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A Study Comparing the Technical Problem Solving Abilities of Middle School Students who have Participated in one or more Technology Education Courses to those of students having no course work in Technology Education

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A STUDY COMPARING THE TECHNICAL PROBLEM SOLVING ABILITIES OF MIDDLE SCHOOL STUDENTS WHO HAVE PARTICIPATED IN ONE OR MORE TECHNOLOGY EDUCATION COURSES TO THOSE OF STUDENTS HAVING NO COURSE WORK IN TECHNOLOGY EDUCATION

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Table of Contents

Table of Tables

Table of Figures

CHAPTER I

INTRODUCTION

Technology has an impact on every aspect of our daily lives - the work we do, our forms of entertainment, the food we eat, the homes we live in, the conveyances used to transport ourselves and our goods, how we communicate around the globe, and so on. Technological advance has provided the greatest source of economic development. It has increased the production of goods and services, resulting in a tremendous increase in our material lives. New products have been created, and the quality of existing ones has been improved. Advances in technology shape society. These advances are occurring at an ever increasing rate.

It has become increasingly clear that industry needs employees well trained in basic skills in order to remain competitive in the high-tech global marketplace. These employees need to be able to adapt to rapidly changing conditions, to communicate effectively, to work with different people, and to solve problems. (*Connections*, August 1997, p. 1; Meier, Hovde & Meier, 1996, p. 230) In particular, technological problem solving has been identified as being a critical survival skill in our advanced technological world. (Wu, Custer & Dryenfurth, 1996, p. 1)

It has also become clear that industry worldwide is experiencing a work force that is ill prepared to meet the needs of the fast changing, technologically advanced workplace. (*Connections*, August 1997, p. 1) Government, business leaders, and educators in response are calling for more emphasis on enhancing the problem solving capabilities of students and employees. (Wu, Custer & Dyrenfurth, 1996, p. 1; Boser, 1993, p. 1) Most educational disciplines claim to teach students to critically analyze information and to effectively solve problems. Both the National Council of Teachers of Mathematics and the National Science Education Standards have set problem solving as one of their primary goals. (Meier, Hovde & Meier, 1996, p. 232) Likewise, technology education programs almost universally claim the enhancement of student technologic problem solving abilities as a primary goal (Boser, 1993, p. 1; Virginia Department of Education, Technology Education Service Competency Package, 1989, p. 7) With the emphasis on promoting problem solving skills in the students of today's classrooms, are our schools developing these skills? This research will investigate the success of one middle school as it attempts to accomplish this goal.

STATEMENT OF THE PROBLEM

The problem in this study was to compare the technical problem solving capabilities of middle school students that have had one or more nine-week courses in technology education with the technical problem solving capabilities of middle school students that have had no course work in technology education.

HYPOTHESIS

H_1: Middle school students that have taken at least one nine-week course in technology education have superior technical problem solving skills compared to middle school students who have had no course work in technology education.

BACKGROUND AND SIGNIFICANCE

With the need established for employees with technical problem solving skills, when is the best time to start teaching these skills to the future work force? In their research published in 1993, Grant and Alexander showed that by teaching first year college students enrolled in the pharmaceutical/chemical technology program the basic steps in problem solving, their mean test scores at midterm - as compared to a control group - were considerably higher at the 0.95 significance level. (Grant & Alexander, 1993, p. 14) They recommended further research to clarify the need to include problem solving in the college curricula.

Other research indicates that the current college curricula does not significantly change either the personal or technological problem solving *styles* of students between the freshman and senior class years. (Wu, Custer & Dyrenfurth, 1996, p. 10) The authors of that study went on to postulate that substantial change could be effected if students were taught problem solving at a much earlier age, such as in elementary school. They reasoned that training received before critical style and attitudinal characteristics could solidify would be much more effective.

There is a plethora of articles calling for this emphasis on developing problem solving skills. Many programs in various disciplines claim to achieve this goal. No research was found that examines the <u>success</u> of middle school curricula in improving the problem solving skills of its students. Nor was any research discovered that investigates how well the technology education programs at the middle school level accomplishes an improvement in students' technical problem solving capabilities.

LIMITATIONS

The following limitations should be considered during a critique of this research study:

1. Landstown Middle School is in a suburban area. The results of this study may not be relevant to schools in urban or rural areas.

2. The students in this study are from varied socioeconomic backgrounds.

3. Students that participated in this study were randomly selected from the population at Landstown Middle School.

4. The study was conducted during the spring semester of academic year 1997-98.

5. A test of technical problem solving was given to a group of students participating in a technology education course as well as to a control group of students participating in a non-technology education course in order to determine the technical problem solving skills of both groups.

ASSUMPTIONS

The following assumptions should be considered when evaluating this research study:

1. The instrument utilized to measure the technical problem solving skills of the students is valid and reliable.

2. The academic background of all students involved in this research is essentially the same, e.g., all students have had similar instruction in mathematics, science, English, history, social studies, etc.

PROCEDURES

The research was conducted to compare the technical problem solving capabilities of Landstown Middle School students who have completed a minimum of one nine-week course in technology education to those of students that have had no technology education. To accomplish this, a test of technical problem solving was given to two groups of seventh-grade students and one group of eighth-grade students enrolled in a technology education class and to a control group of students that were enrolled in four non-technology education classes. The control group consisted of three seventh-grade math classes and one eighth-grade computer class.

The data were analyzed to determine if there was a statistically significant difference in the technical problem solving skills of the students that had instruction in a technology education class compared to students receiving no such instruction.

DEFINITION OF TERMS

The following terms are defined so that the reader can understand their special meaning as they apply to this study.

Problem Solving - a generic ability to deal with problem situations.

Technical Problem Solving - the systematic way of investigating a situation and implementing technical solutions.

Problem Solving Approach - a teaching method that encourages the development of new insights and useful thinking processes through active investigative learning.

OVERVIEW OF CHAPTERS

Our highly technological global market requires industry to have employees that are flexible, good at working in groups, take responsibility for quality products, and are skilled at solving problems. The American education system has responded to the concerns of industry by setting goals to improve the ability of students in such core areas as mathematics, science, and problem solving capabilities. Technology education has embraced the problem solving approach as a central focus of instructional activity. (Boser, 1993, p. 1)

The following chapter will review the literature written by educators that present their findings concerning the need to cultivate problem solving capabilities of students in preparation for entry level employment in industry. Chapter III will discuss the methods and procedures utilized in this study to examine the success of the program at Landstown Middle School in achieving the goal of technical problem solving development of its students. The findings of the research study will be presented in Chapter IV. Chapter V will present a summary of what was learned as a result of the study and conclusions will be drawn. Recommendations for future research will also be made.

CHAPTER II

REVIEW OF LITERATURE

Chapter II of this study is the Review of Literature. Within this chapter are found a section with an overview of the nature of problem solving and a section which discusses the problem solving approach.

THE NATURE OF PROBLEM SOLVING

In Chapter I, the general term "problem solving" was defined as a generic ability to deal with problem situations. Problem solving can be further defined as the process used to obtain a solution to a perplexing question or situation. (Meier, Hovde, & Meier, 1996, p. 232) The important point to note is that problem solving is a process. It is a very important process. The skill level of students in performing the problem solving process can determine their future employability and the ability of our industries to compete in the global marketplace. Many educators believe that it may be the single most important factor in determining the future success of the students.

To become skilled in solving problems, the student must have a knowledge base that is pertinent to the content of the problem being solved; the ability to locate, identify, obtain, and evaluate missing information; the cognitive skills to analyze, reason, classify, and establish relationships; attitudinal skills to cope with ambiguity, fear, anxiety, and procrastination; and the ability to use creativity, intuition, and analytical reasoning to reach the "best" solution to the problem being solved. (Grant & Alexander, 1993, p. 2)

The following have been identified as common shortcomings of students in problem solving: difficulty in isolating the problem; lack of a systematic procedure for solving the problem; inability to hypothesize solutions; overlooking evidence; making inappropriate associations between problem elements; functional constraints - the bias to see problem elements in only their usual function; habitual constraints - the tendency to repeat an already successful solution path; perspective constraints - the inability to view the problem from other vantages, or viewing it from a restricted perspective; failure to use all relevant information due to stereotyping, other limiting biases, or limited memory; emotional constraints - fear of failure; and using inappropriate representation. (Lee, 1996, p. 8; Anderson, 1989, p. 6)

Bloom's taxonomy of the cognitive domain is taught to prospective teachers to be used in writing behavior objectives and organizing curriculum content. Bloom's cognitive domain levels begin at the lower order skills of knowledge, comprehension, and application and progress to the higher order skills of analysis, synthesis, and evaluation.

Level one, knowledge, requires the knowledge of specific facts, terminology, ways of organizing information, sequences, and trends. These are all basic facts and information residing in the memory of the students. The next level, comprehension, requires the student to understand what has been taught. Application, the third level, demands that the students are able to apply the information they have received to different situations. Analysis is the ability of the students to recognize the differences in hypotheses and to critically separate alternative hypotheses. The ability to collect various parts and put them together to form a whole is known as synthesis. Evaluation, the highest order cognitive skill, is the ability to apply judgment and use criteria and standards to appraise outcomes. (Anderson, 1989, p. 4)

Problem solving requires the student to operate in all six levels of the cognitive domain. Some of the activities of problem solving that relate to the cognitive domain levels include:

- gathering information

- formulating alternative solutions
- checking the application of alternative solutions in different situations
- analyzing information and determining its relationship to the problem
- synthesizing new solutions
- evaluating the options and selecting the optimal one

In the next section of this chapter, The Problem Solving Approach, the levels of cognitive domain will be related to specific steps in the problem solving process.

In their research investigating the differences between technological and personal problem solving styles, Wu, Custer, and Dyrenfurth point out that there are a wide range of problems - such as mathematics, marital, financial, personal difficulties, alcohol, design engineering, technology - that need to be solved. According to the authors, the generic term "problem solving" is insufficient to cover this wide array of problems. They contend that these activities are substantially different in type, focus, and intent. Their study focused on problem solving *style* - the tendency to respond in a certain way - rather than on *ability* or *strategies* used to solve problems. Style should not be confused with knowledge or capability.

The authors used a standardized self-report instrument designed to assess perceptions of personal problem solving styles and abilities. The instrument contains three sub scales: (1) Problem solving confidence - self assurance while engaging in problem solving activities. (2) Approach/Avoidance - a general tendency of students to approach or avoid problem solving activities. (3) Personal Control - the extent to which individuals believe that they are in control of their emotions and behavior while solving problems. (Wu, Custer, & Dyrenfurth, 1996, p. 2)

One purpose of the study was to determine whether style differences existed when students were confronted with different types of problems. The results of the study showed evidence to support that differences do exist between technological and personal problem solving styles of the university students in the study. (Wu, Custer, & Dyrenfurth, 1996, p. 10) The authors went on to state that problem solving should be viewed as nature specific. Different types of problems (e.g., technological or personal) demand different kinds and levels of knowledge and capability.

Other researchers have conducted studies on the effects that teaching problem solving *strategies* has on student performance. Some specific strategies that have been shown to be successful will be discussed in the following section of this chapter. Problem solving is a learned skill that can be taught. Practice and exercise of the skill - like practice and exercise of any skill such as music, athletics, flying an aircraft - improves the level of skill.

In her research with fifth grade students, King showed that by teaching strategic problem solving skills to students, existing knowledge was supplemented by the process, student success was facilitated, and superior performance on both practical problems and written problems was attained. Further, general strategies that are content free can be applied in any problem context, as indicated by the trained students (the treatment group) to outperform the untrained students (the control group) in solving a novel problem. (King, 1991, p. 316)

In his article, Patrick also supports the contention that teaching a general approach to problem solving has application to a broad range of problems. Although the process or strategy may be taught in a technology, science, or mathematics course, it will be transferable to other tasks as well. The technique he suggests is a methodological approach to obtaining real solutions to open-ended problems and provides a means for logically understanding a problem prior to attempting a solution. Patrick argues that it is applicable to any of life's problems and can be a very useful tool for a child's entire education if taught at an early age. (Patrick, 1993, p. 1) Boser, a strong proponent of teaching pedagogical skills to teachers that promote problem solving capabilities in students, reports that practice in applying problem solving skills in a variety of instructional settings may facilitate transfer of those skills to novel situations. (Boser, 1993, p. 5)

King discovered in her research that students do not naturally or spontaneously exhibit a strategic approach to solving a problem without explicitly being trained to do so. (King, 1991, p. 316) Patrick has observed that unless taught a more sophisticated solution approach to problems, people tend to continue to utilize methods which are both inefficient and frustrating, resulting in a lack of confidence in one's problem solving skills. (Patrick, 1993, p. 2)

THE PROBLEM SOLVING APPROACH

Problem solving is a learned skill. It has been identified by industry and the teaching profession as a skill key to success and required by students graduating from our secondary schools. There has been much emphasis placed on teaching this skill across many academic disciplines.

The problem solving approach involves the students in "hands on", investigative learning that enhances understanding. Students remember more of what they are taught by the "doing" associated with problem solving. By participating in a series of practical problem solving activities such as designing, modeling, and testing technological solutions, students will acquire both technological knowledge and higher order cognitive skills. (Boser, 1993, p. 2; Sellwood, 1989, p. 4)

There is much that has been written about the process to help achieve success as a problem solver. A select few approaches will be presented to expose the reader to some of the variety being offered in the classrooms across the country. Although the approaches vary in their proposed specific steps, the basic concepts are essentially the same. It is important to note at this point that the specific steps of any one of the approaches is not as important as the process itself. Additionally, the steps in the approaches should not be considered as linear. Often times, some steps are repeated several times, while others may be omitted.

Garcia provides the following basic components to a systematic approach to problem solving: a good problem statement, a research and development component, a testing of solutions component, and an evaluation component. (Garcia, 1994, p. 5) This approach requires that the student:

- Understand the problem - read the problem carefully; determine what to look for; and identify relevant information.
- Develop a systematic plan - break the problem down into small, manageable steps; identify the concepts that apply to each step; select

the best concepts to solve each step; decide how to integrate the identified concepts.

- Check the solution - verify that all relevant concepts are used; check that the answer is feasible.

This approach is shown below in Figure 1. (Garcia, 1994, p. 6)

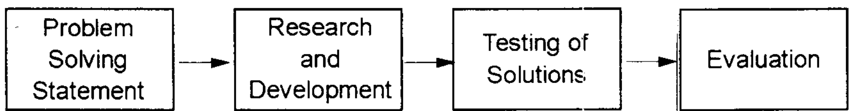

Figure 1. Basic Components in Problem Solving.

Another approach can be depicted as a problem solving process wheel (Figure 2) which has the following six steps (Lee, 1996, p. 4):

- Identify the problem - clearly understand the nature, specifications, and desired results of the problem.
- Gather information - collect as much information about the problem as possible, analyze the data and condense it to the main factors or causes.
- Develop solutions - use divergent thinking to get as many alternative solutions as possible.
- Select solution - use convergent thinking to find the optimal solution.
- Implement solution - try out the solution and get actual results.

- Evaluate results - analyze and evaluate the results, make modifications as necessary.

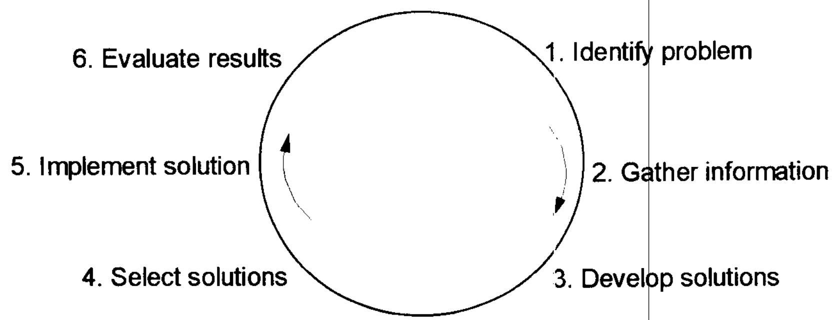

Figure 2. Problem Solving Process Wheel

Many authors use an acronym to help students remember the basic steps of the systematic approach. One such acronym is IDEAL (Anderson, 1989, p. 5):

- I - Identify the problem.
- D - Define the problem, clarify and sharpen the boundaries.
- E - Explore alternative approaches.
- A - Act on a plan.
- L - Look at the effects.

Many other acronyms and process models are available. One last model that will be reviewed is one that is commonly taught in technology education. As can be seen in Figure 3, it is very similar to the others already presented, but visually depicts the reiterative nature of some of the steps (Patrick, 1993, p. 3)

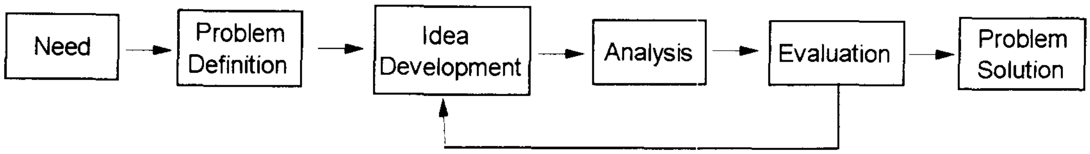

Figure 3. Top-Down Problem Solving Method

In all these methods, some steps are important to remember. The problem needs to be closely scrutinized to ensure that it is clearly understood. Complex problems should be reduced to parts that can be more easily solved, and the criteria by which the solution will be judged must be understood. In looking for alternate solutions, there are many activities that are called upon to explore all possible solutions to the problem: working in teams and using brainstorming and thinking aloud help with creativity and logic. The breadth of background that the team approach brings is very useful at the alternative solutions stage. A depth of content knowledge is required to effectively analyze the alternatives and to determine the most feasible one.

In general, the problem solving skills in students were best developed by the following:

- provide modeling and practice with feedback.
- use realistic, true-to-life problems.

- present material frequently and in varied contexts.
- use a variety of relevant instructional techniques (small group problem solving was the most highly ranked technique, but it is considered desirable to employ a variety of techniques).
- guide the learner through successive levels of complexity.
- make connections between new information and previously acquired knowledge.
- teach practical communication and social skills.
- use an appropriate representation of a problem solving model (such as one of those presented in this chapter).

(Boser, 1993, p. 9; Garcia, 1994, p. 7; Lee, 1996, p. 8; Johnson & Thomas, 1992, p. 10)

Several authors recommended "thinking aloud" as a technique to help students with the meta-cognitive process and to allow fellow students to observe the logic path of their peers. In her research, King taught fifth grade students a strategy of asking peers generic guided questions that prompted them to create their own higher order questions, which in turn drew more elaborate explanations from the group. King proposed that the requirement placed upon the student to explain their ideas to someone else forced them to clarify concepts, elaborate on them, and to reorganize content. (King, 1991,

p. 308) The questions were designed to guide the students through the stages of problem solving as well as to cause them to pay more attention to their thought processes. The questions caused the participants to: determine the nature of the problem more precisely; access prior knowledge more completely; foster greater access to known strategies; generate new ideas and unique perspectives; analyze components of the problem; reconceptualize the problem; and to help monitor progress through the process. (King, 1991, p. 310, 315) As noted earlier in this chapter, the results of learning this questioning technique were superior problem solving capabilities in both practical and written problems as well as superior problem solving abilities that were transferred to a novel problem.

As presented earlier in this chapter, problem solving requires the student to operate in all six levels of the cognitive domain. In the first stage of problem solving, the student must utilize knowledge, comprehension, and application to clearly define the problem and to come to a clear understanding of the final objective. Thinking must be logical and based upon content knowledge of material previously learned. When the student is looking for alternative solutions and idea development, he must operate in the cognitive levels of application and synthesis. Creative thinking is being utilized to generate as many solutions as possible. The knowledge of material previously learned is applied to this new situation that the student is attempting to solve. Various ideas generated may be combined to form new ideas. The student must use analysis and evaluation skills to judge the options when selecting the best one to be utilized to solve the problem. Each idea is broken down and its feasibility discussed. The merits of each idea is evaluated and compared to other ideas. All of the cognitive levels are employed to some extent during the implementation or testing stage. This is the active "doing" - or making - stage in which the student is predicting, measuring, estimating, assembling, using trial and error, and revising until the solution is obtained. (Sellwood, 1989, p. 10) Knowledge, comprehension, application, and synthesis skills are employed when constructing the solution. Analysis and evaluation skills are constantly being utilized to judge the effectiveness of the solution and to make modifications. This is a constant, reiterative portion of the problem solving process. Finally, the solution is evaluated to determine if it effectively satisfies the final objective. The students ask themselves, "Have we successfully met the requirements of the problem? What could we have done better? What have we learned from this problem?" Evaluation skills - the highest order cognitive level - are actively employed throughout much of the problem solving process.

SUMMARY

The process of solving problems is a learned skill that can be effectively taught to students. There are numerous examples of successful programs at different educational levels ranging from elementary school to college that have been instituted to teach the process of problem solving. It is widely accepted that effective problem solving skills are critical to the continued success of the individual students, industry, and even our nation. The debate continues regarding the specificity of problem solving styles for various types of problems that can be encountered. This author contends that teaching a generic approach to problem solving - e.g., teaching students a successful problem solving process - has broad application to a wide range of problems. Once a student has been taught a process to solve problems effectively, the main factor that will determine successful solving of the problem is the content knowledge that the student possesses regarding the problem.

CHAPTER III

METHODS AND PROCEDURES

Chapter III of this quasi-experimental study covers the methods and procedures used to collect data. Within this chapter are found sections which are concerned with the population used in the study, the research variables of the study, the instrument design, classroom procedures, methods used in data collection, and methods of statistical analysis.

POPULATION

The population utilized in this study are male and female students in grades seven and eight at Landstown Middle School in Virginia Beach, Virginia. Landstown Middle School is in a predominantly suburban area with a small proportion of the population coming from rural areas. The population comes from varied socioeconomic backgrounds, with the majority in the middle class range.

The sample population that was tested for this study consisted of seventy-eight students - fifty-two in the treatment group and twenty-six in the control group. The treatment group consisted of students that were enrolled in a technology education class - two seventh-grade and one eighth-grade classes. Four groups of students were used as a control for this study - three were enrolled in a seventh-grade general track math class and one in an eighth-grade computer class. Students were selected based on enrollment in the specific class with no regard to gender, academic performance, or socioeconomic background. Test results were excluded from the study for those students in the control groups that had previously taken technology education.

Students at Landstown Middle School may take technology education as an elective course once during each of their three years at the school. The sixth- and seventh-grade students take the course for a nine-week period. The course at these grade levels consists entirely of *Synergistics* modules. The specific modules include: computer assisted design, automotive research, research and design (CO_2 car), drafting, engineering (bridge building), plastics, materials and processes (wood and Plexiglas desk caddie), aerospace, flight technology, rocketry and space technology, computer graphics and animation, computer-based problem solving, computer fundamentals and MS-DOS, electricity, electronics, Lego/TC Logo, computer applications, transportation, power and energy mechanics, energy and power transmission, audio broadcasting, biotechnology, satellites, and desktop publishing.

The eighth-grade students taking technology education are enrolled for an entire 18-week semester. The eighth-grade course is divided into two parts: *Synergistics* modules for nine weeks and two separate project activities for nine weeks. The project activities are conducted by two different instructors. One instructor introduces the problem solving process during a period of two to three days of instruction. In addition, other academic material relevant to technology education is presented by both instructors. Specific activities aimed at reinforcing problem solving skills are not presented.

The project in one class requires the students, working in groups of two or three, to design an original electronic device. The students conduct research in the area of the device they are designing, produce a computer aided drawing of the device, and build a concept model using electronic parts. The project in the other class is conducted along the lines of a "design brief". The students are given a problem to solve within certain design constraints (such as types and amounts of materials allowed). This project requires the students to produce an original design, an accurate drawing, and a working product that solves the given problem.

RESEARCH VARIABLES

The research variables in this study include variations in the manner in which course materials are taught within the general education courses taken by all students. Although differences in teaching methods - with corresponding success of students' performance in academics - do exist, it was assumed for this study that the differences were negligible.

Student backgrounds and experiences outside the classroom surroundings also differ. Some students may be exposed to learning problem solving through situations other than those presented in the academic environment. Considering the age and developmental stage of the population, this variable was considered inconsequential for this study.

Students at this stage of development vary significantly in emotional maturity. This may have a considerable impact on learning. The groups were picked based solely on enrollment in specific classes. Math is a required class for all students. Technology education is an elective taken by a diverse group of students - e.g., the enrolled population is not specifically skewed. It is therefore assumed that there is equal chance of having an equivalent spread of emotional development levels among the population.

INSTRUMENT DESIGN

The instrument used in this study was designed by the author. It is based on an assessment rubric that was developed by Custer, Valesey, and Burke for their research titled "Evaluating the Effects of the Design Under Constraint Approach to Technological Problem Solving". The rubric incorporates learner outcome dimensions and strands of technological design and problem solving as illustrated in Table 1 below.

Technological Design and Problem Solving Rubric

Dimension:	1. Constraint Clarification	2. Development of Preliminary Design Solution	3. Construct a Prototype	4. Evaluate Design & Incorporate Refinements
Strand 1:	Gain a clear understanding of problem	Brainstorm possible solutions	Select appropriate methods/tools	Critical analysis of design and prototype
Strand 2:	Clarify design constraints	Select a solution based on constraints	Alter design as needed to construct a prototype	Evaluate design in light of design constraints
Strand 3:	Address group organization & process issues	Develop implementation plans	Assess quality of prototype	Redesign and refinement solutions
Strand 4:		Access information from other academic areas (math, science)		

Table 1

The instrument is designed to test each of the four dimensions: constraint clarification, development of preliminary design solution, construct a prototype, and evaluate design and incorporate refinements. The instrument consists of a short passage to orient the students regarding the importance and usage of maps. Next, the students are given information regarding the road segments which can be used to construct a map of the local area between their school and a major shopping mall approximately four miles away.

Dimension one, constraint clarification, is evaluated by a series of five questions. These questions challenge the student to think about such map characteristics as scale, direction (use of a compass rose), and a legend. Development of preliminary design solution, dimension two, is evaluated by challenging the students to construct two maps of the area described in the paragraph above as possible solutions. The five questions posed and the information on road segments provide information to guide the students in creating possible solutions (maps) which are credible. Dimension three, construct a prototype, is evaluated by asking the students to alter their designs as necessary and create a final solution - draw a final map showing the area between their school and the shopping mall. Finally, the students were given a copy of a commercial map and asked to evaluate their final design, in order to judge dimension four - evaluate design and incorporate refinements. The instrument is presented in Appendix I.

CLASSROOM PROCEDURES AND DATA COLLECTION

Students worked alone on the test. The test was administered at one time to each class during a period of forty-five minutes. Students in the control classes were asked to indicate on the test whether they had previously taken a technology education course.

Due to the somewhat subjective nature of evaluating this instrument, the tests were graded by a panel of two teachers to evaluate quality of responses. Each dimension was evaluated on a scale of 1-5, with 1 being the lowest possible score and 5 the highest. A score of 1 represents an evaluation of unsatisfactory, 2 is below average, 3 average, 4 above average, and 5 represents an excellent score. Scores were tabulated by group: treatment groups (7th grade and 8th grade grouped separately) and control group (7th and 8th grades grouped together).

STATISTICAL ANALYSIS

The mean, the range, and the standard deviation were computed for the scores for each group. A series of one tail t-tests were conducted to determine if there was a significant difference between the means of the different groups.

SUMMARY

The instrument designed for this quasi-experimental study by the author will help to determine the technical problem solving abilities of middle school students with varying backgrounds in technology education. Using the results of the test, it may be determined statistically if one group of students had a superior ability to solve the problems presented. Once it has been determined which groups were better able to solve the problems presented by the test instrument, conclusions can be drawn. Chapter IV of the study will present test scores and research findings.

CHAPTER IV

FINDINGS

The findings of this study are presented in Chapter IV. The purpose of this study - to compare the technological problem solving capabilities of middle school students that have had one or more technology education classes to those of students having had no course work in technology education - was accomplished by administering an instrument designed by the author. The results of the test will be presented for both the treatment group and the control group. The treatment group results are further separated into 8th grade and 7th grade groups to investigate whether the different curricula in the technology education courses make a difference in the problem solving abilities of the students. Data are presented in both narrative form and in tables.

PRESENTATION OF DATA

The scores are based on a scale of 1-5, with 1 being the lowest score and 5 the highest. A score of 1 represents an evaluation of unsatisfactory, 2 is below average, 3 average, 4 above average, and 5 represents an excellent score.

The control group consisted primarily of students in 7th grade general track mathematics, with one student from an 8th grade computer course included. The mean overall score for the control group was 2.432, with a range of 2.83, a variance of 0.4239, and a standard deviation of 0.6511. The scores for the control group are presented in Table 2. Each student's performance is recorded for each dimension and an overall score is presented as well, using the 1-5 scale. Dimension 1 is constraint clarification; dimension 2 is development of preliminary design solutions; construct a prototype is dimension 3; and evaluate design and incorporate refinements is dimension 4.

The performance on the instrument of the first treatment group - 7th grade students that are enrolled in a technology education class - is presented in Table 3. Their mean overall score was 2.24, with a range of 2.73, a variance of 0.5525, and a standard deviation of 0.7433.

The second treatment group - 8th grade students enrolled in a technology education class - scored a mean overall of 2.69 on the test, with a range of 2.57, a variance of 0.4278, and a standard deviation of 0.6616. The individual student scores for this group are presented in Table 4.

SCORES FOR **CONTROL GROUP**

Students That Have NOT Taken a Technology Education Class

Stud #	**Dim 1**	**Dim 2**	**Dim 3**	**Dim 4**	**Total** (mean)
1	1.7	1	1.5	1.5	**1.43**
2	4.4	2.5	3	3	**3.23**
3	3.3	2	3	1	**2.33**
4	2	3	3	2.5	**2.63**
5	4.8	2.5	4	4	**3.83**
6	3.3	1.5	3	3	**2.7**
7	2.7	2	3	3	**2.68**
8	3.6	2	3	4	**3.15**
9	1	1	1	1	**1**
10	2.9	3	3	1.5	**2.6**
11	2.1	2.3	1	2	**1.85**
12	2.4	2.5	2.5	2	**2.35**
13	1.9	1.5	2	2	**1.85**
14	1.8	2	2	3	**2.2**
15	2	2	3	2	**2.25**
16	3.9	3	2.5	2.5	**2.98**
17	2.5	2	2.5	2	**2.25**
18	2.2	2	2.5	1	**1.93**
19	2.6	2	2.5	2	**2.28**
20	2.8	2.5	4	3	**3.08**
21	1.5	2	2	1	**1.63**
22	2.3	2	1	1	**1.58**
23	2.9	2.3	3.3	3.5	**3**
24	3.6	1.8	2	3.5	**2.73**
25	3.8	3	2.5	4.5	**3.45**
26	3	1.5	2.5	2	**2.25**
mean:	2.73	2.11	2.51	2.37	**2.43**

Table 2

SCORES FOR **TREATMENT GROUP**
7th Grade Students Enrolled in a Technology Education Class

Stud #	Dim 1	Dim 2	Dim 3	Dim 4	Total (mean)
1	1.3	1.3	1.5	1.5	**1.4**
2	3.1	2.8	4	5	**3.73**
3	3.2	2.5	1	2	**2.18**
4	3.4	1.3	1	2.5	**2.05**
5	4.8	3	3	1.5	**3.08**
6	1.6	1	1	1	**1.15**
7	1.7	1	1	1	**1.18**
8	2.7	1.3	3	3	**2.5**
9	2.4	2	1.5	4.5	**2.6**
10	2	2	1	1	**1.5**
11	2.9	3.5	4	2.5	**3.23**
12	2.7	3	2.5	3	**2.8**
13	2.9	1.5	1.5	1	**1.73**
14	1.6	2.3	2.5	2	**2.1**
15	1.6	2.8	2.5	2	**2.23**
16	1.3	3	4	3	**2.83**
17	2.2	2.3	2.5	1	**2**
18	2.9	2.8	2.5	1.5	**2.43**
19	2.3	3	4	2.5	**2.95**
20	2.4	1.5	1	1	**1.48**
21	2.4	1.3	1	1	**1.43**
22	3.2	2.5	4	4.5	**3.55**
23	1.4	1	1	5	**2.1**
24	2.3	3.3	3	2.5	**2.78**
25	1	1	1	1	**1**
26	2	1	1	3.5	**1.63**
27	4	3.3	3	3.5	**3.45**
28	1.5	1.5	2	3.5	**2.13**
29	1	2	1	3.5	**1.88**
mean:	2.34	2.1	2.14	2.43	**2.24**

Table 3

SCORES FOR **TREATMENT GROUP**
8th Grade Students Enrolled in a Technology Education Class

Stud #	Dim 1	Dim 2	Dim 3	Dim 4	**Total** (mean)
1	3	2.5	2.5	2.5	**2.63**
2	2	2.3	1	2	**1.83**
3	3.2	2.5	2.5	4.5	**3.18**
4	2.5	2.8	4	2.5	**2.95**
5	2	2	1	1	**1.5**
6	2.7	2	3.5	3	**2.8**
7	3.3	1.3	1.5	1.5	**1.9**
8	2.2	3	3	4.5	**3.33**
9	2.8	3	3	3	**2.95**
10	3	3	3	3	**3**
11	3	2.3	3	3.5	**2.95**
12	2.5	1.5	1.5	3.5	**2.25**
13	4.1	2.3	3.5	3	**3.23**
14	3.1	2.3	3.5	1	**2.48**
15	3.8	2	2.5	3.5	**2.95**
16	2.9	4.3	5	4	**4.05**
17	4.4	3.8	2.5	4.5	**3.8**
18	4.1	3	3	3.5	**3.4**
19	2	2.3	1	4.5	**2.45**
20	1.6	2.3	1	1	**1.48**
21	2.7	3.8	1.5	1.5	**2.38**
22	3.3	1.5	2	1.5	**2.08**
23	2.4	2.8	3	1	**2.3**
mean:	2.9	2.55	2.52	2.76	**2.69**

Table 4

STATISTICAL ANALYSIS

Using the data presented, it is noted that there is a difference in the means of the scores of the different groups. A t-test is used to determine if there is a *significant* difference between two sample means. The mean overall score of the control group was compared to the mean overall scores of each of the treatment groups using the statistical t-test method. Additionally, the mean score of the control group for each dimension was compared to the mean scores of each of the treatment groups for each corresponding dimension using the statistical t-test method. The one tail t-test calculations were performed using the computer-based program *StatMost, Statistical Analysis and Graphics*.

Seventh Grade Overall Comparison

The resulting calculation for the one tail t-test comparing the mean overall score of the control group to the mean overall score of the treatment group of 7th graders enrolled in technology education is 0.9718 at a confidence level of 0.95 and with a degree of freedom of 53. The critical t-value is 1.6741.

Eighth Grade Overall Comparison

The resulting calculation for the one tail t-test comparing the mean overall score of the control group to the mean overall score of the treatment group of 8th graders enrolled in a technology education class is 1.3439 at a confidence level of 0.95 and with a degree of freedom of 47. The critical t-value is 1.6779.

Seventh Grade Dimension 1 Comparison

The resulting calculation for the one tail t-test comparing the mean score of the control group for dimension 1 to the mean score for dimension 1 of the treatment group of 7th graders enrolled in technology education class is 1.5970 at a confidence level of 0.95 with a degree of freedom of 53. The critical t-value is 1.6741.

Seventh Grade Dimension 2 Comparison

The resulting calculation for the one tail t-test comparing the mean score of the control group for dimension 2 to the mean score for dimension 2 of the treatment group of 7th graders enrolled in technology education class is 0.0773 at a confidence level of 0.95 with a degree of freedom of 53. The critical t-value is 1.6741.

Seventh Grade Dimension 3 Comparison

The resulting calculation for the one tail t-test comparing the mean score of the control group for dimension 3 to the mean score for dimension 3 of the treatment group of 7th graders enrolled in technology education class is 1.3921 at a confidence level of 0.95 with a degree of freedom of 53. The critical t-value is 1.6741.

Seventh Grade Dimension 4 Comparison

The resulting calculation for the one tail t-test comparing the mean score of the control group for dimension 4 to the mean score for dimension 4 of the treatment group of 7th graders enrolled in technology education class is 0.2069 at a confidence level of 0.95 with a degree of freedom of 53. The critical t-value is 1.6741.

Eighth Grade Dimension 1 Comparison

The resulting calculation for the one tail t-test comparing the mean score of the control group for dimension 1 to the mean score for dimension 1 of the treatment group of 8th graders enrolled in technology education class is 0.6895 at a confidence level of 0.95 with a degree of freedom of 47. The critical t-value is 1.6779.

Eighth Grade Dimension 2 Comparison

The resulting calculation for the one tail t-test comparing the mean score of the control group for dimension 2 to the mean score for dimension 2 of the treatment group of 8th graders enrolled in technology education class is 2.3468 at a confidence level of 0.95 with a degree of freedom of 47. The critical t-value is 1.6779.

Eighth Grade Dimension 3 Comparison

The resulting calculation for the one tail t-test comparing the mean score of the control group for dimension 3 to the mean score for dimension 3 of the treatment group of 8th graders enrolled in technology education class is 0.0381 at a confidence level of 0.95 with a degree of freedom of 47. The critical t-value is 1.6779.

Eighth Grade Dimension 4 Comparison

The resulting calculation for the one tail t-test comparing the mean score of the control group for dimension 4 to the mean score for dimension 4 of the treatment group of 8th graders enrolled in technology education class is 1.2206 at a confidence level of 0.95 with a degree of freedom of 47. The critical t-value is 1.6779.

SUMMARY

The findings of the research study, obtained by using a one tail t-test to determine if there is a significant difference in the means of the control group compared to the means of the treatment groups of students enrolled in a technology course at either the 7th grade or 8th grade level, were presented in this chapter. Chapter V will provide a summary of this research study, a conclusion based upon the data that has been collected and statistically analyzed, and recommendations on how this research may be of value.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter will summarize the preceding four chapters. It will review the problem of the study, the research goals, why the study is significant, the limitations of the study, the population used for the research, the instrument used to obtain data, data collection procedures, and statistical procedures. Conclusions will be offered based upon the findings of the research. That is, the research goals will be answered based upon the data that was collected. Finally, recommendations will be suggested as to how the research findings may be practically implemented.

SUMMARY

The problem in this study was to compare the technical problem solving capabilities of middle school students that have had one or more nine-week courses in technology education with the technical problem solving capabilities of middle school students that have had no course work in technology education.

Research goals are presented to provide the direction or framework to solve the problem. The goal for this research is presented in the following hypothesis:

H_1: Middle school students who have taken at least one nine-week course in technology education have superior technical problem solving skills compared to middle school students who have had no course work in technology education.

A review of literature indicates that in order to be competitive in the global marketplace, industry needs employees that are well trained in problem solving, able to communicate effectively, are flexible to changing work conditions, and are able to work well with different people. It was found that many disciplines in our schools claim to achieve the goal of developing problem solving skills in students. In particular, modern technology education programs universally claim to improve the students' abilities in the area of solving technological problems. Despite all this emphasis on teaching problem solving skills, no research was found that examines the success of middle school programs in improving their students' abilities in this area. Neither was any research discovered that investigates how well middle school technology education programs currently in place are able to improve the students' technological problem solving abilities.

This study was conducted at Landstown Middle School in Virginia Beach, Virginia, during the spring semester of 1998. The school is in a suburban area, with the majority of the students from the middle socioeconomic class. Therefore, the results of this study may not be relevant to schools in urban or rural areas.

The population used in this study consisted of both male and female students in grades seven and eight at Landstown Middle School. Three seventh-grade general track math classes and one eighth-grade computer class were utilized as a control group for this study. The results of those students from these classes that indicated that they had previously taken a technology education class were omitted from the study. A total of 26 students indicated that they had no previous instruction in technology education. Only one eighth-grader was in this category. The treatment group consisted of students currently enrolled in technology education classes. One class of twenty-three eighth graders and two classes for a total of twenty-nine seventh graders were used as the treatment groups in the study.

The seventh-grade technology education curriculum at Landstown Middle School consists of nine weeks of "career exploration", utilizing only *Synergistics* modules. No other technology concepts are taught outside of what the modules present. The eighth-grade curriculum lasts an entire semester and is divided into two nine-week periods. One nine-week period consists of the same *Synergistics* modules that the sixth- and seventh-grade students use. The other nine-week period consists of instruction on the history of technology, the problem solving process, basic mechanical drawing/sketching, machine safety, and materials processes. The instruction is a prelude to completing two separate projects. One project requires the students to research, design, and build a concept model of an original electronic device utilizing electronic parts. The other project is a "design brief" type problem that challenges the students to find a solution to a given problem within certain design constraints. The project involves materials processing with primarily wood and Plexiglas. Although the problem solving process is introduced to the students, the concepts are not specifically reinforced with practice problems or drills.

The instrument used in this study was designed by the author. It is based on an assessment rubric that was developed by Custer, Valesey, and Burke for their research titled "Evaluating the Effects of the Design Under Constraint Approach to Technological Problem Solving". The rubric incorporates learner outcome dimensions and strands of technological design and problem solving. The instrument is designed to test each of the four dimensions: constraint clarification, development of preliminary design solution, construct a prototype, and evaluate design and incorporate refinements.

Students worked alone on the test. The test was administered during the end of the semester at one time for each class during a period of forty-five minutes. Due to the somewhat subjective nature of evaluating this instrument, the tests were graded by a panel of two teachers to evaluate quality of responses. Each dimension was evaluated on a scale of 1-5, with 1 being the lowest possible score and 5 the highest. A score of 1 represents an evaluation of unsatisfactory, 2 is below average, 3 average, 4 above average, and 5 represents an excellent score. Scores were tabulated by group: treatment groups (7th grade and 8th grade grouped separately) and control group (7th and 8th grades grouped together).

The mean, the range, and the standard deviation were computed for the scores for each group. A series of one tail t-tests were conducted to determine if there was a significant difference between the means of the different groups.

CONCLUSIONS

The goal for this research is presented in the following hypothesis:

H_1: Middle school students who have taken at least one nine-week course in technology education have superior technical problem solving skills compared to middle school students who have had no course work in technology education.

The mean overall score for the control group was 2.432, with a range of 2.83, a variance of 0.4239, and a standard deviation of 0.6511. The mean overall score of the seventh grade treatment group was 2.24, with a range of 2.73, a variance of 0.5525, and a standard deviation of 0.7433. The mean overall score for the eighth grade treatment group was 2.69, with a range of 2.57, a variance of 0.4278, and a standard deviation of 0.6616. The resulting calculation for the one tail t-test comparing the control group mean to the eighth grade treatment group mean is 1.3439. The critical t-value at the 0.95 confidence level is 1.6779. Based upon the statistics reported, the hypothesis is rejected.

After observing the curriculum at Landstown Middle School, the author suspected that the sixth- and seventh-grade technology education programs, which are based solely upon *Synergistics* modules, would yield no significant difference in the technological problem solving skills of the students enrolled. In fact, the treatment group at the seventh-grade level actually achieved lower on the mean overall score than did the control group.

Though, it was not statistically a significantly lower score. While the *Synergistics* modules may provide the developing, middle school-age student exposure to different technological career areas, presented as a stand alone program they do not enhance the technical problem solving capabilities of the students.

The treatment group at the eighth-grade level achieved a higher overall mean score than did the control group. However, the difference was not significant at the 0.95 confidence level.

The students in Landstown Middle School technology education classes at the eighth-grade level receive an introduction to the problem solving process - though no drills/exercises are utilized to reinforce primary learner outcome dimensions and strands of technological design and problem solving. The curriculum at this level appears to have some beneficial impact on the students' abilities to solve technological problems, though not a profound effect.

RECOMMENDATIONS

From this study it is apparent that modular, computer-based instruction that is independent of any other pedagogy does not effectively improve students' technical problem solving capabilities. Additionally, the teaching of the problem solving process without emphasis on learning to effectively perform each portion of the process results in very limited student success in technical problem solving. Based on these observations and the review of literature, the following recommendations are made:

- Technology education courses should include the teaching of problem solving strategies with exercises, drills, and projects used to reinforce concepts.
- The focus of teaching problem solving skills should be on the systematic process, not fact memorization.
- Problems presented to challenge the technical problem solving abilities of the students should be practical, with relevant, real-world applications. The problems should be open ended and multi-faceted.
- Technology education programs in the schools should review their curriculum to evaluate whether or not the goals of the program are being met. Exposure to high tech equipment does not necessarily mean that the students' minds are actively engaged in the identification and solution of problems.
- Students should have the opportunity to work in pairs or small groups in problem solving activities. Thinking aloud, strategic questioning,

positive responses to questioning, and ideation strategies should be emphasized.

- Provide positive reinforcement to individual students that exhibit appropriate problem solving strategies.

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Appendix I

Instrument for Evaluating the Technical Problem Solving Skills of Middle School Students

NAME: ______________________________ GRADE LEVEL: _________ AGE: ______

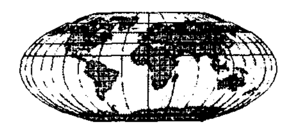
CLASS IN WHICH YOU ARE TAKING THIS TEST: _________________________________

TEACHER: ____ BELL: _________

HAVE YOU TAKEN A TECHNOLOGY EDUCATION CLASS BEFORE? YES NO

IF YES, WHAT GRADES? 6th 7th 8th

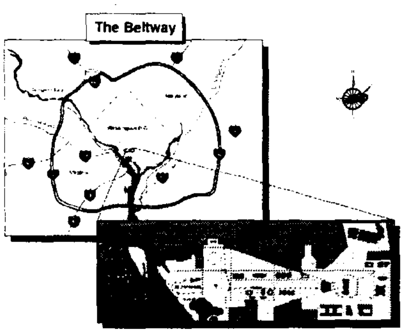
MAPS



Maps are powerful representations of Earth's features. The purpose of a map is to bring the world to a reduced scale view so we can understand patterns of geographic space.

The first known map has been dated to approximately 2500 B.C., found in what is now known as Iraq. The map was drawn on a clay tablet and showed land boundaries as a way of keeping peace among land owners.

Today, to name just a few of their uses, maps are used to locate natural resources, site manufacturing centers, allocate voters to members of Congress, assess environmental damage, show flooding zones in case of a hurricane, and to navigate highways and surface streets in order to find the place to which we are travelling, . Maps also play a vital role in structuring our everyday perceptions of neighborhoods and communities.



Maps are generalizations of reality. Many features in the real world are not shown on maps, depending on its scale. For instance, the city of Baltimore may not be on a page-size map of the U.S. because some other cities around it are so large that there may not be room to feature it on the map. However, the city of Omaha may be on the same map, even though it is much smaller than Baltimore.

Mental maps are internal maps built into our heads. They are a direct perception of the environment in which we live. Mental maps are essential for use in our everyday life. You use your mental map everyday when you walk around the school to find your next class and when you are riding in the car with your parents to go to the store or a friend's house.

CONSTRUCTING YOUR OWN MAP

Later, during this class, you will be asked to construct a map showing the most direct route to get from Landstown Middle School to Lynnhaven Mall. Listed below are distances and headings between major intersections as well as intersections of interest in order for you to make your map as accurate as possible. The map will have to fit on half a standard sheet of paper, e.g. the size of the paper will be 5½ in. X 8½ in. The entire area that the map will represent is approximately 3 mi. X 3 mi.

Segment of Road	Distance (mi.)	Initial Heading
Landstown M.S. - Concert Dr.	0.2	Southeast
Recreation Dr. - Princess Anne Rd.	0.4	Northeast
Concert Dr. - Independence Blvd	1.1	Northwest
Independence Blvd - Lynnhaven Pkwy (on Princess Anne)	0.5	Northwest
Princess Anne - Independence (on Lynnhaven)	0.6	Northeast
Princess Anne - Lynnhaven (on Independence)	0.4	North
Independence - Holland	1.6	Northeast
Holland - Lynnhaven Mall Main Entrance (at International Parkway)	1.7	Northeast
LMS **direct** to Mall (as crow flies)	3.7	Northeast

Questions

1. What is the maximum scale that can be used for the map that you draw (i.e. x in. = y mi.)?

___

2. How will a user of your map know what the scale is? ___

___

3. How will a user of your map know what direction the roads are going (i.e. north, northwest, south, etc.)?

___

4. How will a user of your map know which roads are highways, major surface streets, or minor surface streets?

___

5. How will special interest locations such as schools, churches, and shopping malls be indicated on your map? How will the user of the map know what the symbols mean? ___

___

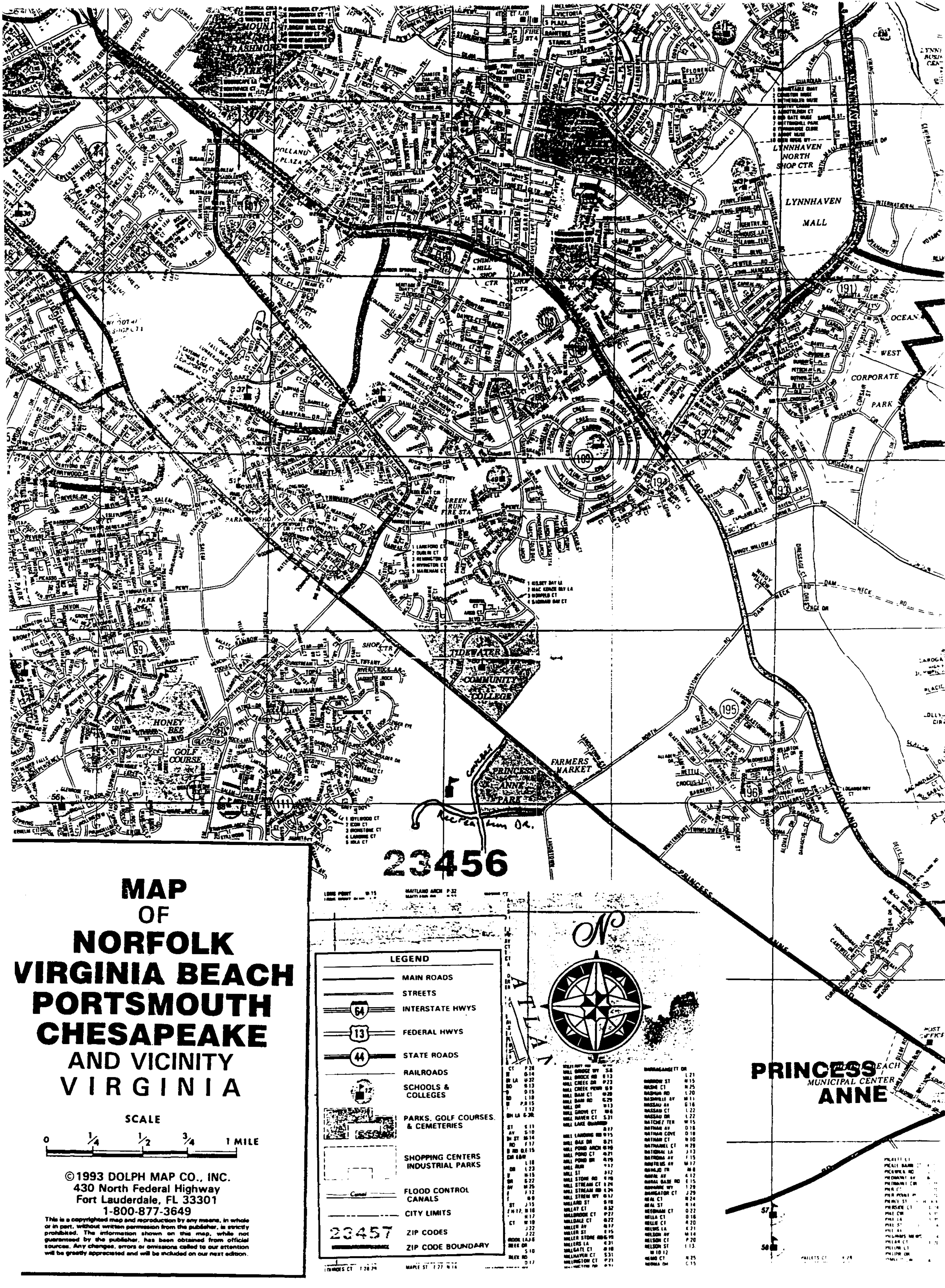
___

Draw Your First Possible Solution Above This Line

Draw Your Second Possible Solution Below

Draw Your Final Solution Above

6. After you have been given time to draw your final map, the teacher will give you a photocopy of a commercial map showing the area that you have been challenged to draw. Using this map, evaluate the map that you have drawn. List below the things that you would change to make your map better.



MAP
OF
NORFOLK VIRGINIA BEACH PORTSMOUTH CHESAPEAKE
AND VICINITY
VIRGINIA

SCALE

0 1/4 1/2 3/4 1 MILE