PERCEPTIONS AND IDENTIFICATION OF PROBLEM SOLVING ACTIVITIES IN SECONDARY INDUSTRIAL ARTS AND TECHNOLOGY EDUCATION PROGRAMS IN MONTANA

by

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APPROVAL

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This professional paper has been read by each member of the graduate committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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This paper is dedicated to the memory of my father,

Edwin Joseph Lodermeier.

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ABSTRACT

The major purpose of this study was to determine the perceptions of Montana secondary industrial arts and technology education instructors relative to the degree of importance and occurrence placed on different problem solving activities in their classrooms. The objectives for this study were: (1) to identify what activities instructors use to teach problem solving, (2) to determine the perceptions of instructors concerning occurrence of problem solving in the industrial arts or technology education program, and (3) to determine the perceptions of the instructors concerning their personal rating of the degree of importance of problem solving activities in the industrial arts or technology education program.

The problem solving statements were developed from a collection of different resources to represent the three types of problem solving structures and the two instructional categories. The problem solving section was validated by a judging panel, and input was provided for the instructional content, student, and instructor sections by the Specialist of Trade and Industrial Education of Montana.

Data for this study were collected from 141 Montana industrial arts and technology education instructors through a mailed questionnaire which yielded a 58.3 percent usable return.

The results conclude that: (1) problem solving activities that occur the most frequently and are considered by the industrial arts and technology education teachers to be of highest importance are activities that utilize either routine, repetitive, and mathematical procedures, or that utilize heuristic approaches to solve problems that involve the use of tools, processes, and materials; and (2) problem solving activities that occur the least frequently and are considered the least important are activities that exercise either creative problem solving processes or routine, repetitive, and mathematical approaches to solve problems relating to technological systems, their resources, processes, and impacts on society.

CHAPTER 1

INTRODUCTION

Today all students are faced with challenges and problems at an unprecedented rate. Technology education programs should reflect this change. The need to replace traditional content methods with current problem solving and critical thinking approaches which reflect changes in technology is addressed by Barnes (1989, p. 25):

> The study of technology provides the means to develop problem solving and creative/critical thinking abilities thus producing a technologically literate citizen. This concept is paramount, since the purpose of education is to prepare children for the future in which they will live. With knowledge and technology doubling every two and a half years, technology educators cannot any longer continue to prepare teachers or to educate children through traditional content methods.

The industrial education profession is changing to reflect the knowledge and technology explosion, as noted by Balistreri (1987), Pullias (1987), and Oaks (1987). Because our industrial education programs reflect our technological world, it is the role of educators to offer our students the best possible education in this area. It grows increasingly evident that up-to-date teaching approaches and curriculums should be used by instructors to educate our students with the appropriate skills. Through carefully selected activities, students can increase their problem solving and decision making skills. In order for Montana students to be competitive, industrial arts and technology

education programs should offer challenge and appropriate instruction in problem solving techniques.

To reflect the knowledge and technology explosion currently occurring in society, Kemp and Schwaller (1988), in Papers from the 37th Yearbook: Council on Technology Teacher Education, describe six specific approaches and delivery systems for teaching technology education. These six approaches are: (1) conceptual learning, (2) interdisciplinary, (3) social/cultural, (4) problem solving, (5) integrating the systems of technology, and (6) interpretation of industry.

The problem solving approach is explained by Kemp and Schwaller (1988, p. 21) as follows:

> Problem solving is another major approach to teaching technology education. Problem solving has become a basic survival skill in today's society. Technology education teachers should provide an educational atmosphere in which students can gain skills in problem solving. If this is done, the students' level of technological literacy will be increased. When using the problem solving approach, teachers become facilitators who provide solvable problems for the students. The technology education teacher has the opportunity to present complex concepts in the laboratory and have students verify these concepts through a problem solving style of teaching.

Baker and Dugger (1986), Johnson (1987), and Tidewater Technology Associates (1986) have discussed the considerable importance placed on problem solving in our profession in the past few years and the need to create an environment that offers the necessary problem solving teaching approaches. The researcher was unable to find literature providing evidence of measurable instruments that determined the degree placed on occurrence and importance for structured problem solving activities.

To attempt to determine what problem solving activities were shaping the industrial education curriculums, the researcher categorized the structure of these activities by curriculum content and problem types. The curriculum included traditional and non-traditional problem solving statements. Three types of problem solving activities were identified (VanGundy, 1988). The types are well-structured, semi-structured, and ill-structured.

It is critical to recognize that technology education is evolving from traditional (industrial arts) curriculums. This change is a reflection not only of the present world, but of the future. The evolution has caused both progression and regression within the profession. The researcher has taken care not to separate the two curriculums into individual entities, but rather to treat them as one evolving from the other.

The curriculum content of *Jackson's Mill Industrial Arts Curriculum Theory* (Hales, 1980) represents the establishment of a common content base that is widely accepted by industrial educators. The revision and acceptance of the curriculum suggested by Jackson's Mill reflects the evolution in the knowledge and skills needed by contemporary society. Problem solving is a skill that links the student with an interactive curriculum which conveys the changing technological world.

Purpose of the Study

The purpose of this study was to determine the perceptions of Montana industrial arts and technology education instructors relative to the degrees of occurrence and importance of the three levels of problem

solving (well-structured, semi-structured, and ill-structured) in their instructional programs.

Objectives

The objectives for this study were:

(1) To identify what activities instructors use to teach problem solving.

(2) To determine the perceptions of instructors concerning occurrence of problem solving in the industrial arts or technology education program.

(3) To determine the perceptions of the instructors concerning their personal rating of the degree of importance of problem solving activities in the industrial arts or technology education program.

Need for the Study

As our society moves from its present post-industrial context to a super industrial-information society, our students must be equipped with practical thinking skills to function productively. One of these skills is problem solving. Problem solving will help provide the proper knowledge base for individuals to function adequately and adapt to the changing world in which we live. Shane (1981, p. 356) addresses this point:

> To help our youth to survive and live humanely, we must recognize that the most important social decisions in human history must be made soon, within the next 20 to 25 years. They can only be made wisely by educated persons.

Technology education can make a significant contribution to the learning process in the area of problem solving (Baker and Dugger, 1986). A careful look at Montana's secondary industrial arts and technology

education programs should indicate whether a systematic approach to teaching problem solving is being utilized.

The early reports of Schmitt and Pelley (1966) summarized that industrial arts instructors place a medium degree of emphasis on problem solving activities relating to materials and processes. Knowing how to teach problem solving was rated moderately difficult for instructors. A study by Bame and Miller (1980) rank-ordered the 12 purposes of industrial arts, 10 of which were taken from the Schmitt and Pelley (1966) study. Of the 12 purposes selected for ranking, on a scale of 1 through 12, the development of problem solving skills was ranked number 6.

Not until the last five years have systematic procedures for problem solving techniques appeared in the industrial education literature. There is a need to identify a procedure to help classroom instructors teach problem solving in the typical technology education classroom (Baker and Dugger, 1986). Barnes (1989) speaks of problem solving as a universal model for transferring knowledge. Holistic in nature, this approach takes into account the unknown and/or changing technologies and integration and application of other school disciplines.

The relationship between science and technology is interactive as well. Technology education students should have a feel for what science and technology are about so they can observe the relationship among the many components of technology. "Problem solving is basic to all aspects of technology; education must teach problem solving skills to ensure that our citizens will be able to adapt to the ever-changing world, to meet personal needs as well as needs of society as a whole" (Tidewater Technology Associates, 1986, p. 15).

> The 1986 space shuttle disaster was a poignant reminder that individuals are needed at all levels who possess an understanding of technological systems. In addition, society needs individuals capable of finding viable solutions to a variety of challenges. These needs have prompted many leaders to suggest that education now implement methods of teaching that can enhance the problem solving abilities of young Americans. The technology education laboratory provides a rich environment for students to develop an understanding of technology and the capacity for solving technological problems. (Hatch, 1988, p. 88)

Brightman (1980, p. 4) states that business management places high priority on solving problems and the need to know how to do so.

> Problem solving is one of the most essential skills of the effective manager, and yet little attention has been paid to problem solving as a field of study. In fact, organizations and individuals frequently construct roadblocks to effective problem solving.

It is not that some people are better at it than others, but most importantly, problem solving can be learned. Problem solving often is not learned because it is not taught. Bransford and Stein (1984, p. 3) expand on this point:

> In school, for example, we are generally taught what to think rather than how to think. This is not due to some great conspiracy to 'hide the secrets of thinking and problem solving from the general public.' Instead, many teachers are simply unaware of the basic processes of problem solving even though they may unconsciously use these processes themselves. It therefore never occurs to them to make these processes explicit and to teach them in school.

The need to teach problem solving processes systematically is confirmed on the basis that we live in a changing technological society where critical thinking skills are needed, and maintain that the industrial education curriculum is evolving to meet these changes.

Definition of Terms

For purposes of this study, the following terms will be interpreted as stated below.

(1) Industrial Arts Education Program (IA): Those occupations by which changes are made in the form of materials to increase their value for human use; an area of education dealing with socioeconomic problems and occupational opportunities involving experience with a wide range of materials, tools, processes, products, and occupations typical of an industrial and technological society; a curriculum area in general education in which students may create, experiment, design, and plan while dealing with issues related to technology (Good, 1973).

(2) Industrial Education: A generic term including those programs dealing with industry and technology. This term encompasses industrial arts, technical education, technology education, and trade and industrial education.

(3) Technology Education Program (TE): "An integrated discipline designed to develop technological literacy as part of the past, present, and future technological systems; their resources, processes, and impacts on society" (New York State Education Department, 1987, p. 2).

(4) Problem Solving: "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" (Cohen, 1971, p. 5).

(5) Well-Structured Problems: These problems are characterized by the availability of all the information needed to close a problem gap. Such a situation is typified by its routine, repetitive aspects and usually can be solved using standard operating procedures that provide ready-made solutions (VanGundy, 1988). These problems are relatively narrow in scope and usually have only one correct answer. The problem solver must arrive at the one best solution. Algorithms are typically used to solve these types of problems. As defined by Morris (1973), an algorithm is any mechanical or recursive computational procedure. An example of this type of problem is *determining voltage to a given situation* (Hatch, 1988).

(6) Semi-Structured Problems: This problem type falls between well-structured and ill-structured types of problems. Typically, a combination of standard operating procedures and creative responses will be required to solve this type of problem (VanGundy, 1988). These problems have more than one correct answer. Heuristics are used to solve this problem type and are characterized as rules-of-thumb or guidelines that increase the likelihood of successfully solving a problem. A typical heuristic approach to solving a problem would consist of using a sequence of steps similar to: (a) recognizing the problem, (b) defining the problem, (c) selecting a strategy, (d) attempting to solve by acting on a strategy, and (e) drawing conclusions and checking results. An example of this type of problem is *performing tasks in order of importance* (Hatch, 1988).

(7) Ill-Structured Problems: This problem type provides the problem solver with little or no information on the best way to develop a solution. Because no clear-cut procedures exist for closing a problem gap, the problem solver must improvise and use custom-made solutions (VanGundy, 1988). These types of problems have a variety of potentially correct solutions. They require divergent thinking and utilize creative problem solving techniques. This type of problem is almost never solved by looking for an algorithm, nor will heuristics ensure an acceptable solution. An example of this type of problem is *the development of a better means of transporting people in an urban setting* (Hatch, 1988).

Limitations

The following limitations were placed on this research:

(1) Data were collected from junior high and senior high school industrial arts and technology education programs in Montana.

(2) The problem solving activity statements were chosen and designed to best represent as many of the instructional content areas as possible.

Summary

Technology education has evolved dramatically in the past few years from traditional (industrial arts) programs whose main instructional focus was materials, processes, and products. Present program emphasis has refocused its curriculum to reflect technological advancements, technological systems, technological impacts, and societal changes and

needs. To incorporate the present curriculum content of technology education, the profession has identified six specific teaching approaches and delivery systems. These different teaching approaches will reinforce and strengthen the skills needed by students in the study of technology. Problem solving is identified as one of the teaching approaches that assists with the development of creative and critical thinking skills.

CHAPTER 2

REVIEW OF LITERATURE

Importance of Problem Solving

The interest in problem solving as a part of industrial education has accelerated in recent years. The largest notable movement in education to promote problem solving was the establishment of the *Invent America* program in 1986 by the U.S. Patent Model Foundation, a non-profit organization. The creation of this program was founded on the need for our country to remain competitive on the world market by providing students with opportunities to learn and apply higher level thinking skills at the elementary level. Competitive in nature, *Invent America* is structured to provide hands-on experience and processes to invent solutions to everyday problems. There were over 10,000 elementary schools participating in the inventor's competition as of 1987, while there are plans for including high schools, colleges, and universities in the future (Metz, 1987).

The magazine *TIES (Technology, Innovation & Entrepreneurship for Students)* lists in its calendar of events 33 professional meetings, conferences, and conventions that deal specifically with creativity, innovation, thinking strategies, and problem solving (Anderson, 1989, pp. 47-48). The Future Creative Problem-Solving Workshop, Odyssey of the Mind World Finals, and the Fifth National Conference on Thinking are some of the seminars offered that integrate math, science, and technological

concepts to enhance critical thinking skills. Workshops in teaching problem solving with elementary students, teaching problem solving with microelectronics, and problem solving in structures, mechanisms, and computer control were offered to educators at the 51st Annual International Technology Education Association's Conference held in Dallas, Texas, March 20-23, 1989 (Starkweather, 1989).

The accelerated interest in problem solving is a by-product of new teaching approaches introduced into technology education curriculum, reflecting the changes and technological advancements taking place in industry and society. "With knowledge and technology doubling every two and a half years, technology educators cannot any longer continue to prepare teachers or to educate children through traditional content methods" (Barnes, 1989, p. 25). Other reasons for emphasizing problem solving include expectations of future employers in addition to assuring our citizens the ability to adapt to the ever-changing world for their personal needs as well as the needs of society.

The study of problem solving is a relatively new area of interest in the industrial education profession. The researcher found conceptual literature dealing with problem classifications, problem solving methodology, and structure, but was unable to find concrete data and tested hypotheses relating to problem solving classifications, methodology and structure in the field under study.

An early study indicated that problem solving activities related to materials and processes had a medium degree of importance in the classroom, while the knowledge of how to teach problem solving was rated moderately difficult for instructors (Schmitt and Pelley, 1966). Another

study (Bame and Miller, 1980) rank-ordered 12 purposes of industrial arts while placing the development of problem solving skills as sixth in the level of importance.

The researcher did not find any studies dealing with the following areas of concern: (1) what types of problem solving activities occurred, (2) what level of difficulty was placed on activities, and (3) the importance placed on the activity by the instructor.

Historical Development of Problem Solving

Until recently, problem solving was not considered a field of study. The first documented formal course designed to teach problem solving was in journalism in 1931. Six years later, General Electric Company developed a problem solving course for its technicians. During the 1950's, Alex Osborn developed a brainstorming technique that was adapted by many companies, the armed forces, and the federal government. It was not until that time that problem solving was accepted as a legitimate field of study (Brightman, 1980).

In the early 1960's, the Synectics Corporation was formed by William J.J. Gordan. The corporation's main functions were: (1) solving design engineering problems, (2) training professional problem solving groups, and (3) developing inner-city educational materials based on creative thinking. By 1980, the Synectics Corporation was conducting over 100 problem solving seminars annually around the world for banking institutions, governments, and service and manufacturing industries (Brightman, 1980). Brightman (p. 3) offered his feelings about education's role relative to the problem solving process:

> In the field of education, the training of problem solvers is still in its infancy. While there have been many programs directed at the elementary level and secondary level in education, there has been an appalling lack of work at the university level. A recent encouraging sign is the implementation of problem solving courses in the curricula of several medical schools; however, more must be done to develop professional problem solvers.

It was not until the mid-1980's that industrial education literature started to have articles that dealt specifically with problem solving procedures and techniques (Baker and Dugger, 1986; Johnson, 1987; Tidewater Technology Associates, 1986). The relevance of problem solving is addressed by the Council on Technology Teacher Education (Kemp and Schwaller, 1988), which contributed an entire chapter on problem solving as an instructional approach. The chapter discusses the need and importance of problem solving, the role of technology education instructors, problem structures, and techniques for solving problems (Hatch, 1988).

Problem Solving in the Industrial Education Setting

Citing the need and opportunity to provide structured problem solving activities in the industrial education laboratory, Baker and Dugger (1986, p. 13) comment:

> Technology education teachers need to recognize that simply stating that problem solving activities are provided is not enough. An attempt to provide structured problem solving activities should be made in order that the students receive the maximum benefit from their experiences. Technology education (industrial arts) is unique in that it is an ideal area to provide structured problem solving experiences. Not only can opportunities be provided to recognize and generate possible solutions to problems, but opportunities also abound to test the possible solutions.

Johnson (1987) suggests that industrial education labs give students a unique opportunity to learn about and experience higher-level thinking. Citing the change in problem solving applications with the evolution of curriculum content, Johnson (p. 15) comments:

> Once, we found it appropriate to focus primarily on materials and process through courses in drafting, woodworking, and metalworking. Now it grows increasingly evident that up-to-date curricula should focus on industrial and technical systems. With a curriculum that reflects this perspective, industrial educators can help their students become technologically literate and gain the skills they will need to cope with the changes in our industrial and technological society.

Theoretical Basis for Thinking

Determining what is meant by thinking, or developing a model of the thinking process, is difficult for educators. "Currently, there is a great deal of interest in improving student thinking abilities, but there is also considerable confusion about what thinking is, the kinds of experiences or programs that advance it, and the implications of such efforts for school personnel and policies" (Presseisen, 1985, p. 43).

Thinking skills can be viewed along a continuum beginning with basic thinking skills and then developing into higher order, more complex thinking process skills. A model for basic thinking process skills with appropriate characteristics is presented by Presseisen (1985, p. 45):

1. *Causation:* Establishing cause and effect, assessment -- predictions, inferences, judgment, evaluations.
2. *Transformations:* Relating known to unknown characteristics, creating meaning -- analogies, metaphors, logical inductions.

3. *Relationships:* Detecting regular operations -- parts and wholes, patterns, analysis and synthesis, sequences and order, logical deductions.
4. *Classification:* Determining common qualities -- similarities and differences, grouping and sorting, comparisons, either/or distinctions.
5. *Qualifications:* Finding unique characteristics -- units of basic identity, definitions, facts, problem/task recognition.

These five basic thinking skills are essential for the complex thinking process skills to occur. The higher order skills are addressed by Cohen (1971, p. 5):

1. *Problem Solving:* Resolve a known difficulty.
2. *Decision Making:* Choose a best alternative.
3. *Critical Thinking:* Understand particular meanings.
4. *Creative Thinking:* Create novel or aesthetic ideas/products.

The basic thinking skills are essential for developing and using the more complex thinking skills. Young learners develop competence in the essential skills during their early years of schooling. As students enter middle and junior high school, they are introduced to more complex processes in specific content matter. Presseisen (1985) writes that different subject areas offer higher order or complex thinking processes that draw upon the essential thinking skills. Presseisen (pp. 45-46) further comments:

> Some complex thinking processes may be more relevant to certain subject areas than to others. For example, problem-solving thinking skills seem ideal for mathematics or science instruction. Decision making may be useful for social studies and vocational studies. Creative thinking might enhance all subjects. Most important, the goals of the specific complex process and objectives of the learning in the particular subject area should be parallel and reinforcing.

What Is Problem Solving?

To establish an origin for what problem solving is, definitions for problems and problem solving are given. According to The American Heritage Dictionary, in its very basic form, "a problem is a question or situation that presents uncertainty, perplexity, or difficulty" (Morris, 1973, p. 1043). VanGundy (1988, p. 3) states, "A problem is any situation in which a gap is perceived to exist between what is and what should be." Problem solving, as described by Cohen (1971, p. 5) and used for this study, is:

> 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.

Problem Classifications-Structure

The procedure or method for solving a problem lies in the classification or structure of the problem. Several problem solving structures are identified in the literature. Proactive and reactive problem structures are discussed by Baker and Dugger (1986), the ill-structured/well-structured continuum is presented by Brightman (1980), and well-structured, semi-structured, and ill-structured classifications are introduced by VanGundy (1988).

Proactive problem solving activities are addressed as preparation activities, such as checking, correcting, planning, selecting, and varying. These activities are considered important exercises, but caution

should be taken so the instructor does not give the answers prior to the students solving them. Reactive problem solving activities are reactions to situations that are not working properly. Heuristics, which utilize guidelines to lead to solutions, are used to solve proactive and reactive problems (Baker and Dugger, 1986).

Another classification of problems is identified along an ill-structured/well-structured continuum.

> Problems are considered well-structured when they are repetitive, routine, well-defined, and can be solved solely by standardized or automated procedures. Ill-structured problems are novel, elusive, and slightly out-of-focus messes in the sense that a problem is often ambiguous and poorly understood. (Brightman, 1980, p. 6)

To find solutions for ill-structured problems, students are required to use judgment, intuition, creativity, general problem solving processes, and heuristics.

VanGundy (1988, p. 4) states, "Most problems can be classified according to their degree of structure." The classifications of problems are well-structured, semi-structured, and ill-structured. By structuring problems into classifications, one can observe the characteristics of the problem and use the appropriate approach or technique to solve the problem.

Well-Structured Problems

Typically, well-structured problems can be solved with algorithms. Algorithms are mechanical or mathematical based procedures and if applied correctly will produce the right solution. The range of well-structured problems is usually limited and such problems have only one correct answer. In discussing the relevance of well-structured problems in

technology education programs, Hatch (1988, p. 90) states, "Once learned, however, they are no longer useful in developing the skills of a problem solver."

Semi-Structured Problems

Semi-structured problems are generally solved by employing a heuristic problem solving approach. Although the literature addresses the heuristic approach only for solving semi-structured problems, this approach may be utilized for ill-structured problems as well. Many five- to seven-step heuristic models are identified containing similar characteristics (Bransford and Stein, 1984; Brightman, 1980; Koberg and Bagnell, 1981; Kurulik and Rudnick, 1984).

The components of a typical heuristic approach are: (1) identify the problem, (2) define and represent the problem, (3) explore possible strategies, (4) act on strategies, and (5) look back and evaluate the effects of your activities.

Ill-Structured Problems

The problem solving techniques utilized to resolve ill-structured problems are usually in the form of creative responses or a form of heuristics. Ill-structured problems are identified closely with the design process and creative problem solving. Solutions to ill-structured problems may utilize any or all of the complex thinking process skills of problem solving, decision making, critical thinking, or creative thinking.

Intelligence, design, and choice are three elements that make up a well-known model for solving ill-structured problems. "In the

intelligence stage, the problem is recognized and information gathered for formulating a problem definition; in the design stage, problem solutions are developed; in the choice stage, the solution alternatives are selected and implemented" (VanGundy, 1988, p. 5). When applying any of the 40 problem solving techniques listed by VanGundy (1988), care must be taken with structured problem solving procedures so creative processes are not inhibited.

Summary

The review of literature addressed the importance placed on problem solving in public schools as well as the industrial education profession. With the emphasis of problem solving strengthening in the technology education profession, problem solving structures and problem solving approaches must be identified. The problem solving structures that were identified are: (1) proactive and reactive problem structures (Baker and Dugger, 1986), (2) ill-structured/well-structured continuum (Brightman, 1980), and (3) well-structured, semi-structured, and ill-structured (VanGundy, 1988).

Algorithms, heuristics, and creative problem solving techniques are problem solving approaches utilized to solve given problem structures, although some solutions may be found using any problem solving approach to a given structure. Generally algorithms are used to solve well-structured problems which usually have one correct answer. Heuristics, which utilize a set of guidelines to lead to a solution, are used to solve semi-structured problems which may have more than one correct solution. Creative problem solving and design processes are utilized for

solving ill-structured problems which may have a multitude of correct solutions. The literature suggests that strong efforts are being made to enhance and provide problem solving techniques and applications for elementary and secondary schools through professional meetings, organizations, and conferences.

CHAPTER 3

METHODOLOGY

This study used a survey instrument designed to determine what types of problem solving activities were occurring in secondary industrial arts and technology education programs in Montana and the importance the instructors placed on those activities.

Population and Sample

The population for the research involved all industrial arts and technology education instructors who taught in Montana secondary programs during the 1988-89 school year. A complete list of all industrial education personnel was obtained from the State Specialist of Trade and Industrial Education, Mr. Jeff Wulf, Office of Public Instruction, Helena, Montana. From approximately 450 industrial education personnel, 242 instructors were classified by the State Specialist as secondary level industrial arts and/or technology education teachers. The industrial education personnel not used for the survey were classified as secondary trade and industry instructors, university level instructors, and vocational center instructors.

Instrument Design

The ideas for and formulation of the survey instrument (Appendix E) were developed from the knowledge and information gained during the review

of literature. This study was conducted with a mailed questionnaire designed by the researcher. The instrument was assembled in three sections.

The first section of the survey instrument pertained to the curriculum content presented in courses offered by the teacher respondents. The curriculum content was grouped by title for the two instructional categories of industrial arts (IA) and technology education (TE), and definitions were given for each. Each category contained specific teaching areas. The respondent was asked to indicate what percentage of time was allotted for teaching in each area. The procedure for completing the industrial arts category followed the progression of identifying: (1) the IA curriculum category, (2) the IA curriculum areas (mechanical drafting, metalworking, woodworking, etc.), and (3) what percentage of time is designated in that area of instruction. Ten instructional areas were listed under the IA category.

The procedure for completing the technology education category was similar to that for the industrial arts category. The four clusters of communications, construction, manufacturing, and transportation were listed under the TE instructional category, with 20 subgroups (graphic communications, building systems, power systems, etc.) (Hales, 1980).

The second section of the survey instrument consisted of 36 problem solving activities in statement form. The purpose was to identify how often the problem solving activity occurred in a nine-week period and the respective level of importance the instructor placed on each activity. The level of occurrence for each problem statement was measured by teacher response to a six-category Likert scale. The degree of importance placed

on the problem statement was measured by teacher response to another six-category Likert scale. For each problem statement, NR represented no rating, 1 represented the lowest rating, and 5 represented the highest rating.

The problem solving statements were designed to represent the instructional categories of industrial arts and technology education, and the three problem types of well-structured, semi-structured, and ill-structured. During the development and testing phases of the problem solving statements, the problem statements remained in their designated divisions. The problem solving section of the final survey instrument placed each problem statement in random order. The procedure for assigning numbers to problem solving statements was determined by drawing random numbers from a bowl. The 36 problem statements are representative of the six divisions shown in Table 1.

Table 1. Instructional categories and problem types identified by division.

Division Title	Instructional Category	Problem Type
Industrial Arts Well-Structured	IA-based	Well-structured
Technology Education Well-Structured	TE-based	Well-structured
Industrial Arts Semi-Structured	IA-based	Semi-structured
Technology Education Semi-Structured	TE-based	Semi-structured
Industrial Arts Ill-Structured	IA-based	Ill-structured
Technology Education Ill-Structured	TE-based	Ill-structured

The third section of the survey instrument contained student and instructor demographics and classroom computer usage data. Student enrollments were indicated for grade 7 through grade 12. Teaching experience was indicated by selecting a classification of 1-5 years, 6-10

years, 11-16 years, 17-25 years, or 26 or more years. The computer data area addressed instructor and student access to computers, types of hardware available, and software application.

Development and Testing of Problem Solving Statements

The basis for the design and formulation of the problem solving statements was selected from various industrial arts/technology education activity guides, teacher handbooks, textbooks, and workbooks (Appendix I). Forty-eight problem solving activities were compiled into six divisions, with eight statements per division (Appendix B).

Ideas and direction for the design of the survey instrument were provided by the researcher's graduate committee during its development. The faculty in the Montana State University Department of Agricultural and Technology Education proofread and checked the problem solving statement section for readability prior to sending the rating form to the judging panel.

A five-member judging panel was selected and asked to participate in testing the content validity of the problem solving statement portion of the instrument. The selection of the panel was based on each member's individual contributions and professional activities relating to problem solving in the industrial arts/technology education profession (Appendix A).

Each panel member was contacted by telephone on February 13, 1989, was apprised of the research being done, and agreed to participate on the panel. On February 16, 1989, the members were sent directions and judging panel/rating forms to rate the validity of each problem solving statement (Appendices B and C).

The statements were ranked on the basis of the numerical tabulation and comments provided by the panel. After interpretation of the data, six problem solving statements were assigned to each of the six divisions. The final selection of problem statements was based on judging panel comments, numerical tabulation, and graduate committee review. The problem statements were placed in the final survey format by random placement.

The Specialist of Trade and Industrial Education for the State of Montana was sent a survey instrument on February 20, 1989, to review and add recommendations (Appendix D). Suggestions from the State Specialist involved adding the percentage of time taught for each of the two instructional areas of industrial arts and technology education.

Data Collection

An introductory letter providing the purpose of the study and directions for completion of the questionnaire was sent on March 8, 1989, to the entire population, along with a self-addressed, stamped envelope (Appendix F). The population consisted of 242 industrial arts and technology education instructors. The instruments were alphabetically and numerically coded with invisible ink to ensure accuracy and efficiency upon decoding. The returned questionnaires were identified with an ultraviolet lamp. Return percentages were tabulated on a daily basis. This effort yielded 66 returns from a mailing of 242 instruments, representing a return rate of 27 percent on March 26, 1989.

A follow-up letter and second questionnaire were sent on March 27, 1989, to the non-respondents, approximately three weeks after the initial

mailing (Appendix G). This effort yielded 71 additional returns, bringing the return rate to 56 percent on April 9, 1989.

On April 10, 1989, the second and final follow-up reminder was mailed to the remaining non-respondents (Appendix H). This effort yielded 16 returns. Thus, of the 242 problem solving survey instruments mailed, the total number returned was 153, representing a 63 percent rate of return. Twelve of the returned instruments were unusable because they were not completed properly, reducing the total number of usable instruments for data analysis to 141, which represented a 58.3 percent usable rate of return as of April 25, 1989.

Data Analysis

The data were processed using *dBase III Plus*, Version 1.1 (Stultz, 1988) and *MSUSTAT: Statistical Analysis Package*, Version 4.2 (Lund, 1988) statistical software on an IBM-compatible XT microcomputer. The data obtained were used to develop the tables for this study and are presented in Chapter 4.

Summary

This study consisted of surveying the entire population of 242 secondary industrial arts and technology education instructors in the state of Montana. The instrument used in the study was designed by the researcher to detect the occurrence of and instructor importance placed upon problem solving activities related to classroom instruction. Data were collected via a mailed survey instrument with a total usable return response rate of 58.3 percent.

CHAPTER 4

ANALYSIS OF DATA

Introduction

Industrial education instructors in Montana public schools comprised the population for this study. A survey instrument was designed to determine what types of problem solving activities were occurring in secondary industrial arts and technology education programs and the importance the instructor placed on those activities. The problem solving section of the instrument was tested by a panel of professional teachers active in the problem solving teaching area (Appendix C).

This study was conducted using the following three objectives:

(1) To identify what activities instructors use to teach problem solving.

(2) To determine the perceptions of instructors concerning occurrence of problem solving in the industrial arts or technology education program.

(3) To determine the perceptions of instructors concerning their personal rating of the degree of importance of problem solving activities in the industrial arts or technology education program.

Industrial education instructors at the 242 Montana schools identified as having industrial arts and/or technology education programs were sent questionnaires. A total of 141 (58.3%) usable questionnaires were returned.

The research results are presented in three sections: (1) instructor and student demographics and computer usage data, (2) instructional content data, and (3) problem solving statement data assembled by divisions.

Instructor and Student Demographics and Computer Usage Data

Instructor and Student Data

The years of teaching experience of industrial education instructors in Montana are presented in Table 2. Data in Table 2 indicate that 31 (22%) of the instructors taught for five years or less. In comparison, 32 (23%) of the teachers have taught for 11 to 16 years. The group containing the smallest number of responses is the "26 or more" category, with 4 (3%) instructor responses.

Table 2. Years of teaching experience for industrial education teachers (N=141).

Number of Years Taught	No.	Percent
5 years or less	31	22
6 to 10 years	24	17
11 to 16 years	32	23
17 to 25 years	50	35
26 or more years	4	3

The industrial education programs offered at various grade levels are presented in Table 3. Seventh grade is the least taught, as indicated by 62 (44%) of the respondents. The largest offerings of industrial education programs are indicated by 108 (77%) responses for the eleventh grade and 107 (76%) for the twelfth grade.

Table 3. Industrial education programs offered at various grade levels (N=141).

Grade Level	Industrial Edn. Programs Offered		Industrial Edn. Programs Not Offered	
	No.	Percent	No.	Percent
7th Grade	62	44	79	56
8th Grade	71	50	70	50
9th Grade	92	65	49	35
10th Grade	100	71	41	29
11th Grade	108	77	33	23
12th Grade	107	76	34	24

Computer Usage Data

Several forms of computer information were collected. The groups of computer information included student and instructor access to computers, types of hardware possessed, types of software application, and frequency of software application in the industrial education program.

Table 4 presents student and instructor access to computers for IA/TE activities. Evidence shows that instructors have more access to computers than their students. Only 81 (57%) of the IA/TE programs offer access for student computer use, while 102 (72%) of the programs offer computer access to teachers.

Table 4. Student/instructor access to computer(s) for IA/TE activities (N=141).

	Access to Computers			
	Yes	Percent	No	Percent
Students	81	57	60	43
Instructors	102	72	39	28

The data in Table 5 indicate the types of computer hardware declared by industrial education program instructors. Of the instructors surveyed, 104 (74%) indicate their programs do possess computer hardware and 37 (26%) say their programs do not. Of the 104 (74%) instructors who indicate their programs have computer hardware, from Table 4 it can be seen that 102 (72%) of the instructors actually have access to computers. The reason for this is that two instructors have obsolete computers.

Table 5. Types of computer hardware declared by industrial education programs (N=141).

Computer Hardware Types	No.	Percent*
Apple II	83	59
Macintosh	6	4
IBM	19	14
IBM Compatible	26	18
Other	2	1
One use	80	57
Combination of two	19	14
Combination of three	5	4
No. programs w/computer hardware	104	74
No. programs w/o computer hardware	37	26

*Total computer combination usage exceeds 100% due to rounding.

According to data in Table 5, Apple II computers make up the majority of computers used for IA/TE activities, as indicated by 83 (59%) of the respondents. The least number of responses indicating specific computer hardware types declared by industrial education programs are those possessing Macintosh (6, or 4%) and computers in the "other" category (2, or 1%). Individual computer use occurs with 80 (57%) programs, while 19

(14%) of the programs use a combination of two computers and 5 (4%) of the programs use a combination of three different types.

The types of computer software applications are addressed in Table 6. The most frequent use of software is for word processing, occurring in 85 (60%) of the programs. The smallest software application group is tele-communications, accounting for 10 (7%) of the programs. Thirty-seven (26%) of the respondents indicate they are using other forms of software applications in their programs.

Table 6. Types of computer software applications utilized by industrial education programs (N=141).

Computer Software Type	No.	Percent*
Word Processing	85	60
Computer-Aided Drafting (CAD)	61	43
Graphics	37	26
Tele-communications	10	7
Other	37	26

*Total exceeds 100% because respondents have more than one choice.

Table 7 presents data showing frequency of computer software applications currently in use by industrial education programs. A modest number of programs (38, or 27%) do not have computer applications. The majority of computer applications occur in 41 (29%) programs, with one application only. As many as 19 (14%) of the programs are using three applications, while only 6 (4%) programs have five or more applications available.

Table 7. Frequency of computer software applications utilized by industrial education programs (N=141).

Frequency of Application	No.	Percent
No application	38	27
One application	41	29
Two applications	31	22
Three applications	19	14
Four applications	6	4
More than five applications	6	4

Instructional Content Data

Data were collected for the instructional categories of industrial arts education and technology education. Each category contained specific teaching areas. The respondents provided the percentage of time taught for each content area.

Table 8 displays the percentage of time taught in the industrial arts content areas. The highest incidence of teachers providing instruction in any industrial arts content area is 103 teachers in woodworking. Woodworking also has the largest number of instructors designating the highest percentage of time, with 6 instructors teaching 100 percent, 3 teaching 90 percent, 4 teaching 80 percent, 3 teaching 70 percent, 5 teaching 60 percent, and as many as 16 teaching 50 percent of the time.

As shown in Table 8, the instructors offer instruction in mechanical drafting the second most frequently, with 1 instructor teaching 50 percent, 8 teaching 40 percent, 19 teaching 30 percent, 40 teaching 20 percent, and 22 teaching 10 percent of the time. Industrial arts content

areas that are taught the least are reported by 119 instructors not teaching electronics, 119 not teaching in the "other" category, and 118 not teaching crafts. As indicated in Table 8, a sum of 503 instructor-related industrial arts content area offerings exist in Montana.

Teacher responses to the percentage of instructional time spent teaching in the technology education content area are displayed in Table 9. The highest incidence of instruction is in the area of building design, with a total of 22 instructors responding. The least taught content areas in technology education are those in the communications cluster, with only 2 instructors teaching offset and photography. As shown in Table 9, the total number of instructor-related technology education content area offerings is 234.

Table 8. Teacher responses to the percentage of instructional time spent in Industrial Arts education content areas (N=141).

IA Content Areas	Percentage of Instruction Time Spent											Total No. of Instructors Teaching in Individual Content Area
	None	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	
	<---------- Response Frequency (No.) ---------->											
Auto-Small Engines	82	12	20	8	5	4	4	1	2	3	0	59
Building Trades	93	15	18	7	5	3	0	0	0	0	0	48
Electronics	119	12	6	3	1	0	0	0	0	0	0	22
Manufacturing	114	14	8	4	1	0	0	0	0	0	0	27
Mechanical Drafting	51	22	40	19	8	1	0	0	0	0	0	90
Metalworking	88	19	21	2	7	1	2	1	0	0	0	53
Welding	85	13	21	12	2	1	3	4	0	0	0	56
Woodworking	38	6	26	19	15	16	5	3	4	3	6	103
Crafts	118	6	6	8	1	2	0	0	0	0	0	23
Other	119	9	6	1	5	0	0	0	1	0	0	22
												Total no. of instructor related IA content areas offered: 503

Table 9. Teacher responses to the percentage of instructional time spent in Technology Education content areas (N=141).

TE Content Areas	Percentage of Instruction Time Spent							Total No. of Instructors Teaching in Individual Content Area
	None	2%	5%	10%	20%	30%	40%	
	<---------- Response Frequency (No.) ---------->							
Communications:								
Visual Communication	126	4	7	2	2	0	0	15
Electronics Communication	129	5	5	1	1	0	0	12
Graphics Communication	122	8	5	2	2	1	1	19
Offset	139	0	2	0	0	0	0	2
Photography	139	0	0	2	0	0	0	2
Other	134	0	5	0	0	2	0	7
Construction:								
Building Design	119	5	7	6	1	2	1	22
Surveying	135	1	4	1	0	0	0	6
Zoning	138	2	1	0	0	0	0	3
Building Systems	125	4	5	4	1	2	0	16
Materials	131	1	4	3	0	2	0	10
Other	134	1	4	0	0	2	0	7
Manufacturing:								
Metals Processing	128	3	5	4	0	1	0	13
Casting	138	3	0	0	0	0	0	3
Machining	135	1	2	3	0	0	0	6
Finishing	133	4	4	0	0	0	0	8
Shaping	134	4	2	1	0	0	0	7
Other	133	0	4	2	0	2	0	8

Table 9--Continued.

TE Content Areas	Percentage of Instruction Time Spent							Total No. of Instructors Teaching in Individual Content Area
	None	2%	5%	10%	20%	30%	40%	
	<---------- Response Frequency (No.) ---------->							
Transportation:								
Guidance and Control	131	2	5	2	0	1	0	10
Power Systems	123	4	6	5	1	1	1	18
Electricity	129	3	6	3	0	0	0	12
Auto Power Systems	130	2	5	2	0	0	2	11
Study of Energy	134	2	3	1	1	0	0	7
Other	131	1	4	1	1	2	1	10
						Total no. of instructor related TE content areas offered:		234

Problem Solving Statement Data

This section is arranged in six problem solving divisions. The classifications of problem solving statement divisions and division rubrics are shown in Table 10.

Table 10. Problem solving statement divisions and division rubrics.

Division Classification	Division Rubric
Industrial Arts Well-Structured Division	IA Well-Str
Technology Education Well-Structured Division	TE Well-Str
Industrial Arts Semi-Structured Division	IA Semi-Str
Technology Education Semi-Structured Division	TE Semi-Str
Industrial Arts Ill-Structured Division	IA Ill-Str
Technology Education Ill-Structured Division	TE Ill-Str

A table is provided for each division presenting the frequency and mean ranking of problem solving statements based on occurrence and importance. Occurrence is established by the instructor's perception of each problem solving statement in a nine-week period. The importance of each problem solving statement is determined by the instructor's perception of the degree of importance placed on each statement.

The statistical importance for each problem solving statement was determined by comparing the differences among the means. Based on the distribution of respondent choices for occurrence and importance ratings of problem solving statements, and to permit a more accurate description of data, a range of limits for each of the 141 responses was created by assigning the numerical values of zero (0) for no rating to five (5) for

high. The numerical values and range of limits for degree of occurrence or importance are presented in Table 11.

Table 11. Numerical values and range of limits for degree of occurrence or importance.

Numerical Value	Range of Limits	Degree of Occurrence or Importance
0 (NR)	0 - 0.49	No occurrence or no importance
1	0.50 - 1.49	Low
2	1.50 - 2.49	Moderately low
3	2.50 - 3.49	Moderate
4	3.50 - 4.49	Moderately high
5	4.50 - 5.00	High

As Table 11 indicates, a range of limits was established to represent the degree of occurrence and the degree of importance given by the respondents (N=141) for each statement. The means for each problem statement were determined by the statistical program *SumStat*, within *MSUSTAT* (Lund, 1988). Statement means ($\bar{x}$) that fell between 4.50 and 5.00 were assigned a high rating. Problem statement means that were given a moderately high, moderate, moderately low, or low rating were assigned a range of limits of 3.50 to 4.49, 2.50 to 3.49, 1.50 to 2.49, and 0.50 to 1.49, respectively. Statement means that fell between 0 and 0.49 were rated as not occurring or not important.

Industrial Arts Well-Structured Division

Table 12 presents the frequency and mean ranking for the problem solving statements based on occurrence and importance for the industrial arts well-structured division.

The data indicate that problem statements 5 ($\bar{x}$ = 4.043), 24 ($\bar{x}$ = 3.716), and 18 ($\bar{x}$ = 3.674) had a moderately high rate of occurrence, while

Table 12. Frequency and mean rankings of problem solving statements based on occurrence and importance for the Industrial Arts Well-Structured Division (N=141).

No.	Problem Solving Statements		Rank Order	No Rating	Rating Low 1	2	3	4	High 5	Mean	S.D.
5	Selecting the appropriate hand tool for a specific task.	OCC	1	2	6	3	25	42	63	4.043	1.152
		IMP	1	2	4	7	18	28	82	4.213	1.164
24	Calculating the cost of a project.	OCC	2	7	4	11	32	33	54	3.716	1.380
		IMP	2	5	1	6	29	34	36	4.014	1.219
18	Drawing and/or reading a drawing to scale.	OCC	3	10	6	11	20	40	54	3.674	1.505
		IMP	3	10	2	4	21	32	72	3.979	1.432
13	Determining how to make the appropriate adjustments on a given piece of stationary power equipment.	OCC	4	15	2	15	28	39	42	3.418	1.559
		IMP	4	14	4	7	26	38	52	3.603	1.567
11	Converting measurements from English to metric and metric to English.	OCC	5	42	26	27	36	6	4	1.645	1.395
		IMP	5	34	18	21	40	16	12	2.156	1.609
28	Calculating turning speeds with different pulley or gear sizes.	OCC	6	59	23	21	23	9	6	1.418	1.522
		IMP	6	47	13	13	33	22	13	2.064	1.770

having moderately high importance means ($\bar{x}$ = 4.213, $\bar{x}$ = 4.014, and $\bar{x}$ = 3.979, respectively). Statement 5, *selecting the appropriate hand tool for a specific task*, had the largest frequency of response in the high rating category, with 63 responses for occurrence and 82 for importance.

An observed difference in Table 12 was with statement 13, *determining how to make the appropriate adjustments on a given piece of stationary power equipment*. This statement was rated moderately high in importance ($\bar{x}$ = 3.603), but had only a moderate rate of occurrence ($\bar{x}$ = 3.418). Another difference that was observed was with statement 28, *calculating turning speeds with different pulley or gear sizes*. This activity had a low rating of occurrence ($\bar{x}$ = 1.418), but was considered more important with a moderately low rating ($\bar{x}$ = 2.064).

The largest difference noted between individual problem statements for the industrial arts well-structured division was the moderately high importance placed on statement 5 ($\bar{x}$ = 4.213) compared with the moderately low rate of importance placed on statement 28 ($\bar{x}$ = 2.064).

Technology Education Well-Structured Division

The frequency and mean ranking of problem solving statements based on occurrence and importance for the technology education well-structured division are displayed in Table 13.

The six problem solving statements in the technology education well-structured division were given either moderately low, low, or no ratings for occurrence and importance.

Statement 30, *completing an assignment with the use of computer-aided drafting*, was ranked the top problem solving activity in this division for both importance and occurrence. This statement was rated moderately

Table 13. Frequency and mean rankings of problem solving statements based on occurrence and importance for the Technology Education Well-Structured Division (N=141).

No.	Problem Solving Statements		Rank Order	No Rating	Rating Low 1	2	3	4	High 5	Mean	S.D.
30	Completing an assignment with the use of computer-aided drafting.	OCC	1	78	17	8	14	18	6	1.2550	1.6710
		IMP	1	53	7	6	21	30	24	2.2840	1.0080
20	Calculating gas mileage for given conditions, distances, vehicles.	OCC	2	94	14	9	15	5	4	0.8298	1.3830
		IMP	2	71	15	18	19	11	7	1.3260	1.6060
14	Calculating lift, drag, etc., for a specific airplane.	OCC	3	107	13	10	5	4	2	0.5248	1.1120
		IMP	4	85	11	13	15	10	7	1.1130	1.6000
7	Determining the mechanical advantages of a ten-speed bicycle; calculating different sprocket ratios.	OCC	4	107	17	8	7	0	2	0.4539	0.9745
		IMP	3	84	11	11	20	7	8	1.1420	1.6110
10	Investigating and presenting how a tele-conferencing system works.	OCC	5	119	10	9	2	1	0	0.2695	0.7059
		IMP	5	94	11	15	12	7	2	0.8156	1.3290
1	Investigating how a tele-conferencing system works.	OCC	6	119	11	8	2	1	0	0.2624	0.6933
		IMP	6	95	10	14	14	6	2	0.8085	1.3250

low in importance ($\bar{x}$ = 2.284) while occurring at a low rate ($\bar{x}$ = 1.255). Statement 20, *calculating gas mileage for given conditions, distances, vehicles* ($\bar{x}$ = 1.326), statement 14, *calculating lift, drag, etc., for a specific airplane* ($\bar{x}$ = 1.113), and statement 7, *determining the mechanical advantages of a ten-speed bicycle; calculating different sprocket ratios* ($\bar{x}$ = 1.142) were each considered low in importance.

Statement 10, *investigating and presenting how a tele-conferencing system works* ($\bar{x}$ = .2695), and statement 1, *investigating how a tele-conferencing system works* ($\bar{x}$ = .2624) each were placed in the no occurrence category.

Industrial Arts Semi-Structured Division

Table 14 presents the frequency and mean ranking of problem solving statements based on occurrence and importance for the industrial arts semi-structured division.

Problem statement 29, *developing a plan of procedure*, and statement 21, *designing and sketching a product that the student would like to build*, each were rated moderately high in occurrence with means of 3.511 and 3.674, respectively; each rated moderately high in importance with means of 4.000 and 3.929, respectively.

An interesting comparison can be made in the occurrence and importance placed on statement 26, *selecting the appropriate fastener type for a specific need*. A mean of 3.582 rated this activity moderately high in importance, but it was rated only moderate in occurrence with a mean of 3.220.

Statement 25, *comparing the machining qualities of two common corner joints*, and statement 33, *comparing the machining qualities of two common cabinet woods*, were each rated moderately low in occurrence

Table 14. Frequency and mean rankings of problem solving statements based on occurrence and importance for the Industrial Arts Semi-Structured Division (N=141).

No.	Problem Solving Statements		Rank Order	No Rating	Rating Low 1	2	3	4	High 5	Mean	S.D.
21	Designing and sketching a product that the student would like to build.	OCC	1	11	5	7	23	45	50	3.674	1.481
		IMP	2	11	2	5	16	41	66	3.929	1.452
29	Developing a plan of procedure.	OCC	2	7	10	17	25	34	48	3.511	1.486
		IMP	1	6	3	3	25	40	64	4.000	1.265
26	Selecting the appropriate fastener type for a specific need.	OCC	3	8	10	21	37	34	31	3.220	1.425
		IMP	3	8	4	11	35	41	42	3.582	1.364
17	Selecting the appropriate adhesive for a specific need.	OCC	4	17	10	25	46	33	10	2.695	1.409
		IMP	4	15	3	24	42	37	20	3.014	1.434
25	Comparing the machining qualities of two common corner joints.	OCC	5	38	22	27	28	19	7	1.922	1.559
		IMP	5	37	13	19	32	26	14	2.277	1.716
33	Comparing the machining qualities of two common cabinet woods.	OCC	6	48	20	15	32	21	5	1.809	1.621
		IMP	6	43	12	14	36	24	12	2.156	1.733

($\bar{x}$ = 1.922 and $\bar{x}$ = 1.809, respectively), and moderately low in importance ($\bar{x}$ = 2.277 and $\bar{x}$ = 2.156, respectively).

The largest range of means for the industrial arts semi-structured problems was between statements 21 and 33. Statement 21 was ranked first for occurrence with a mean of 3.674, while statement 33 was ranked sixth for occurrence with a mean of 1.809.

Technology Education Semi-Structured Division

Table 15 arrays the frequency and mean ranking of problem solving statements based on occurrence and importance for the technology education semi-structured division.

For this division of problem statements, two activities were found to occur at a moderate rate. Statement 15, *determining the most suitable material from a selection of different materials for a specific application and describing why*, had a mean occurrence of 2.830, and statement 8, *selecting a machine, tool, or process and explaining operating principles, both past and present*, had a mean occurrence of 2.794.

Statement 35, *writing and publishing a newsletter for your school*, and statement 22, *designing a tele-conferencing system for a large company*, rated no occurrence with means of .2340 and .1418, respectively. Although both of the statements were considered no-occurrence activities in Montana schools, they were rated low in importance with means of .7376 for statement 35 and .4894 for statement 22.

The largest range between individual problem statement means was between statement 15, with a moderately rated mean occurrence of 2.830, and statement 22, with a no occurrence rating mean of .1418.

Table 15. Frequency and mean rankings of problem solving statements based on occurrence and importance for the Technology Education Semi-Structured Division (N=141).

No.	Problem Solving Statements		Rank Order	No Rating	Rating Low 1	2	3	4	High 5	Mean	S.D.
15	Determining the most suitable material from a selection of different materials for a specific application and describing why.	OCC	1	11	12	24	44	43	7	2.8300	1.3040
		IMP	1	9	3	12	43	45	29	3.4110	1.3150
8	Selecting a machine, tool, or process and explaining operating principles, both past and present.	OCC	2	23	8	19	36	35	20	2.7940	1.6190
		IMP	2	19	3	11	40	41	27	3.1490	1.5580
23	As a group activity, have groups list as many solutions as possible to a given problem.	OCC	3	37	23	29	25	20	7	1.9220	1.5540
		IMP	3	30	5	14	47	30	15	2.6170	1.6330
31	Investigating and listing ten important inventions and determining the influences they had on society.	OCC	4	93	14	17	14	3	0	0.7234	1.1410
		IMP	4	72	12	15	26	13	3	1.3260	1.5610
35	Writing and publishing a newsletter for your school.	OCC	5	120	14	3	3	1	0	0.2340	0.6616
		IMP	5	100	6	13	17	4	1	0.7376	1.2630
22	Designing a tele-conferencing system for a large company.	OCC	6	128	9	1	3	0	0	0.1418	0.5152
		IMP	6	109	11	10	7	3	1	0.4894	1.0460

Industrial Arts Ill-Structured Division

The frequency and mean ranking of problem solving statements based on occurrence and importance for the industrial arts ill-structured division are addressed in Table 16.

Two activities, statement 3, *developing and selecting an item for a manufacturing class that can be sold to make a profit*, and statement 4, *planning and designing a residential home of the student's choice*, each occurred in industrial education programs at a moderate level. The mean ratings were 1.560 for statement 3 and 1.525 for statement 4.

Three activities, statement 6, *organizing a student management structure for a manufacturing class*, statement 27, *planning, designing, and equipping an ideal 'shop' of the student's choice*, and statement 19, *designing, estimating cost, and proposing a bid for a school playground to your local school board*, were each rated low in occurrence. The means were 1.426, 1.014, and .6738, respectively. In contrast to statements 6 and 27 being rated low in occurrence, slightly higher ratings for importance were indicated for these same statements with means of 2.227 and 1.504, respectively. There were no other important differences noted.

Table 16. Frequency and mean rankings of problem solving statements based on occurrence and importance for the Industrial Arts Ill-Structured Division (N=141).

No.	Problem Solving Statements		Rank Order	No Rating	Rating Low 1	2	3	4	High 5	Mean	S.D.
3	Developing and selecting an item for a manufacturing class that can be sold to make a profit.	OCC	1	61	17	17	20	21	5	1.5600	1.6530
		IMP	1	42	9	13	29	34	14	2.3260	1.7990
4	Planning and designing a residential home of the student's choice.	OCC	2	76	6	14	13	18	14	1.5250	1.8690
		IMP	3	57	6	13	20	28	17	2.0500	1.9250
6	Organizing a student management structure for a manufacturing class.	OCC	3	67	15	17	23	12	7	1.4260	1.6270
		IMP	2	48	5	7	39	32	10	2.2270	1.7860
27	Planning, designing, and equipping an ideal "shop" of the student's choice.	OCC	4	82	17	15	15	9	3	1.0140	1.4290
		IMP	4	61	18	20	22	12	8	1.5040	1.6240
19	Designing, estimating cost, and proposing a bid for a school playground to your local school board.	OCC	5	103	12	6	12	5	3	0.6738	1.2960
		IMP	5	81	16	11	16	12	5	1.1280	1.5620
32	Making a model of a manufacturing plant of the student's choice.	OCC	6	121	9	6	3	2	0	0.2695	0.7642
		IMP	6	99	12	12	8	9	1	0.7163	1.2780

Technology Education Ill-Structured Division

Table 17 displays frequency and mean rankings of problem solving statements based on occurrence and importance for the technology education ill-structured division.

Four technology education ill-structured problem solving statements were rated as not occurring in the programs surveyed, yet each of these statements was rated as low in importance. Statement 12, *designing and constructing a solar water-heating unit*, statement 36, *designing and building a 'learning game,'* statement 16, *formulating a plan for a futuristic travel system for your community*, and statement 34, *designing and building a balloon-powered device that will travel the farthest distance on a fixed suspended string*, were considered no-occurrence activities with means of .4326, .4184, .4184, and .3475, respectively. These statements were given low importance ratings with means of 1.106, .9858, .8794, and .8156, respectively.

The highest rated statement for occurrence and importance was problem solving statement 2, *designing a home that conserves energy best for this climate*. Although this activity was ranked as number one in the technology education ill-structured division, a low occurrence rating with a mean of 1.319 and a moderately low importance rating with a mean of 2.050 were conferred.

Table 17. Frequency and mean rankings of problem solving statements based on occurrence and importance for the Technology Education Ill-Structured Division (N=141).

No.	Problem Solving Statements		Rank Order	No Rating	Rating Low 1	2	3	4	High 5	Mean	S.D.
2	Designing a home that conserves energy best for this climate.	OCC	1	69	15	21	21	9	6	1.3190	1.5510
		IMP	1	54	7	8	32	30	10	2.0500	1.8220
9	Describing how an individual might function in the year 2020 with the advent of common "super conductor" usage.	OCC	2	99	13	9	9	8	3	0.7447	1.3490
		IMP	2	77	8	10	23	16	7	1.3900	1.7190
12	Designing and constructing a solar water-heating unit.	OCC	3	109	15	9	5	2	1	0.4326	0.9510
		IMP	3	82	12	11	25	8	3	1.1060	1.4910
36	Designing and building a "learning game."	OCC	4	112	12	5	11	1	0	0.4184	0.9347
		IMP	4	86	10	16	20	8	1	0.9858	1.3890
16	Formulating a plan for a futuristic travel system for your community.	OCC	5	111	12	8	9	1	0	0.4184	0.9115
		IMP	5	93	8	13	19	7	1	0.8794	1.3600
34	Designing and building a balloon-powered device that will travel the farthest distance on a fixed suspended string.	OCC	6	118	9	6	5	2	1	0.3475	0.9180
		IMP	6	97	8	14	11	9	2	0.8156	1.3710

Mean Rankings of the Six Problem Solving Divisions

Table 18 presents data concerning the mean rankings of the six problem solving divisions based on occurrence and importance.

The industrial arts well-structured problem statements were ranked number one as a division in occurrence ($\bar{x}$ = 2.986) and number one in importance ($\bar{x}$ = 3.338), although given only a moderate rating overall. The second highest ranked division was the industrial arts semi-structured problem solving division. Overall ratings of moderate occurrence ($\bar{x}$ = 2.805) and moderate importance ($\bar{x}$ = 3.160) were given to this division.

Table 18. Mean rankings of the six problem solving divisions based on occurrence and importance.

Problem Solving Division	Occurrence			Importance		
	Rank Order	Mean	S.D.	Rank Order	Mean	S.D.
IA Well-Structured	1	2.9860	1.4190	1	3.338	1.460
TE Well-Structured	6	0.5993	1.0900	6	1.165	1.581
IA Semi-Structured	2	2.8050	1.4970	2	3.160	1.494
TE Semi-Structured	3	1.4410	1.1320	3	1.955	1.396
IA Ill-Structured	4	1.0780	1.4400	4	1.658	1.662
TE Ill-Structured	5	0.6135	1.1030	5	1.204	1.525

An examination of the data in Table 18 indicates that two divisions, technology education semi-structured and industrial arts ill-structured, were rated low in occurrence ($\bar{x}$ = 1.441 and $\bar{x}$ = 1.078, respectively), while both divisions received moderately low ratings of importance ($\bar{x}$ = 1.955 and $\bar{x}$ = 1.662, respectively). As observed in Table 18, the

technology education well-structured division was considered a no-occurrence division with a mean of .5993.

Mean Rankings of the Thirty-Six Problem Solving Statements

The data in Table 19 show the mean rankings of the 36 problem solving statements based on occurrence and importance. Each statement is labeled with its appropriate division rubric.

The data in Table 19 indicate that the five top-ranked problem solving statements were industrial arts well-structured and industrial arts semi-structured activities. The highest ranked statements were three industrial arts well-structured statements (statements 5, 24, and 18) and two industrial arts semi-structured statements (statements 21 and 29), which were rated moderately high in occurrence and importance. Industrial arts well-structured statement 13, *determining how to make the appropriate adjustments on a given piece of stationary power equipment*, was ranked fifth in occurrence and sixth in importance.

An interesting finding was that 10 problem statements (statements 7, 12, 36, 16, 34, 32, 10, 1, 35, and 22) were considered to have no occurrence, while only statement 22 was rated no importance.

Table 19. Mean rankings of the 36 problem solving statements based on occurrence and importance.

No.	Problem Solving Statements	Occurrence			Importance			Division
		Rank Order	Mean	S.D.	Rank Order	Mean	S.D.	
5	Selecting the appropriate hand tool for a specific task.	1	4.043	1.152	1	4.213	1.164	IA Well-Str
24	Calculating the cost of a project	2	3.716	1.380	2	4.014	1.219	IA Well-Str
18	Drawing and/or reading a drawing to scale.	3*	3.674	1.505	4	3.979	1.432	IA Well-Str
21	Designing and sketching a product that the student would like to build.	3*	3.674	1.481	5	3.929	1.452	IA Semi-Str
29	Developing a plan of procedure.	4	3.511	1.486	3	4.000	1.265	IA Semi-Str
13	Determining how to make the appropriate adjustments on a given piece of stationary power equipment.	5	3.418	1.559	6	3.603	1.567	IA Well-Str
26	Selecting the appropriate fastener type for a specific need.	6	3.220	1.425	7	3.582	1.364	IA Semi-Str
15	Determining the most suitable material from a selection of different materials for a specific application and describing why.	7	2.830	1.304	8	3.411	1.315	TE Semi-Str
8	Selecting a machine, tool, or process and explaining operating principles, both past and present.	8	2.794	1.619	9	3.149	1.558	TE Semi-Str

Table 19--Continued.

No.	Problem Solving Statements	Occurrence Rank Order	Occurrence Mean	Occurrence S.D.	Importance Rank Order	Importance Mean	Importance S.D.	Division
17	Selecting the appropriate adhesive for a specific need.	9	2.695	1.409	10	3.014	1.434	IA Semi-Str
25	Comparing the machining qualities of two common corner joints.	10*	1.922	1.559	14*	2.277	1.716	IA Semi-Str
23	As a group activity, have groups list as many solutions as possible to a given problem.	10*	1.922	1.554	11	2.617	1.633	TE Semi-Str
33	Comparing the machining qualities of two common cabinet woods.	11	1.809	1.621	15*	2.156	1.733	IA Semi-Str
11	Converting measurements from English to metric and metric to English.	12	1.645	1.395	15*	2.156	1.609	IA Well-Str
3	Developing and selecting an item for a manufacturing class that can be sold to make a profit.	13	1.560	1.653	12	2.326	1.799	IA Ill-Str
4	Planning and designing a residential home of the student's choice.	14	1.525	1.869	17*	2.050	1.925	IA Ill-Str
6	Organizing a student management structure for a manufacturing class.	15	1.426	1.627	14*	2.227	1.786	IA Ill-Str
28	Calculating turning speeds with different pulley or gear sizes.	16	1.418	1.522	16	2.064	1.770	IA Well-Str

Table 19--Continued.

No.	Problem Solving Statements	Occurrence			Importance			Division
		Rank Order	Mean	S.D.	Rank Order	Mean	S.D.	
2	Designing a home that conserves energy best for this climate.	17	1.3190	1.551	17*	2.050	1.822	TE Ill-Str
30	Completing an assignment with the use of computer-aided drafting.	18	1.2550	1.671	13	2.284	2.008	TE Well-Str
27	Planning, designing, and equipping an ideal "shop" of the student's choice.	19	1.0140	1.429	18	1.504	1.624	IA Ill-Str
20	Calculating gas mileage for given conditions, distances, vehicles.	20	0.8298	1.383	20*	1.326	1.606	TE Well-Str
9	Describing how an individual might function in the year 2020 with the advent of common "super conductor" usage.	21	0.7447	1.349	19	1.390	1.719	TE Ill-Str
31	Investigating and listing ten important inventions and determining the influences they had on society.	22	0.7234	1.141	20*	1.326	1.561	TE Semi-Str
19	Designing, estimating cost, and proposing a bid for a school playground to your local school board.	23	0.6738	1.296	22	1.128	1.562	IA Ill-Str
14	Calculating lift, drag, etc., for a specific airplane.	24	0.5248	1.112	23	1.113	1.600	TE Well-Str

Table 19--Continued.

No.	Problem Solving Statements	Occurrence Rank Order	Occurrence Mean	Occurrence S.D.	Importance Rank Order	Importance Mean	Importance S.D.	Division
7	Determining the mechanical advantages of a ten-speed bicycle; calculating different sprocket ratios.	25	0.4539	0.9745	21	1.1420	1.611	TE Well-Str
12	Designing and constructing a solar water-heating unit.	26	0.4326	0.9510	24	1.1060	1.491	TE Ill-Str
36	Designing and building a "learning game."	27	0.4184*	0.9347	25	0.9858	1.389	TE Ill-Str
16	Formulating a plan for a futuristic travel system for your community.	27	0.4184*	0.9115	26	0.8794	1.360	TE Ill-Str
34	Designing and building a balloon-powered device that will travel the farthest distance on a fixed suspended string.	28	0.3475	0.9180	27*	0.8156	1.371	TE Ill-Str
32	Making a model of a manufacturing plant of the student's choice.	29	0.2695*	0.7642	30	0.7163	1.278	IA Ill-Str
10	Investigating and presenting how a tele-conferencing system works.	29	0.2695*	0.7059	27*	0.8156	1.329	TE Well-Str
1	Investigating how a tele-conferencing system works.	30	0.2624	0.6933	28	0.8085	1.325	TE Well-Str

Table 19--Continued.

No.	Problem Solving Statements	Occurrence Rank Order	Occurrence Mean	Occurrence S.D.	Importance Rank Order	Importance Mean	Importance S.D.	Division
35	Writing and publishing a newsletter for your school.	31	0.2340	0.6616	29	0.7376	1.263	TE Semi-Str
22	Designing a tele-conferencing system for a large company.	32	0.1418	0.5152	31	0.4894	1.046	TE Semi-Str

*Indicates two identical rankings.

Summary

This chapter offered a compilation of tables to represent the data collected for this study. The data were gathered using a survey instrument designed by the researcher to collect: (1) instructor and student demographics and computer usage data, (2) instructional content data, and (3) problem solving statement data. Based on the analysis of data presented in this chapter, conclusions and recommendations for this study are presented in Chapter 5.

CHAPTER 5

SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

The purpose of this chapter is to report the results of survey research which was performed to determine the perceptions of industrial arts and technology education instructors in Montana concerning the occurrence and importance placed on problem solving activities relative to their programs.

Summary

Recent changes that have resulted from technological advancements have created new demands and challenges for people at a more accelerated rate than ever before. The effective use of critical thinking skills such as problem solving is one of these demands. Other reasons for learning problem solving techniques include the ability to adapt to the ever-changing world, meeting personal needs, and preparation to meet future employer expectations.

The review of literature suggests several reasons why industrial education programs should offer a multitude of different problem solving applications for students. It is the role of industrial education instructors to ensure that their students are obtaining the proper guidance for developing problem solving skills for these activities. The need to create an environment that offers the necessary problem solving atmosphere is a part of this responsibility. To perform this task,

teachers must have an understanding and awareness of the characteristics of the problem solving structures and knowledge of the different problem solving approaches that apply to a given situation.

A questionnaire was developed with the aid of a panel of national technology education leaders in problem solving, faculty members at Montana State University, and the State Specialist of Trade and Industrial Education in Montana. The survey instrument was sent to 242 teachers in Montana secondary schools. There were 141 teacher respondents, for a usable return rate of 58.3 percent.

The nature of this *problem solving study* resulted in determining the occurrence and instructor importance placed on problem solving activities by industrial arts and technology education instructors. The development of an instrument to reveal if well-structured, semi-structured, and ill-structured problems occurred or were important among those surveyed allows findings to be drawn and conclusions and recommendations to be made.

Findings

Based on the analysis of data provided by the industrial arts and technology education instructors in Montana for problem solving activities, the following findings are summarized:

(1) Activities that require the use of tools, processes, and materials are perceived by the instructors as the most important problem solving activities and occur the most frequently.

(2) Problem solving activities that occur the most frequently and have the greatest importance utilize problem solving approaches that are

either routine, repetitive, and mathematical in nature, or utilize a heuristic style approach.

(3) Activities that deal with the study of technological systems, their resources, processes, and impacts on society are perceived by the instructors as the least important and occur the least frequently.

(4) Problem solving activities that occur the least frequently and have the least importance utilize problem solving approaches that are either routine, repetitive, and mathematical in nature, or utilize creative problem solving style processes.

Conclusions

The researcher offers the following conclusions:

(1) The industrial educators in Montana are not providing activities that involve creative problem solving techniques to find solutions.

(2) The industrial educators in Montana are not providing their students with problem solving activities that relate to technological systems, their resources, processes, and impacts on society.

Recommendations

As a result of the findings and conclusions drawn from this study, the researcher offers several recommendations:

(1) Courses in technology education at Montana State University should continue to emphasize problem solving structures and techniques as a component of the instruction.

(2) Industrial educators should be informed about the different problem solving structures and suitable problem solving approaches through newsletters, workshops, and update conferences.

(3) Industrial educators should offer more problem solving activities that present technological systems, their resources, processes, and impacts on society, rather than offer only materials, tools, and process problem activities.

(4) Industrial educators should offer problem solving activities that involve heuristics and creative problem solving processes which enhance higher levels of thinking.

(5) Research efforts involving problem solving statements in the future should allow for *similarities* or *relationships* which may exist for the said statements.

(6) Future research should be performed with problem solving structures by identifying *action words* or *action statements* such as *calculating, designing, determining, investigating, organizing, selecting,* etc., that will descriptively identify problem solving structures.

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APPENDICES

APPENDIX A:

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APPENDIX B:

JUDGING PANEL RATING FORM

JUDGING PANEL/RATING FORM

The following statements were selected from problem-solving/activity sections of Industrial Arts and Technology Education textbooks and workbooks. The design of this rating form is intended to arrange problem types with instructional categories. This will permit the comparison between problem type level and instructional category (IA/TE).

Please rate each statement for its accuracy by circling NR 1 2 3 4 5. Comments and suggestions are welcome in the space provided after each group and at the end of the form.

		PLEASE RATE THE VALIDITY OF EACH STATEMENT BY CIRCLING					
		(no rating)	(low)				(high)
I.A. based: well-structured							
1.	Comparing the advantages and disadvantages of carbide tipped tools.	NR	1	2	3	4	5
2.	Selecting the appropriate hand tool for a specific task.	NR	1	2	3	4	5
3.	Calculating the cost of a project.	NR	1	2	3	4	5
4.	Calculating area.	NR	1	2	3	4	5
5.	Ability, to make adjustments on power equipment.	NR	1	2	3	4	5
6.	Drawing and/or reading a drawing to scale.	NR	1	2	3	4	5
7.	Converting measurements from English to metric and metric to English.	NR	1	2	3	4	5
8.	Calculating turning speeds with different pulley or gear sizes.	NR	1	2	3	4	5

comments:

T.E. based: well-structured							
1.	Diagraming how a telephone works.	NR	1	2	3	4	5
2.	Explaining how telecommunication satellites work.	NR	1	2	3	4	5
3.	Mapping a chart of man's progress from the stone age to present day.	NR	1	2	3	4	5
4.	Determining the mechanical advantages of a ten-speed bicycle; calculation of different sprocket ratios.	NR	1	2	3	4	5
5.	Giving a presentation on how and why a airplane stays in the air.	NR	1	2	3	4	5
6.	Explaining how a tel-conferencing system works.	NR	1	2	3	4	5
7.	Calculating gas mileage for given conditions, distances, vehicles.	NR	1	2	3	4	5
8.	Completing a assignment with the use of computer aided drafting.	NR	1	2	3	4	5

comments:

I.A. based: semi-structured							
1.	Designing and sketching a product that the student would like to build.	NR	1	2	3	4	5
2.	Developing a plan of procedure.	NR	1	2	3	4	5
3.	Developing a cleanup schedule as a member of a group.	NR	1	2	3	4	5
4.	Comparing the strength of various common corner joints.	NR	1	2	3	4	5
5.	Comparing the machining qualities of two common cabinet woods.	NR	1	2	3	4	5
6.	Selecting the appropriate adhesive for a specific need.	NR	1	2	3	4	5
7.	Assigning students to contact corporations for information.	NR	1	2	3	4	5
8.	Selecting the appropriate fastener type for a specific need.	NR	1	2	3	4	5

comments:

T.E. based: semi-structured

1.	Listing ten important inventions and determine the influences they had on society.	NR	1	2	3	4	5
2.	Selecting a machine, tool, or process and explain how it should be operated safely.	NR	1	2	3	4	5
3.	Selecting a machine, tool, or process and explain operating principals, both past and present.	NR	1	2	3	4	5
4.	Designing a tel-conferencing system for a large company.	NR	1	2	3	4	5
5.	Writing and publishing a newsletter to your school.	NR	1	2	3	4	5
6.	Locating and presenting information on the differences between craft manufacturing and mass production.	NR	1	2	3	4	5
7.	Determining the most suitable material from a selection of different materials for a specific application and describe why.	NR	1	2	3	4	5
8.	As a group activity, have groups list as many possible solutions to a given problem.	NR	1	2	3	4	5

comments:

I.A. based: ill-structured

1.	Designing, estimating cost, and proposing a bid for a school playground to your local school board.	NR	1	2	3	4	5
2.	Planning and designing a residential home of the students choice.	NR	1	2	3	4	5
3.	Planning, designing, and equipping an ideal "shop" of their choice.	NR	1	2	3	4	5
4.	Developing and selecting an item for a manufacturing class that can be sold to make a profit.	NR	1	2	3	4	5
5.	Organizing a student management structure for a manufacturing class.	NR	1	2	3	4	5
6.	Planning, organizing, and implementing ways to raise money for your students to attend a conference.	NR	1	2	3	4	5
7.	Planning, organizing, and developing ways of finding a summer job(s) in any of the trade areas for those students interested.	NR	1	2	3	4	5
8.	Making a model of a manufacturing plant of the students choice.	NR	1	2	3	4	5

comments:

T.E. based: ill-structured

1.	Formulating a plan for a futuristic travel system for your community.	NR	1	2	3	4	5
2.	Designing and building a "learning game".	NR	1	2	3	4	5
3.	Designing and building a balloon-powered device that will travel the farthest distance on a fixed suspended string.	NR	1	2	3	4	5
4.	Describing how a individual will function in the year 2020 with the advent of the "super conductor".	NR	1	2	3	4	5
5.	Planning and estimating costs for a one month trip to Northern Europe for July, 1999.	NR	1	2	3	4	5
6.	Designing a home that conserves energy best for this climate.	NR	1	2	3	4	5
7.	Describing and showing the advantages of manufacturing precision parts in a space station.	NR	1	2	3	4	5
8.	Designing and constructing a solar water-heating unit.	NR	1	2	3	4	5

comments:

Other comments and suggestions:

APPENDIX C:

COVER LETTER, DIRECTIONS, AND DEFINITION OF TERMS TO JUDGING PANEL

MONTANA STATE UNIVERSITY

Department of Agricultural and Technology Education

Cheever Hall
Montana State University
Bozeman, Montana 59717
406-994-3201 or 994-3691

February 16, 1989

Dear Panel Member:

Thank you for being a participant on the five-member judging panel for my survey instrument. The members of the panel represent Technology Education personnel at the university level that have shown much interest, knowledge, and leadership in the study of problem solving. I am asking you to check the validity of the statements selected. The outline below addresses the structure of the instrument, purposes, and directions for completing the rating form.

Structure of Professional Paper

The title of my professional paper is "Perceptions and Identification of Problem Solving Activities in the Industrial Arts and Technology Education Programs in Montana."

Judging Panel-Rating Form

As a member of the Judging Panel, I am asking you to judge the validity of each problem solving statement (large sheets) as it pertains to instructional category and problem type. The Judging Panel-Rating Form is assembled into two main groups. One group represents instructional categories (IA/TE). The other group represents problem types (well-structured, semi-structured, and ill-structured). The combined groups are:

IA Based:	Well-Structured	TE Based:	Well-Structured
IA Based:	Semi-Structured	TE Based:	Semi-Structured
IA Based:	Ill-Structured	TE Based:	Ill-Structured

The final survey instrument will be constructed based on your responses to the statements. The selected statements will be placed randomly and will not be identifiable by instructional category or problem type.

Structure and Purpose of Final Survey Instrument

The purpose of the survey will be to: (1) determine the degree of occurrence in the classroom in a nine-week period, and (2) determine the instructor's personal rating of the degree of importance of each of the problem solving statements.

The survey instrument will have thirty-six (36) problem solving statements. The population for the survey will be two hundred and sixty-one (261) Industrial Arts and Technology Education instructors in Montana. The target date for the first mailing is March 1, 1989.

Summary

As a participating judging panel member, you will be listed in the final publication of this paper. No mention or reference will be made concerning the judges' personal ratings. If you have any questions regarding the rating form, please contact me at (406) 994-3201. Thank you for sharing your knowledge and time in developing this instrument!

Sincerely,

William D. Lodermeier
Masters Candidate
Technology Education
Montana State University

Dr. Doug Polette, Advisor

Attachment

Judging Panel Members
February 16, 1989
Attachment

Definition of Terms

Industrial Arts: Instructional content pertaining to the understanding of industry, and development of basic and advanced skills with tools, machines, and processes.

Technology Education: Instructional content pertaining to the study of systems, techniques, industries organization, personnel, resources and products, and their social and cultural impact.

Well-Structured Problems: These problems are relatively narrow in scope and usually have only one correct answer. The problem solver must arrive at the one best solution. Algorithms are typically used to solve these types of problems. An example of this type of problem is: "Determine voltage to a given situation."[1]

Semi-Structured Problems: These problems have more than one correct answer. Heuristics are used to solve this problem type. A typical heuristic approach to solving a problem would consist of using a sequence of steps similar to the following: (1) recognizing the problem, (2) defining the problem, (3) selecting a strategy, (4) attempting to solve by acting on a strategy, and (5) drawing conclusions and checking results. An example of this type of problem is: "Performing tasks in order of importance."[2]

Ill-Structured Problems: These types of problems have a variety of potentially correct solutions. They require divergent thinking and utilize creative problem solving techniques. This type of problem is almost never solved by looking for an algorithm, nor will heuristics ensure an acceptable solution. An example of this type of problem is: "Developing a better means of transporting people in an urban setting." (This problem has a multitude of potential solutions.[3])

References:

[1]L. Hatch, "Problem Solving Approach," Papers from the 37th Yearbook: Council on Technology Education (Mission Hills, CA: Glencoe Publishing Co., 1988), pp. 89-90.

[2]Ibid., pp. 91-92.

[3]Ibid.

APPENDIX D:

COVER LETTER TO STATE SPECIALIST OF TRADE AND INDUSTRIAL EDUCATION

MONTANA STATE UNIVERSITY

Department of Agricultural and Technology Education
Cheever Hall
Montana State University
Bozeman, Montana 59717
406-994-3201 or 994-3691

February 20, 1989

Mr. Jeff Wulf, State Specialist
Department of Trade and Industrial Education
Office of Public Instruction
1300 Eleventh Avenue
Helena, Montana 59620

Dear Mr. Wulf:

Enclosed is the survey instrument with demographic information that we discussed on the phone. Please comment and provide input on the demographic section of the instrument. The final questionnaire will be sent to 241 industrial arts and technology education instructors on a double-sized 8.5″ x 11″ single sheet of paper. There may be some room for other demographics.

I look forward to hearing from you.

Sincerely,

William D. Lodermeier
Graduate Student

Enclosure

APPENDIX E:

PROBLEM SOLVING SURVEY INSTRUMENT

Problem Solving Survey

I am asking you to help me identify problem solving activities that are being taught or applied in your program and the degree of importance you place on these activities. This survey instrument is being sent to approximately two hundred Industrial Arts and Technology Education Junior and Senior High instructors in Montana.

Please indicate what your instructional category (Industrial Arts or Technology Education), and instructional areas are. Give the amount of instructional time (%___) provided after each instructional area indicated.

( ) **Industrial Arts:** (Instructional content pertaining to the understanding of industry, and development of basic and advanced skills with tools, machines, and processes).

( ) Auto-Small Engines %___ ( ) Building Trades %___ ( ) Electronics %___ ( ) Manufacturing %___
( ) Mechanical Drafting %___ ( ) Metal Working %___ ( ) Welding %___ ( ) Woodworking %___
( ) Crafts_____ %___ ( ) other_____ %___

( ) **Technology Education:** (Instructional content pertaining to the study of systems, techniques, industries organization, personnel, resources and products, and their social and cultural impact).

COMMUNICATIONS:
( ) Visual Communication %___ ( ) Electronics Communication %___ ( ) Graphic Communication %___
( ) Offset %___ ( ) Photo %___ ( ) other_____ %___

CONSTRUCTION:
( ) Building Design %___ ( ) Surveying %___ ( ) Zoning %___
( ) Building Systems %___ ( ) Materials %___ ( ) other_____ %___

MANUFACTURING:
( ) Metals Processing %___ ( ) Casting %___ ( ) Machining %___
( ) Finishing %___ ( ) Shaping %___ ( ) other_____ %___

TRANSPORTATION:
( ) Guidance and Control %___ ( ) Power Systems %___ ( ) Electricity %___
( ) Auto Power Systems %___ ( ) Study of Energy %___ ( ) other_____ %___

Directions for filling out survey:

This instrument lists problem solving activities and statements. After each statement listed below, rank the DEGREE OF OCCURRENCE, (column #1) and the DEGREE OF IMPORTANCE, (column #2) by circling the number most appropriate to your program. Your response to column #1 may vary from "LOW" to "HIGH" depending upon the degree of occurrence each activity takes place in your classroom. Your response to column #2 may vary from "LOW" to "HIGH" depending upon how important you feel the activities or statements relate to your instruction. Circle NR (no rating) for column #1 if the activity does not occur in your classroom. Circle NR (no rating) for column #2 if you place no importance on the activity.

		#1 DEGREE OF OCCURRENCE IN YOUR CLASSROOM IN A NINE WEEK SESSION: (LOW) (HIGH)	#2 INSTRUCTORS PERSONAL RATING OF THE DEGREE OF IMPORTANCE: (LOW) (HIGH)
(Examples)			
x.	Selecting the best joint for a specific need.	NR 1 2 (3) 4 5	NR 1 2 3 (4) 5
x.	Calculating voltage, amperage, and resistance.	(NR) 1 2 3 4 5	(NR) 1 2 3 4 5
		**********	
1.	Investigate how a tele-conferencing system works.	NR 1 2 3 4 5	NR 1 2 3 4 5
2.	Designing a home that conserves energy best for this climate.	NR 1 2 3 4 5	NR 1 2 3 4 5
3.	Developing and selecting an item for a manufacturing class that can be sold to make a profit.	NR 1 2 3 4 5	NR 1 2 3 4 5
4.	Planning and designing a residential home of the student's choice.	NR 1 2 3 4 5	NR 1 2 3 4 5
5.	Selecting the appropriate hand tool for a specific task.	NR 1 2 3 4 5	NR 1 2 3 4 5
6.	Organizing a student management structure for a manufacturing class.	NR 1 2 3 4 5	NR 1 2 3 4 5
7.	Determining the mechanical advantages of a ten-speed bicycle; calculation of different sprocket ratios.	NR 1 2 3 4 5	NR 1 2 3 4 5
8.	Selecting a machine, tool, or process and explain operating principles, both past and present.	NR 1 2 3 4 5	NR 1 2 3 4 5
9.	Describing how a individual might function in the year 2020 with the advent of common "super conductor" usage.	NR 1 2 3 4 5	NR 1 2 3 4 5
10.	Investigating and presenting how a tele-conferencing system works.	NR 1 2 3 4 5	NR 1 2 3 4 5
11.	Converting measurements from English to metric and metric to English.	NR 1 2 3 4 5	NR 1 2 3 4 5
12.	Designing and constructing a solar water-heating unit.	NR 1 2 3 4 5	NR 1 2 3 4 5
13.	Determining how to make the appropriate adjustments on a given piece of stationary power equipment.	NR 1 2 3 4 5	NR 1 2 3 4 5

14.	Calculating lift, drag, etc., for a specific airplane.	NR	1	2	3	4	5	NR	1	2	3	4	5
15.	Determining the most suitable material from a selection of different materials for a specific application and describe why.	NR	1	2	3	4	5	NR	1	2	3	4	5
16.	Formulating a plan for a futuristic travel system for your community.	NR	1	2	3	4	5	NR	1	2	3	4	5
17.	Selecting the appropriate adhesive for a specific need.	NR	1	2	3	4	5	NR	1	2	3	4	5
18.	Drawing and/or reading a drawing to scale.	NR	1	2	3	4	5	NR	1	2	3	4	5
19.	Designing, estimating cost, and proposing a bid for a school playground to your local school board.	NR	1	2	3	4	5	NR	1	2	3	4	5
20.	Calculating gas mileage for given conditions, distances, vehicles.	NR	1	2	3	4	5	NR	1	2	3	4	5
21.	Designing and sketching a product that the student would like to build.	NR	1	2	3	4	5	NR	1	2	3	4	5
22.	Designing a tele-conferencing system for a large company.	NR	1	2	3	4	5	NR	1	2	3	4	5
23.	As a group activity, have groups list as many possible solutions to a given problem.	NR	1	2	3	4	5	NR	1	2	3	4	5
24.	Calculating the cost of a project.	NR	1	2	3	4	5	NR	1	2	3	4	5
25.	Comparing the machining qualities of two common corner joints.	NR	1	2	3	4	5	NR	1	2	3	4	5
26.	Selecting the appropriate fastener type for a specific need.	NR	1	2	3	4	5	NR	1	2	3	4	5
27.	Planning, designing, and equipping an ideal "shop" of the student's choice.	NR	1	2	3	4	5	NR	1	2	3	4	5
28.	Calculating turning speeds with different pulley or gear sizes.	NR	1	2	3	4	5	NR	1	2	3	4	5
29.	Developing a plan of procedure.	NR	1	2	3	4	5	NR	1	2	3	4	5
30.	Completing an assignment with the use of computer aided drafting.	NR	1	2	3	4	5	NR	1	2	3	4	5
31.	Investigate and list ten important inventions and determine the influences they had on society.	NR	1	2	3	4	5	NR	1	2	3	4	5
32.	Make a model of a manufacturing plant of the student's choice.	NR	1	2	3	4	5	NR	1	2	3	4	5
33.	Comparing the machining qualities of two common cabinet woods.	NR	1	2	3	4	5	NR	1	2	3	4	5
34.	Designing and building a balloon-powered device that will travel the farthest distance on a fixed suspended string.	NR	1	2	3	4	5	NR	1	2	3	4	5
35.	Writing and publishing a newsletter to your school.	NR	1	2	3	4	5	NR	1	2	3	4	5
36.	Designing and building a "learning game."	NR	1	2	3	4	5	NR	1	2	3	4	5

The following are demographic questions:
How many students are currently enrolled in the Industrial Arts or Technology Education classes that you teach?

7th grade_____ 8th grade_____ 9th grade_____ 10th grade_____ 11th grade_____ 12th grade_____

How many years have you been teaching? (please circle)

a. 1-5 b. 6-10 c. 11-16 d. 17-25 e. 26 or more

Does the student have access to a computer(s) for IA/TE activities? YES NO

Do you have access to a computer(s) for instructional use? YES NO
(if you answered YES to either of the above, please complete the following)

Please indicate what hardware and software you possess.

Type of Hardware: ( ) Apple II ( ) Macintosh ( ) IBM ( ) IBM compatible

Type of Application: ( ) Word Processing ( ) Computer Aided Drafting (CAD) ( ) Graphics
( ) Tele-Communication ( ) other_____

Comments:

APPENDIX F:

FIRST MAILING COVER LETTER

MONTANA STATE UNIVERSITY

Department of Agricultural and Technology Education

Cheever Hall
Montana State University
Bozeman, Montana 59717
406-994-3201 or 994-3691

March 8, 1989

Dear Montana IA/TE Educator:

This study is being conducted in part to fulfill my obligations for a master's degree in Technology Education at Montana State University. The information gained from this study will be very useful for IA/TE teachers in developing and designing problem solving activities for Industrial/Technology Education programs in Montana.

Having taught for seven years in public schools, I realize the shortage of personal time in a day. Realizing this, I have attempted to make the enclosed questionnaire as brief as possible, so it will take only a few minutes of your time to complete.

Individual comments and responses on the questionnaire will remain confidential and no judgments will be made from this study. Demographic information, such as instructional categories, instructional areas, enrollment, etc., will be utilized in part by the Office of Public Instruction (OPI) for national statistics collection.

I look forward to receiving your completed questionnaire, and would appreciate receiving it no later than March 22, 1989.

Your comments are welcome. Please use any space on the questionnaire for that purpose. Thank you very much for your help. Best wishes!

Sincerely,

_____

William D. Lodermeier
Graduate Student

_____

Dr. Doug Polette, Advisor

Enclosure

APPENDIX G:

SECOND MAILING COVER LETTER

MONTANA STATE UNIVERSITY
Department of Agricultural and Technology Education
Cheever Hall
Montana State University
Bozeman, Montana 59717
406-994-3201 or 994-3691

March 8, 1989

Dear Montana IA/TE Educator:

Could you take a few minutes of your time to complete the problem solving questionnaire mailed from Montana State University approximately three weeks ago? I have enclosed another questionnaire in the event that the first instrument did not reach you.

The information collected from teachers in the field such as yourself will be invaluable for developing and designing problem solving activities for Industrial and Technology Education programs in Montana.

Disregard this letter if you have already responded to the first mailing. Thank you for your cooperation!

Sincerely,

William D. Lodermeier
Graduate Student

Dr. Doug Polette, Advisor

Enclosure

APPENDIX H:

POSTCARD FOLLOW-UP

April 10, 1989

Dear Industrial Education Instructor:

This short memo is a reminder to those IE teachers who are still in the process of completing the ***Problem Solving Survey*** sent from Montana State University by me on March 8th and 27th. If you have not completed and returned your survey yet, I would appreciate very much if you would take the time to do so. I firmly believe that thoroughly collecting this information from people like yourself will be of great value to our profession. (It will help me graduate also.) Disregard this note if you have already responded to either of the two previous mailings.

Sincerely,

Willie Lodermeier

APPENDIX I:

SOURCES FOR PROBLEM SOLVING STATEMENTS

Table 20. Sources of the 36 compiled problem solving statements by author, year, and page numbers.

No.	Problem Solving Statements	Author(s)	Year	Page(s)
1	Investigate how a tele-conferencing system works.	Hacker & Barden	1988a	194-203
2	Designing a home that conserves energy best for this climate.	**		
3	Developing and selecting an item for a manufacturing class that can be sold to make a profit.	Lux & Ray	1971	29-50
4	Planning and designing a residential home of the student's choice.	Kicklighter & Baird	1976	45
5	Selecting the appropriate hand tool for a specific task.	Spence & Griffiths	1981	77
6	Organizing a student management structure for a manufacturing class.	Lux & Ray	1971	24-28
7	Determining the mechanical advantages of a ten-speed bicycle; calculation of different sprocket ratios.	Bohn et al.	1986	85-87
8	Selecting a machine, tool, or process and explaining operating principles, both past and present.	Hacker & Barden	1988b	72-73
9	Describing how an individual might function in the year 2020 with the advent of common "super conductor" usage.	Listar	1987	223
10	Investigating and presenting how a tele-conferencing system works.	Hacker & Barden	1988a	194-203
11	Converting measurements from English to metric and metric to English.	Repp et al.	1982	79
12	Designing and constructing a solar water-heating unit.	Bohn et al.	1986	73-74

Table 20--continued.

No.	Problem Solving Statements	Author(s)	Year	Page(s)
13	Determining how to make the appropriate adjustments on a given piece of stationary power equipment.	Spence & Griffiths	1981	261
14	Calculating lift, drag, etc., for a specific airplane.	Schwaller	1980	58
15	Determining the most suitable material from a selection of different materials for a specific application and describing why.	Listar	1987	101-107
16	Formulating a plan for a futuristic travel system for your community.	Hatch	1988	91
17	Selecting the appropriate adhesive for a specific need.	Feirer	1970	784
18	Drawing and/or reading a drawing to scale.	Spence & Griffiths	1981	46
19	Designing, estimating cost, and proposing a bid for a school playground to your local school board.	**		
20	Calculating gas mileage for given conditions, distances, vehicles.	Bohn et al.	1986	93-94
21	Designing and sketching a product that the student would like to build.	Feirer	1970	64
22	Designing a tele-conferencing system for a large company.	Hacker & Barden	1988a	169-203
23	As a group activity, have groups list as many solutions as possible to a given problem.	Listar	1987	133
24	Calculating the cost of a project.	Spence & Griffiths	1981	18
25	Comparing the machining qualities of two common corner joints.	Feirer	1970	784

Table 20--continued.

No.	Problem Solving Statements	Author(s)	Year	Page(s)
26	Selecting the appropriate fastener type for a specific need.	Feirer	1970	226
27	Planning, designing, and equipping an ideal "shop" of the student's choice.	**		
28	Calculating turning speeds with different pulley or gear sizes.	Bohn & MacDonald	1970	53
29	Developing a plan of procedure.	Wagner	1980	18
30	Completing an assignment with the use of computer-aided drafting.	Wohlers	1988	356-381
31	Investigating and listing ten important inventions and determining the influences they had on society.	Listar	1987	73-80
32	Making a model of a manufacturing plant of the student's choice.	Feirer	1970	226
33	Comparing the machining qualities of two common cabinet woods.	Feirer	1970	226
34	Designing and building a balloon-powered device that will travel the farthest distance on a fixed suspended string.	Listar	1987	135
35	Writing and publishing a newsletter for your school.	Hacker & Barden	1988a	206-209
36	Designing and building a "learning game."	Listar	1987	135

**Ill-structured problems formulated by researcher, with graduate committee review.