signature: Marcia L. Tilley Date: 9-2-92
Chair of Institutional Review Board

VITA

Gary Steven Mahoney

Candidate for the Degree of

Doctor of Education

Thesis: THE EFFICACY OF DEVELOPING CRITICAL THINKING AND PROBLEM SOLVING SKILLS THROUGH TECHNOLOGY EDUCATION TO EIGHTH GRADE STUDENTS

Major Field: Occupational and Adult Education

Biographical:

Personal Data: Born in Madison, Indiana, July 9, 1960, the son of Gayle and Vivian Mahoney.

Education: Graduated from Trimble County High School, Bedford, Kentucky, in May 1978; received Bachelor of Science Degree in Industrial Arts from Berea College, Berea, Kentucky, in May, 1982; Received Master of Science in Industrial Education from Murray State University, Murray, Kentucky, in May, 1983; completed requirements for the Doctor of Education degree at Oklahoma State University in May, 1993.

Professional Experience: Instructor, Department of Technology and Industrial Arts, Berea College, Berea, Kentucky, 1989, to present; Assistant Professor, Industrial Education Department, McPherson College, McPherson, Kansas, 1983, to 1989; Graduate Research Assistant, Occupational and Adult Education, Oklahoma State University, Stillwater, Oklahoma, Spring 1992; Graduate Assistant, Industrial Education Department, Murray State University, Murray, Kentucky, 1982, to 1983.