

A CASE STUDY OF PROBLEM SOLVING INSTRUCTION
IN SELECTED VOCATIONAL PROGRAMS WITHIN
A VOCATIONAL TECHNICAL SCHOOL

By

STEPHANIE A. CURTIS

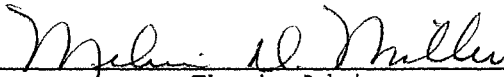
Bachelor of Science
Oklahoma State University
Stillwater, Oklahoma
1982

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1988

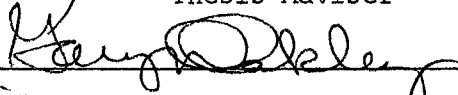
Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF EDUCATION
May, 1995

A CASE STUDY OF PROBLEM SOLVING INSTRUCTION
IN SELECTED VOCATIONAL PROGRAMS WITHIN
A VOCATIONAL TECHNICAL SCHOOL

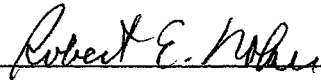
Thesis Approved:

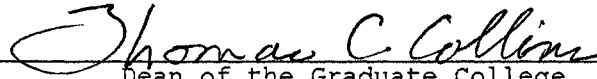


Thesis Adviser









Dean of the Graduate College

ACKNOWLEDGEMENTS

Gratitude is extended to many people who have contributed to the completion of the study. The writer expresses grateful appreciation to her dissertation advisor, Dr. Melvin D. Miller, for his encouragement and guidance. Sincere appreciation is extended to Dr. Robert Nolan, chair of the dissertation committee, for his scholarly advice. Many thanks go to Dr. Gary Oakley and Dr. Beulah Hirschlein, dissertation committee members, for their suggestions, time, and cooperation.

The writer wishes to thank the vocational instructors who participated in the pilot study and the actual case study. Without their involvement the study would not have been possible. Thanks is extended to Kay Porter and Wilda Reedy for their knowledge and expertise in putting the dissertation manuscript together.

The writer wishes to express a special appreciation to her parents, V. K. and Doris Curtis, and her many friends who provided encouragement and understanding throughout the completion of the study.

TABLE OF CONTENTS

Chapter	Page
I. INTRODUCTION	1
Research Problem	4
Purpose	4
Research Objectives	4
Definitions	5
Importance of the Study	6
Theoretical Construct	8
Scope and Limitations	12
Summary and Overview	12
II. REVIEW OF LITERATURE	14
Changing Workplace Dynamics	14
Workplace Skills	17
Lifelong Learning	18
Collaboration	19
Self-Management	19
Adaptability to Change	20
Abstraction	20
Systems Thinking	21
Problem Solving	21
Problem Solving	22
Problem Solving Defined	22
Problem Solving Skills	23
Problem Solving Instructional Practices	24
Fluid and Crystallized Intelligence	26
Memory and Problem Solving	28
Problem Solving Models	33
Polya's Problem Solving Model	33
Resnick and Glaser's Problem Solving Model	39
A Critique of Resnick and Glaser's Model	45
The Scientific Method Approach to Problem Solving	46
The Workplace Skill Approach to Problem Solving	51
The Cognitive Apprenticeship Problem Solving Model	58
General Problem Solver Model	68
Strategies of Expert Problem Solvers	71
Case Study Research	76
Foundations of Case Study Research	76
The Case Study Researcher	79
The Methodology of Triangulation	80
Summary	82

Chapter	Page
III. RESEARCH PROCEDURES	89
Introduction	89
Research Design	89
Population and Sample Selection	90
Securing Permission to Conduct the Research	92
Data Collection	93
Triangulation	93
Observations	94
Interviews	95
Curriculum Reviews	95
Field Testing	96
Recording of the Data	98
Observations	98
Interviews	99
Curriculum Reviews	100
Data Analysis	100
Observations	100
Interviews	101
Curriculum Reviews	102
IV. Vocational Program Data	103
Introduction	103
Applied Accounting Program	105
Applied Accounting Observations	105
Applied Accounting Interview	113
Applied Accounting Curriculum Review	117
Summary of the Applied Accounting Program ...	120
Engineering Drafting Program	121
Engineering Drafting Observations	121
Engineering Drafting Interview	129
Engineering Drafting Curriculum Review	132
Summary of the Engineering Drafting Program .	134
Instrumentation and Control Technician Program	136
Instrumentation and Control Technician	
Observations	136
Instrumentation and Control Technician	
Interview	145
Instrumentation and Control Curriculum	
Review	150
Instrumentation and Control Technician	
Summary	154
Child Care Program	157
Child Care Observations	157
Child Care Interview	165
Child Care Curriculum Review	170
Summary of the Child Care Program	173
Licensed Practical Nursing Program	175
Licensed Practical Nursing Observations	175
Licensed Practical Nursing Interview	189
Licensed Practical Nursing Curriculum Review .	193
Summary of the Licensed Practical	
Nursing Program	200
Summary of Five Vocational Programs	202

Chapter	Page
V. FINDINGS, CONCLUSIONS, RECOMMENDATIONS AND IMPLICATIONS FOR PRACTICE	206
Summary	206
Research Objectives and Findings	210
Discussion of the Findings	212
Conclusions	220
Recommendations for Research and Practice	221
Discussion of Recommendations and Implications for Practice	222
BIBLIOGRAPHY	225
APPENDIXES	230
APPENDIX A - RESEARCH PROJECT INFORMATION SHEET	231
APPENDIX B - RESEARCH INSTRUMENTS	233
APPENDIX C - INSTITUTIONAL REVIEW BOARD APPROVAL FORM	240

LIST OF TABLES

Table	Page
I. Problem Solving Model Matrix	85
II. Level* and Time Devoted to Problem by Category During Applied Accounting Observations	110
III. Level* and Time of Instructional Strategies Used During Applied Accounting Observations	112
IV. Level* and Time Devoted to Problem Solving by Category During Engineering Drafting Observations	124
V. Level* and Time of Instructional Strategies Used During Engineering Drafting Observations	128
VI. Level* and Time Devoted to Problem Solving by Category During Instrumentation and Control Technician Observations	140
VII. Level* and Time of Instructional Strategies Used During During Instrumentation and Control Technician Observations	144
VIII. Level* and Time Devoted to Problem Solving by Category During Child Care Observations	160
IX. Level* and Time of Instructional Strategies Used During Child Care Observations	162
X. Level* and Time Devoted to Problem Solving by Category During Licensed Practical Nursing Observations	177
XI. Level* and Time of Instructional Strategies Used During Licensed Practical Nursing Observations	179
XII. The Occurrence of Problem Solving by Category Based on Observations in Five Vocational Programs	203
XIII. The Use of Instructional Strategies Based on Observations in Five Vocational Programs	205

CHAPTER I

INTRODUCTION

The workplace is changing and so are the workplace skills that employees must have in order to keep up with the changes (Carnevale, Gainer, & Meltzer, 1990). Many workers do not have the skills necessary to succeed in the workplace. Workers deficient in skills are not a new problem, but have become a growing problem due to demographic, economic and technical forces (Carnevale, Gainer, & Meltzer, 1988; 1990).

There is evidence that workers entering the workforce for the first time are less skilled than ever before (Chute, Hancock, & Balthazar, 1991). Some researchers attribute this to the shrinking pool of labor. The traditional pool of entry level workers, ages 16 to 24 years old, is shrinking and will continue to do so through the year 2000 (Carnevale et al., 1988; 1990; Feuer, 1987). Employers may have to hire less qualified workers to get the number of entry level workers that they need. Employers will no longer be able to easily replace unsatisfactory workers with new workers since the supply of workers is shrinking (Carnevale et al., 1988: 1990; Feuer, 1987: Brock, 1991). As a result, interest in providing quality entry level training is becoming more important to employers.

According to Senge (1990), workplaces should aspire to become learning organizations. Senge (1990) further states that as the world

becomes more interconnected and business becomes more complex and dynamic, work must become more "learningful". The organizations that will excel in the future will be the organizations that discover how to tap people's commitment and capacity to learn at all levels in an organization (Senge, 1990). At the heart of the learning organization is a shift of mind - from seeing ourselves as separate from the world to connected to the world, from seeing problems as caused by someone or something "out there" to seeing how our own actions create the problems we experience (Senge, 1990).

There is a linkage between the competitive cycle of business and industry, and workplace skills (Carnevale et al., 1988; 1990; Berryman & Bailey, 1992). Berryman and Bailey (1992) further state that the competitive life cycle of any new strategy, technology, product, or service usually consists of six distinct stages: discovery, design, development and articulation of the management and production systems and processes, production and service delivery, and development of new applications. Workers with good workplace skills can mean a shorter production cycle, improved products, and high quality. Deficiencies in workplace skills can undermine the cycle and cause delays, defects, and customer rejections (Carnevale et al., 1990).

Sound workplace skills benefit the employer and the worker. A work force with good skills strengthens the employer's ability to compete (Carnevale et al., 1990). Employers with good skills are more productive than those with weaker skills. For the individual worker, good workplace skills are the keys to greater opportunity and a better quality of life. Workers with good skills find it easier to acquire

more sophisticated skills that leverage better jobs and higher pay (Carnevale et al., 1990).

Workers often lack both basic workplace skills and advanced higher order thinking skills. Deficiencies in the basic workplace skills of reading, writing, and computation are barriers to entry level employees, experienced employees, and dislocated workers attempting to adapt to economic and technological change within the employer institutions (Carnevale et al., 1988; 1990). Higher order thinking skills previously considered only necessary for the professional are now considered to be essential workplace skills for all workers. The higher order thinking skills that workers need to have are problem solving skills, critical thinking skills, group interaction skills, and communication skills (Carnevale et al., 1988; 1990).

Problem solving, the focus of this study, has been identified as an essential skill needed by entry level workers. Employees need problem solving skills in order to feel comfortable with innovation. Workers must be able to think creatively as they cope with new challenges which arise in the workplace (Carnevale et al., 1988; 1990). According to Carnevale, Gainer, and Meltzer (1990) problem solving and creative thinking are essential during the last phase of the competitive cycle when increased efficiencies, quality improvement, and new applications of the original innovation are developed. Problem solving skills enable the worker to engage in tasks which include participative team management, new technologies, sophisticated quality controls, the customization of goods and

services, and just-in-time production (Berryman & Bailey, 1992; Carnevale et al., 1990).

Wirth (1992) states that the long term welfare of the nation depends on inventive technology combined with a well-educated, engaged workforce capable of learning. A viable workforce depends on having employees with strong number and literacy skills, the ability to learn, to think abstractly and contextually, and to collaborate in problem solving (Wirth, 1992). The fact is that entry level workers lack the problem solving abilities necessary to find successful employment and keep up with technological change.

Research Problem

The problem identified for the study was that entry level workers lack sufficient problem solving abilities.

Purpose

The purpose of the research study was to investigate through a case study the problem solving instruction occurring in an area vocational technical school in Oklahoma.

Research Objectives

The following research objectives were identified for the study:

1. To identify the occurrence of problem solving instruction in a selected area vocational technical school in Oklahoma.
2. When problem solving is taught, to determine if vocational educators address specific problem solving skills or are such skills an incidental outcome of instruction?

3. To identify instructional strategies that appear to be used by vocational educators to teach problem solving.

Definitions

For the purpose of this study, the following terms have been defined:

Abstraction: The ability to deal with the possible without reference to the actual. Thinking is not bound to direct experience. The individual is able to construct theories and make logical deductions as to their consequences without the necessity for empirical evidence (Inhelder & Piaget, 1964; Almy, 1966).

Critical Thinking: A thinking process in which the learner questions the assumptions underlying customary ideas and actions, and contemplates alternative ways of thinking and acting (Brookfield, 1987, p. x).

Problem Solving: Problem solving is a process in which an individual uses previously acquired knowledge, skills, and understanding and synthesizes what he or she has learned and applies it to a new or different situation (Krulik & Rudnick, 1980).

Triangulation: Triangulation is using multiple investigators, multiple sources of data, or multiple methods to confirm the emerging findings. Methodological triangulation combines dissimilar methods such as interviews, observations, and physical evidence to study the same unit. Triangulation strengthens the reliability and internal validity of a study (Merriam, 1988, p. 169).

Importance of the Study

Worker deficiencies in problem solving abilities have been reported by employers and documented by many researchers (Carnevale et al., 1988; 1990; Feuer, 1987; Brock, 1991; Berryman & Bailey, 1992; Wirth, 1993; Reich, 1991; and Zuboff, 1988). Problem solving skills include the ability to recognize and define problems, invent and implement solutions, and track and evaluate results. Cognitive skills, group interaction skills, and problem-processing skills are all crucial to successful problem solving. Workplace training programs in problem solving stimulate real problems and are keyed to an organization's goals (Carnevale et al., 1988).

New approaches to problem solving, organizational design, and product development all spring from the individual capacity for creative thinking (Carnevale et al., 1988). In the workplace, creative thinking is generally expressed through the process of creative problem solving. Often a group activity, creative problem solving is characterized by effective teamwork, the examination of problems in new ways, and the invention of new solutions to existing problems. Either an individual or group activity, creative innovation refers to the development of new activities that expand markets, and improve such elements as productivity (Carnevale et al., 1988; 1990). Increasingly, companies are identifying creative problem solving as critical to their success and are instituting structured approaches to problem identification, analysis, and resolution (Carnevale et al., 1990; Wirth, 1992).

Problem solving skills are closely associated with critical thinking skills. According to Brookfield (1987), critical thinking involves "calling into question the assumptions underlying customary, habitual ways of thinking and acting and then being ready to think and act differently on the basis of critical questioning" (p. 1). Without critical thinking and problem solving in the workplace, workplaces remain organized as they were twenty years ago (Brookfield, 1987). Some examples of critical thinking activities in business and industry are the following seven concepts: strategic planning, effective decision making, creative problem solving, situational leadership, entrepreneurial risk taking, research and development activities, and organizational team building (Brookfield, 1987).

Demographic, economic, and technical forces indicate a need for workers who are able to engage in problem solving. Vocational education students need to be able to detect and diagnose problems, as well as, solve problems in the workplace. The student needs to be able to engage in problem solving both as an individual and cooperatively with fellow workers in groups. According to Wirth (1992), "if students are to be problem solvers, we must get them into schools where students take responsibility for making critical decisions and obtaining problem solving experiences" (p. xii).

It is currently not clear the extent that problem solving is taught, if at all. If it is taught, how it is accomplished. The study is a case study which sought to explore problem solving instruction within a single vocational technical school. The study will provide valuable information on problem solving instruction to

academicians and practitioners in the field of vocational and technical education.

Theoretical Construct

A problem is a perplexing situation which calls for consideration and some sort of resolution from the problem solver. The problem solver uses immediate information which is available, and also calls upon knowledge stored in memory which is then applied to the context of the current problem (Rubinstein & Firstenberg, 1987).

Problem solving is a process. According to Carnevale et al. (1990) problem solving is the process of bridging a perceived gap between what is and what ought to be. Problem solving involves systematic processes used to guide both individual and group efforts. Carnevale et al. (1990) further state that problem solving naturally divides into three sequential stages: problem identification, problem analysis, and problem resolution.

The problem solver must call upon his knowledge, skills, and mental abilities to find a solution to the problem. Sellwood (1989) states that the ability to recognize, analyze and solve problems is a fundamental part of a child's intellectual development and is important as a life skill.

The skills to perform problem solving operations need to be taught (James, 1990). Problem solving is the basis for all good teaching practices (Sellwood, 1989). Problem solving instruction needs to be constant and integrated into all school subjects within the school curriculum at all age levels (Sellwood, 1989).

According to Woods (1987) problem solving skills can be facilitated through instruction. Woods (1987) further states,

the skills needed in the problem solving process include a knowledge base pertinent to the content of the problem; the ability to learn on one's own, the thinking skills of analysis - classify, check for consistency, reason, and identify relationships; creativity, ability to generalize and to simplify and broaden perspectives; such attitudes as motivation and perseverance; ability to cope with ambiguity, fear, anxiety, and procrastination; interpersonal and group skills, communication skills; and an awareness of how one thinks, one's personal preference or style when learning or processing information. In addition the problem solver should use an organized approach and a host of heuristics or hints (p. 55).

Many students demonstrate that they are excellent at recalling memorized procedures for solving one type of problem. Recalling memorized procedures is not problem solving but "exercise solving" (Woods, 1987). Students may be excellent solvers of exercises yet be poor problem solvers. Teachers and students rarely distinguish between these two processes, and the misconception arises that experience gained by solving many exercises develops skills at solving problems (Woods, 1987).

To be both effective and transferable, the training in problem solving should be embedded in a subject discipline (Woods, 1987). Woods (1987) further states that problem solving should not be taught as a separate course. Problem solving should have applications to real world problems.

Woods (1987) has identified five steps that instructors can take to facilitate student problem solving skills. The first step is to help the students see the structure of the knowledge in the discipline. Instructors can help the student identify a global

perspective about the subject and provide advance organizers that give the big picture. In addition, instructors can use explicit activities to help the students acquire the desired hierarchical structure of fundamentals (Woods, 1987).

The second step that instructors can take is to help the students learn the tacit knowledge of the subject matter (Woods, 1987). Tacit knowledge is the heuristic strategies or tricks of the trade that the students learn through experience and practice. Without tacit knowledge, students have trouble creating internal representations, selecting reasonable assumptions, and deciding whether an answer sounds reasonable (Woods, 1987).

According to Woods (1987) the third step that instructors can take is to focus on problem solving as a skill to be taught. Problem solving is a body of knowledge embedded in cognitive and behavioral psychology that can and should be taught. Many of the concepts of problem solving have been developed such as the mathematics of decision making, organizational behavior, and the characteristics of effective groups. Woods (1987) further states that the understanding of the skills and domain of problem solving is evolving gradually.

The fourth step that instructors can take is to make students aware of the mental processes that they use before progress in any problem solving skills can be made (Woods, 1987). Students need to be aware of the mental processes that they use, and they need to be able to describe those processes to others (Woods, 1987).

The fifth step that instructors can take is to set goals when teaching problem solving (Woods, 1987). Learning objectives should be created to develop problem solving skills. After the objectives have

been developed the instructor should choose learning activities and select evaluation procedures. Woods (1987) states that instructors may want to grade an assignment for the process, not for the final answer.

Instructors should not search for good problems and then decide how to use them (Woods, 1987). Rather, instructors should identify the skills that they plan to tackle, the degree of explicitness with which they want to tackle them, and then the steps involved in developing, embedding, and transferring the skills. That is, the instructor selects the objectives first and then chooses the problems and the environment (Woods, 1987).

There are two approaches that work in problem solving instruction. One way to approach problem solving instruction is to use fewer problems and exploit them to satisfy both the problem solving and the subject content goals (Woods, 1987). The teacher assumes the role of facilitator with the students doing the thinking, making the decision, and reflecting on what is going on. Woods (1987) states that another way to approach problem solving instruction is to develop some problem solving skills near the beginning of the course and then embed and transfer these problem solving skills into the discipline during the remainder of the course. The problem solving activities should not be rushed. To acquire problem solving skills requires good planning and a careful statement of overall program and individual course goals (Woods, 1987).

Instructional strategies and problem solving models have been developed which could be used by vocational educators to teach problem solving; however, it is not clear whether vocational educators are

currently using any of these problems solving models or instructional strategies.

The theoretical construct for the case study was that problem solving skills can be taught or improved upon through instruction.

Scope and Limitations

The scope and limitations of the study were:

1. The study was a case study of problem solving instruction in a single area vocational technical school in Oklahoma.

2. The vocational programs observed within the vocational technical school were limited to five programs representing five occupational clusters.

3. The self-paced learning activity packets (LAPS) used as the curriculum by the vocational technical school limited the amount of verbal interaction between the instructors and the students. This influenced the researcher's ability to detect problem solving incidents occurring in the vocational programs during the research study observations.

Summary and Overview

The study was a case study which sought to explore problem solving instruction within a vocational technical school. The researcher observed five specific vocational programs from five broad occupational clusters within a vocational technical school. The applied accounting program represented the business education occupational cluster. The drafting engineering program represented the trade and industry cluster. The instrumentation and control

technician program represented the advanced technology cluster. The child care program represented the home economics cluster. The part-time licensed practical nursing program represented the health occupations occupational cluster.

The researcher used triangulated research methodologies to collect the data on problem solving instruction. First, the researcher observed classroom instruction to determine what kinds of problem solving activities the students were engaged in and what instructional strategies the vocational instructors used to facilitate problem solving abilities. Second, the researcher conducted formal interviews with the vocational instructors using previously developed questions from a structured questionnaire. The vocational instructors were asked questions concerning problem solving in general and the methodologies or techniques they used to teach problem solving skills to students. Lastly, the researcher reviewed the course curriculum from each of the vocational programs for problem solving content, objectives, student activities, and instructional strategies.

Data collected from the study will provide insight as to how vocational educators go about teaching problem solving skills to students.

CHAPTER II

REVIEW OF LITERATURE

This chapter contains information which provides a foundation for the research study. The chapter is divided into the following sections: Changing Workplace Dynamics, Workplace Skills, Problem Solving, Fluid and Crystallized Intelligence, Memory and Problem Solving, Problem Solving Models, Strategies of Expert Problem Solvers, Case Study Research, and Summary.

Changing Workplace Dynamics

Increased international competition is one of the most important issues affecting changes in the organization of the workplace (Berryman & Bailey, 1992; Wirth, 1992). Organizational changes lead to shifts in the nature of work and the skills and educational needs of the worker.

In decades past, the efficiency of scientific management allowed the American workforce to be competitive with other nations. According to Wirth (1992), scientific management, created by Fredrick Taylor was a system of control designed to discipline and keep an ill-educated, immigrant work force tied to assembly line production. It was a system in which thinking and authority were reserved for managerial and technical experts who broke production into minute prescribed tasks, while people at work were reduced to programmed

performance under supervision. It was the hierarchical, bureaucratic control system that Max Weber held to be inevitable under mass industrialism (Wirth, 1992). Its manipulative hierarchical style conflicted with values such as the equal worth and dignity of persons, the chance to participate as an active subject rather than a mere object, and the chance to use one's distinctive capacities to learn, think, and grow. It was at odds in a fundamental way with the tradition of democratic values (Wirth, 1992).

Taylorist efficiency has rapidly become dysfunctional for meeting challenges of the new era (Wirth, 1992). The new style of workplace leadership combines participative values with computer technology. This combination can make America more competitive by releasing creativity and improving the quality of life in work and schools (Wirth, 1992).

As the world continues to rapidly change, business, industry, and government will find it increasingly more difficult to keep their productive workforces competitive and current (Chute, Hancock, & Balthazar, 1991). Flexibility, fast response time, and innovation, as much as cost, are now the keys to growth and competitiveness in the workplace (Berryman & Bailey, 1992).

Another issue affecting the organization of the workplace is the customization of goods and services (Berryman & Bailey, 1992). To compete successfully in the world market, the United States must produce goods that either cost less or display superior quality. Since labor costs in the United States are high compared to those of developing nations, American firms need to focus on superior quality,

producing customized goods and services that command premium prices (Porter, 1990; Berryman & Bailey, 1992).

The production of customized goods depends on a highly skilled, flexible work force. Creating such a work force requires enormous investments in education and training (Airing, 1993). According to Vobejda (1987), employers want workers to be able to work in teams, rotate through various jobs, spot problems, trouble shoot, articulate problems to others, suggest improvements, write detailed charts and memos, and understand how their tasks fit into the entire process. Such tasks require cognitive skills which the worker may need to develop through vocational training and instruction.

The rapid pace of technological change is another issue that is affecting the organization of the workplace (Berryman & Bailey, 1992; Wirth, 1992). Changes in technology increase the demands on the worker. Technology affects the type of jobs and skills needed, as well as, the number of workers necessary to fill those jobs (Brock, 1991). Computers increase the cognitive complexity of the tasks performed by the worker. Instead of simple procedural and predictable tasks, the worker becomes responsible for inferences, diagnoses, judgement, and decision making (Howell & Cooke, 1989). Employment in today's workplace involves interaction in a constantly changing way with production technology (Berryman, 1988).

One profound educational implication of computers in the workplace is that computers force a replacement of observational learning with learning acquired primarily through symbols, whether verbal or mathematical (Scribner & Cole, 1981; Bailey, 1988). Berryman (1988) states that in order to understand, diagnose and fix

these new machines in the workplace, technicians have to be able to represent the machine's structures and processes symbolically in their head. To do this, workers have to be able to follow complicated manuals, diagrams, and updates provided by the manufacturers.

According to Berryman and Bailey (1988) there is a general feeling of uncertainty present in the workplace environment. Resnick (1987) agrees and states that employees are increasingly required to deal with uncertainty, the unfamiliar, and discontinuity in the workplace. There has been a general shift from physical to cognitive skill requirements in the workplace. The workplace environment requires the integration of traditionally separate functional roles (design, engineering, marketing, manufacturing), flatter organizational hierarchies, decentralization of responsibility, and greater employee involvement at all levels of the workplace organization (Berryman & Bailey, 1992).

Employers have discovered that they need more than just a few educated managers; they need entire work forces that are literate and have problem-solving skills. Drucker (1989) identifies this new type of worker as the "knowledge worker".

Workplace Skills

A variety of workplace skills are advocated by industry, educators, and economists as being needed by the worker in order to find successful employment. According to Berryman and Bailey (1992), the measurement of workplace skills has proved to be extremely

difficult. There is no accepted conceptualization of workplace skills or widely used methodology for measuring them.

A review of the literature reveals several workplace skills identified by experts as being important in the workplace. The skills or workplace qualities to be examined are: lifelong learning, collaboration, self-management, adaptability to change, abstraction, systems thinking, and problem solving.

Lifelong Learning

Lifelong learning is a preferred quality among workers. An employee's ability to adapt to company needs through retraining is crucial as technology creates shifts in the job market demand and job content (Carnevale et al., 1988). Evidence suggests that the training workers receive will become obsolete within three to five years after they receive it (Chute et al., 1991). Employees who realize the importance of lifelong learning are an asset to their company. The employee who knows how to learn can help their employer in meeting its strategic goals and competitive challenges by more efficiently applying new knowledge to job duties and tasks (Carnevale et al., 1988).

Senge (1990) carries the notion of lifelong learning further by stating that workplaces need to be learning organizations. An organization's commitment to and capacity for learning can be no greater than that of its members (Senge, 1990). Workers learning together are vital because teams, not individuals, are the fundamental learning unit in modern organizations. Senge (1990) further states that when teams are truly learning, not only are they

producing extraordinary results but the individual members are growing more rapidly than could have occurred otherwise. The learning organization is an organization that is continually expanding its capacity to create its future (Senge, 1990).

Collaboration

The ability to collaborate with others is a preferred skill among workers. In collaboration, teams are organized in the workplace so that appropriate talents and skills can be directed through group effort to accomplish vital tasks and goals (Carnevale et al., 1988). Reich (1991) defines collaboration as the capacity to engage in active communication and dialogue to get a variety of perspectives and to create consensus when necessary. Workers need to be able to express their ideas and provide feedback to fellow team members. The ability to communicate is also essential in collaboration. Team members need to be aware of the technical skills that fellow team members possess and respect the contributions of the other teams members in participative problem solving.

Self-Management

The flattening of workplace hierarchies has created the need for workers that have the ability the manage themselves. Employees must be independent and motivated to set goals, plan, adjust plans, and evaluate their progress toward goals (Marzano & Ewy, 1989). Employees are expected to be responsible and have a positive self-esteem. Workers need to have confidence in themselves in order to make good decisions. Poor performance in the workplace may be linked

to deficiencies in self-management skills. Employers are beginning to recognize that they need to provide training in job specific skills, as well as, training in the more intangible skills involved in self-management (Carnevale et al., 1988).

Adaptability to Change

The ability to adapt to change is a quality needed by workers. Workers need to be able to operate in a less defined environment. This requires greater skills in creative thinking, decision making, reasoning, and problem solving (Berryman & Bailey, 1992). The worker must possess a wide variety of skills which enable him to adapt to any situation which may arise (Berryman & Bailey, 1992).

Abstraction

The ability to engage in abstract thinking is an important skill needed by the worker. Abstraction is the capacity for discovering patterns and meanings; and the ability to simplify a complex reality so that it can be understood and integrated to reveal new solutions, problems and choices (Wirth, 1992; Reich, 1991). According to Berryman and Bailey (1992) workers who have an abstract or conceptual understanding of what they are doing, can carry out tasks or solve problems that they have not encountered before or that they have not been shown specifically how to carry out or solve.

Abstraction is a part of symbolic thinking. Symbolic thinking is the ability to construct meaning internally and externally from a symbolic medium. Reich (1991) states that symbolic analysts are people who solve, identify, and broker problems by manipulating

symbols. Symbolic analysts translate reality into abstract images that can be juggled, experimented with, and communicated to other specialists in the workplace (Reich, 1991).

Systems Thinking

Workers also need to think in terms of the systems in which they operate. Workers need to understand how their decisions or activities affect the performance and the operation of the organization (Berryman & Bailey, 1992). According to Reich (1991) and Wirth (1992), workers can no longer view their activities as being isolated. Workers need to understand how parts of reality are linked together into wholes. In systems thinking, students are taught to examine why problems arise and how they are connected to other problems. Effective workers understand social, organizational, and technological systems (United States Department of Labor, 1991).

Problem Solving

Problem solving skills often separate the above average worker from the average. Problem solving skills include the ability to recognize and define problems, invent and implement solutions, and track and evaluate results. Cognitive skills, group interaction skills, and problem processing skills are all crucial to successful problem solving (Carnevale, Gainer, & Meltzer, 1988). Problem solving, the focus of this study, is the topic of the next section of the review of literature.

Problem Solving

The ability to recognize, analyze, and solve problems is a fundamental part of a child's intellectual development and is becoming increasingly important as a life skill (Sellwood, 1989). The importance of problem investigation, experimentation, and feedback is evident at all levels of education. The skill to perform these operations correctly needs to be taught (James, 1990).

Problem Solving Defined

The term "problem solving" is associated with a wide variety of concepts and meanings. Greenfield (1987) states that many educators equate the teaching of thinking to the teaching of problem solving, but conflicts arise as to the best way of doing it. The difficulty stems in part from different concepts and different meanings attached to the term "problem solving", as well as, from the differences among individual problem solvers and among individual problems. The methods used by educators, psychologists, philosophers, and others to define, describe or analyze problems and problem solving determines the method used to teach problem solving skills and determines the curricular plans and applications (Greenfield, 1987).

Krulik and Rudnick (1980) define a problem as a situation, quantitative or otherwise, that confronts an individual or group of individuals, that requires resolution, and for which the individual sees no apparent or obvious means or path to obtaining the solution. What may be a problem for one person may be an exercise for another, or of no interest to yet another (Krulik & Rudnick, 1980).

According to Krulik and Rudnick (1980), a problem must satisfy three criteria: acceptance, blockage, and exploration. In acceptance the problem solver accepts the problem and becomes personally involved. The problem solver's personal involvement may be due to a variety of reasons which could include internal motivation, external motivation, or the desire to experience the enjoyment of solving a problem (Krulik & Rudnick, 1980). Krulik and Rudnick (1980) state that in blockage, the problem solver's initial attempts to solve the problem are fruitless. The problem solver's habitual responses and patterns of attack do not work. In exploration, the problem solver's personal involvement identified in the acceptance stage leads the problem solver to explore new methods of attacking the problem (Krulik & Rudnick, 1980).

Problem solving is a process. It is a means by which an individual uses previously acquired knowledge, skills, and understanding to satisfy the demands of an unfamiliar situation. The student must synthesize what he or she has learned, and apply it to the new and different situation (Krulik & Rudnick, 1980).

Woods (1987) defines problem solving as the mental process that one uses to arrive at a "best" answer to an unknown or some decision, subject to a set of constraints. The problem situation is not one that has been encountered before; one cannot recall from memory a procedure or a solution from past experience. One has to struggle to obtain the "best" answer.

Problem Solving Skills

There are several skills needed during the problem solving process. The problem solver needs to have a knowledge base in the content of the problem (Woods, 1987). Woods (1987) further states

that the problem solver must have the ability to identify, locate, obtain, and evaluate missing information. The problem solver needs to have the thinking skills of analysis, creativity and diversity. The problem solver must be able to cope with ambiguity, fear, anxiety, and procrastination (Woods, 1987). Communication skills, interpersonal and group skills are also valuable. The problem solver also needs to be aware of their own learning style (Woods, 1987).

According to Krulik and Rudnick (1980) good problem solvers have several common characteristics. Good problem solvers have a desire to solve problems. They are extremely perseverant. They use a variety of methods. They make connections quickly and often skip steps. They make educated guesses at solutions and then try to verify these solutions (Krulik & Rudnick, 1980).

Problem Solving Instructional Practices

Krulik and Rudnick (1980) state that an emphasis on problem solving in the classroom can help to close the gap between the real world and the classroom. Problem solving can be more exciting, more challenging, and more interesting to children than routine exercises. Student success in the classroom leads to persistence and continuation of a task; failure leads to avoidance of a task (Krulik & Rudnick, 1980). The greater the student involvement in problem solving, the better the end product. A carefully selected sequence of problem solving activities that yield success will stimulate students, leading them to a more positive attitude toward problem solving (Krulik & Rudnick, 1980).

Krulik and Rudnick (1980) state that some educators assume that expertise in problem solving develops incidently as one solves many problems. While this may be true in part, some people agree that problem solving skills should be considered as a distinct body of knowledge and should be taught as such (Krulik & Rudnick, 1980).

Sellwood (1989) views problem solving instruction as something that should not be switched on and off. Problem solving is neither a separate subject within the school curriculum, nor is it solely a part of science and technology. Problem solving is the basis for all good teaching practice. The approach should be genuine and the methodologies utilized should not be restricted (Sellwood, 1989).

Problem solving places more responsibility for learning on the student (Sellwood, 1989). Problem solving is an investigative approach that should have its foundations in early schooling and develop with each stage of education. Problem solving instruction should not be limited to high schools and colleges (Sellwood, 1989).

Pellegrino and Schadler (1974) conducted a study which sought to make children more self-conscious about their reasoning and actions in problem solving. When presented with an invention problem, children were asked to "look ahead" and verbalize possible goals and strategies for solving the problem before they took any real action. Under the "look ahead" conditions 14 out of 16 children solved the problem. Of the children who were not asked to "look ahead" only six out of 16 were able to solve the invention problem (Pelligrino & Schadler, 1974).

The results of Pelligrino & Schadler's study suggests that the general strategy of planning ahead and considering alternative goals

may be a very powerful component of problem solving. The looking ahead strategy appears to be both simple to use and easy to teach. Instructors may need to remind students to consider their goals and possible actions; once reminded, students can access what they already have learned to do. The "looking ahead" strategy appears to be generalizable across a variety of tasks, although this remains to be established experimentally (Pelligrino & Schadler, 1974).

Fluid and Crystallized Intelligence

The extent to which one is able to engage in problem solving may be affected by intelligence. Raymond Cattell (1963) conceptualized intelligence as consisting of two primary factors. These primary factors are fluid intelligence and crystallized intelligence. Both fluid and crystallized intelligence involve some similar processes such as perceiving relationships among items, abstract reasoning, concept formation, and problem solving (Schulz & Ewen, 1988).

Crystallized intelligence represents the extent to which an individual has incorporated the valued knowledge of their culture. It is measured by behaviors that reflect culturally valued knowledge and experience, the comprehension of communications, and the development of judgement, understanding, and reasonable thinking in everyday affairs (Cattell, 1963). The domain and heuristic knowledge which make up one's crystallized intelligence provide the foundation necessary for problem solving.

Crystallized intelligence is more likely to be assessed by nontimed measures which call for judgement, knowledge and experience (Cross, 1981). Some of the primary abilities associated with

crystallized intelligence are verbal comprehension, concept formation, logical reasoning, and induction. Tests used to measure the crystallized factor include vocabulary, simple analogies, remote associations, and social judgement (Rybash, Roodin, & Santrock, 1991).

Fluid intelligence represents an individual's ability to perceive, remember and think about a wide variety of basic information (Horn, 1982). Horn (1982) suggests that fluid intelligence represents the integrity of the central nervous system. Abilities which make up fluid intelligence are seeing relationships among patterns, drawing inferences from relationships, and comprehending implications (Cattell, 1963).

The mental abilities which make up fluid intelligence affect the problem solver's ability to accurately process information. Fluid intelligence is most often associated with tests that assess such abilities as memory span and adaptation to new situations (Rybash et al., 1991). These tests tend to be timed. Some of the primary mental abilities that best reflect this factor are number, space, and perceptual speed. Tasks measuring fluid intelligence include letter series, matrices, and spatial orientation (Rybash et al., 1991).

Dixon and Baltes (1986) have found a way to further distinguish fluid from crystallized intelligence. They regard fluid intelligence as the mechanics of intelligence. Fluid intelligence involves the raw basic operations of the human information processing systems. The mechanics of intelligence allow humans to perceive the environment, and then classify and remember their perceptions.

Dixon and Baltes (1986) describe crystallized intelligence as the pragmatics of intelligence. Crystallized intelligence concerns the context and experience related applications of the mechanics of intelligence. The pragmatic component of intelligence involves 1) the general system of factual knowledge accessible to members of a particular culture, 2) specialized systems of knowledge available to individuals within particular occupations and avocations, and 3) an understanding of how to effectively activate different types of knowledge within particular contexts to aid in problem solving (Dixon & Baltes, 1986).

Changes in both fluid and crystallized intelligence may occur as one ages. Crystallized intelligence generally increases and remains stable over the adult years. Fluid intelligence tends to peak in early adolescence. Researchers believe that fluid abilities lost in adulthood can be partially regained through training or compensated for by one's crystallized intelligence. According to Cross (1981), people seem to perform best in their youth on tasks requiring quick insight, short-term memorization, and complex interactions. As people get older, they accumulate knowledge and develop perspective and experience in the use and application of their knowledge.

Memory and Problem Solving

In order to facilitate problem solving, it is helpful to understand human memory and information processing strategies. Human memory has been studied primarily from the information processing approach. The mind is visualized as a computer, with information being entered, stored, and then retrieved as needed (Merriam &

Caffarella, 1991). Where people store and file what they learn is the structural aspect of memory. Three categories have been used to describe the different structures of memory: sensory memory, short-term memory, and long-term memory. Each form of memory structure has a distinct capacity in which information is filed for a period of time (Merriam & Caffarella, 1991).

Sensory memory has a small storage capacity and a brief storage time in terms of milliseconds (Merriam & Caffarella, 1991). Information from the environment is registered within sensory memory via visual, auditory, and tactual senses. Material is then selectively transferred or encoded into short-term memory (Merriam & Caffarella, 1991).

Short-term memory also has a small storage capacity and a brief storage time of about one-half minute (Merriam & Caffarella, 1991). In short-term memory information is sorted and filed by chunking or automatization. Chunking organizes the information in groups or patterns. Automatization allows a chunk of information to become so familiar that a person can handle it without really thinking. Information stored in short-term memory undergoes shallow processing. Some information in short-term memory is also structured for long-term memory.

The storage capacity for long-term memory is enormous. Information can be stored for a lifetime. Information is encoded into the memory bank for permanent storage by highly organized episodes and by meaningful relations to earlier stored material. This type of processing is referred to as deep processing and is structured in short-term memory and then transferred for long-term

memory storage. Information is then retrieved when needed from long-term memory.

Information processing is divided into three phases: encoding, retention, and retrieval. Schulz and Ewen (1988) define information processing as:

the mental activities that are performed when information is put into memory - learning, or made use of at some later date - remembering (p. 134).

The encoding or acquisition phase is the initial process in which the information is entered into the memory system. According to Rubinstein and Firstenberg (1987), isolated pieces of information are hard to remember. Learners need to engage in active processing of the information to be encoded. When faced with new material, it helps to paraphrase the ideas, to assess how various facts relate one to another, to ask questions, or add comments (Rubinstein & Firstenberg, 1987).

In the storage or retention phase, the information is filed for future use. New information should be assimilated with knowledge already in memory so that it can more effectively be retrieved (Rubinstein & Firstenberg, 1987).

In the retrieval phase, the information is retrieved out of storage as needed. Two methods of information retrieval are recall and recognition. Recall brings forth "to be remembered" information while recognition involves choosing from groups of possible answers (Schulz & Ewen, 1988).

Learners should engage in the active retrieval of information (Rubinstein & Firstenberg, 1987). The more demanding the effort to retrieve the information, the easier it becomes to retrieve the

information the next time it is needed. Retrieval is a potent learning device and is often better than listening to another presentation of the material. Searching memory for information has been shown to be beneficial even if the target information is not accessed (Rubinstein & Firstenberg, 1987).

The human memory has a built in monitoring system (Rubinstein & Firstenberg, 1987). When questions are asked of memory, the monitoring procedures analyze whether the relevant information exists, whether it is likely to have been stored, how much effort will be required to retrieve it, and the chances of success in finding the information. The monitoring system does not waste time looking for things it does not know. Rubinstein and Firstenberg (1987) further state that the memory monitoring system can also judge the cost of retrieving information that is difficult to find. Because the monitoring system knows what the knowledge base contains and what it does not, the memory monitor can handle the deluge of incoming information by concentrating on the novel, unique, heretofore unknown aspects of the environment (Rubinstein & Firstenberg, 1987).

The monitoring system that regulates the human memory also serves another purpose. It analyzes the information that is in memory storage to decide whether it is relevant and appropriate for the situation dictated by the circumstances of the problem. The operation of the memory monitor is as important as the actual storage and retrieval of information in memory (Rubenstein & Firstenberg, 1987).

The context in which a problem is framed influences the solutions that the problem solver considers (Rubinstein & Firstenberg, 1987). Context also has a profound effect on memory. The context in which knowledge is acquired is stored in memory together with the target material, and it can later serve as a guide to retrieval. A range of contextual clues has been shown to be beneficial even when the target information is not accessed. Rubinstein & Firstenberg (1987) state that new information which may be used in unknown future circumstances, should be studied in a variety of contexts. This increases the likelihood of a contextual match with the future recall environment.

Memory is crucial to problem solving. If one has no memory of past experiences or facts, one cannot call upon previously acquired information to solve the problem. Problem solving involves the assimilation of new knowledge and procedures with that of previously acquired knowledge, experiences, and procedures.

Scheme theory describes how knowledge is packaged and organized in long-term memory and how this packaging facilitates the use of knowledge in particular ways (Merriam & Caffarella, 1991). Schemata are not passive storehouses of experience; they are active processes whose primary function is to provide a basis for the assimilation of new information (Merriam & Caffarella, 1991).

Merriam and Caffarella (1991) state that there are two types of knowledge identified when categorizing schematic types. Declarative knowledge is what we know about things and often is represented as facts. Procedural knowledge is our knowledge about how to perform various skills and tasks (Merriam & Caffarella, 1991).

Merriam and Caffarella (1991) further state that there are three different modes of learning which fit the scheme framework: accretion, tuning, and restructuring. Accretion is the daily accumulation of information that is usually equated with learning facts. Tuning includes the slow and gradual changes in current schemata. Restructuring involves both the creation of new schemata and reorganization of those already stored (Merriam & Caffarella, 1991).

In most problem solving situations, one tries to fit new ideas (declarative knowledge) into earlier patterns of thinking and doing (one's current schemata). If one is unable to change their earlier thought patterns (fine tune or restructure them), their chances of being able to frame and act on problems from a different perspective is remote if not impossible (Merriam & Caffarella, 1991).

Problem Solving Models

Polya's Problem Solving Model

George Polya was one of the original researchers in the area of problem solving instruction. His problem solving model was one of the first developed and is still considered to be an appropriate approach to problem solving instruction. George Polya spent years showing teachers how to teach mathematics, focusing specifically on those kinds of helps that guide people toward insight into problem solutions (Resnick & Ford, 1981). Polya's questioning technique is designed to help both teachers and students solve problems (Greenfield, 1987).

Polya's problem solving model has four stages. Woods (1987) summarizes these four stages as: Define, Plan, Do It, and Look Back. Each stage asks specific questions of the problem solver or prompts the problem solver to think further on an issue. According to Greenfield (1987),

The first stage is understanding the problem. Questions asked in the first stage are: What is the unknown? What are the data? What is the condition? The second stage is devising a plan. Questions asked during the second stage are: Do you know a related problem? Look at the unknown! Here is a problem related to yours and solved before. Could you use it? The third stage is carrying out the plan. The prompts given in the third stage are: Carry out your plan of solution. Check each step. The fourth stage is looking back. The questions asked during the fourth stage are: Can you check the result? Can you check the argument? (p. 10).

Resnick and Ford (1981) state that Polya's hints encourage the problem solver to reconsider the goals of the problem, search memory for a similar problem solved before, and analyze the materials or givens of the problem. These hints may be helpful in promoting problem reformation and goal analysis that appear to facilitate the emergence of problem insight (Resnick & Ford, 1981).

The Role of the Teacher

According to Polya (1945) helping students demands time, practice, devotion and sound principles. Polya (1945) states that the teacher should help the student naturally. The teacher should put himself in the student's place, see the student's case, and try to understand what is going on in the student's mind. The teacher should then ask a question or indicate a step that could have occurred to the student (Polya, 1945).

According to Polya (1945), there are two aims which the teacher should have in view when addressing a question or a suggestion to students. First, to help the student to solve the problem at hand. Second, to develop the student's ability so that the student may solve future problems alone (Polya, 1945).

The teacher who wishes to improve students' ability to solve problems must instill some interest for problems into their minds and give the students plenty of opportunities for imitation and practice. If the teacher wishes to develop in students the mental operations for problem solving, the teacher uses questions and suggestions from Polya's model frequently.

When the teacher solves a problem before the class, they should dramatize their ideas a little and should ask themselves the same questions that they ask the students (Polya, 1945). From such guidance, the student will eventually discover the right use of these questions and suggestions (Polya, 1945).

Questioning

The teacher should begin with general questions or suggestions from Polya's model. If it is necessary, the teacher should come down gradually to more specific and concrete questions or suggestions until the teacher reaches a question which elicits a response in the student's mind. The suggestion must be general, applicable not only to the present problem but to problems of all sorts, if the suggestion is to help develop the ability of the student and not just a special technique (Polya, 1945).

Polya's list of questions is short so that the questions may be repeated often under varying circumstances; thus, there is a chance that they will be eventually assimilated by the student and will contribute to the development of a mental habit (Polya, 1945).

Polya's questions are not restricted to any subject matter. The questions are generally applicable and can be asked when dealing with all sorts of problems. The questions make sense and might help the students to solve the problem (Polya, 1945). Polya (1945) further states that the questions are natural, simple, obvious, and proceed from plain common sense.

Understanding The Problem

There are four divisions to Polya's problem solving model. First, one has to understand the problem; one has to see clearly what is required. Second, one has to see how the various items are connected, how the unknown is linked to the data in order to obtain the idea of the solution, to make a plan. Third, one must carry out the plan. Fourth, one looks back at the completed solution, reviews and discusses it (Polya, 1945).

Polya (1945) states that it is foolish to answer a question one does not understand. If the student is lacking in understanding or in interest, it is not always the student's fault. The problem should be well chosen, not too difficult and not too easy, natural and interesting, and some time should be allowed for natural and interesting presentation (Polya, 1945).

The teacher should ask the student to repeat the problem statement and the student should be able to state the problem

fluently. The student should also be able to point out the key parts of the problem, the unknown, the data, the condition (Polya, 1945)

The student should consider the main parts of the problem attentively, repeatedly and from various sides (Polya, 1945). If there is a figure connected with the problem, the student should draw a figure and point out on it the unknown and the data. The teacher might also ask the students if it is possible to satisfy the condition of the problem.

Devising a Plan

The way from understanding a problem to conceiving a plan may be long and tortuous (Polya, 1945). The main achievement in the solution of a problem is to conceive the idea of a plan. Polya (1945) further states that the idea may emerge gradually, or as a bright idea. The best the teacher can do is to help the student procure an idea. Good ideas are based on past experience and formerly acquired knowledge. Mere remembering is not enough for a good idea. The student must be able to recollect some pertinent facts concerning the problem. The teacher might want to ask the student to look at the unknown and try to think of a familiar problem having the same or a similar unknown (Polya, 1945).

In trying to apply various known problems or theorems, considering various modifications, experimenting with various auxiliary problems, the problem solver may stray so far from the original problem that he is in danger of losing it altogether (Polya, 1945). Polya further states that there is a good question that may bring the problem solver back to the original problem. The

instructor should ask the student if they used all of the data and if they used the whole condition.

Carrying Out the Plan

To devise a plan or to conceive the idea of the solution is not easy. It takes much to succeed; formerly acquired knowledge, good mental habits, concentration upon the purpose, and good luck (Polya, 1945). To carry out the plan is much easier. What the problem solver needs is patience.

According to Polya (1945), if the student has really conceived a plan, the teacher now has a relatively peaceful time. The main danger is that the student forgets his plan. The teacher must insist that the student should check each step (Polya, 1945).

Looking Back

The problem solver can further his ability in problem solving in the final stage of Polya's model. By looking back, reconsidering, and reexamining the solution and the path that led to it, the problem solver can consolidate his knowledge and develop his ability to solve problems (Polya, 1945). Polya (1945) further states that a good teacher should understand and impress on students the view that no problem is ever completely exhausted. There remains always something to do. Polya (1945) further states that one can improve any solution and always improve the understanding of the solution. The teacher should ask the students to check their results and their argument (Polya, 1945).

Resnick and Glaser's ProblemSolving Model

The classical literature on problem solving has directed much of its attention to tasks that require the invention or construction of a new strategy or material object (Resnick & Glaser, 1976). In these tasks a tool, physical or intellectual is produced. Materials or processes are combined to make available something that had not existed before. The behavioral and technical capabilities of the problem solver are enlarged through processes of cognitive and physical assembly of prior elements (Resnick & Glaser, 1976).

In many invention tasks, objects are combined or assembled in ways to produce new and useful objects (Resnick & Glaser, 1976). Other invention problems are more cognitive in nature, with the problem solver not necessarily engaging in physical manipulation, but with the same combination of processes at work, based on past experience and knowledge, as well as, current tasks demands (Resnick & Glaser, 1976).

According to Resnick and Glaser (1976) successful problem solvers have gained a new competence when they solve an invention problem. They can do or make something they were unable to do or make before. They have learned something new. Further, they have managed this on their own, or with minimal external help. Thus, they have engaged in learning in the absence of instruction. Lastly, in all of the problems the solutions are built out of information or partial solution routines already in the individuals' capabilities (Resnick & Glaser, 1976).

Using information processing constructs, Resnick and Glaser (1976) describe problem solving as a process of encoding a problem by building a mental representation in working memory (WM), and then searching long term memory (LTM) for a stored routine relevant to the problem as formulated. If a routine that works under the present conditions of the task environment (TE) is not found, further features of the task environment may be noted or the immediate goal of the problem solving activity redefined so that routines not previously recognized as relevant or useable to the problem now become available. Resnick and Glaser (1976) describe this problem solving model in terms of three processes: 1) problem detection, 2) feature scanning, and 3) goal analysis (Resnick & Glaser, 1976).

Problem Detection

The first process in Resnick and Glaser's problem solving model is problem detection. The first step in problem detection is to build a mental representation of the problem (Resnick & Glaser, 1976). The features of the problem are encoded so that they can be interpreted by the information processing system. Different representations have the power to call up different facts and procedures from one's long term memory. This in turn will affect the solution process and the likelihood of success (Resnick & Ford, 1981).

After encoding the problem, the problem solver has established a goal in working memory (WM). Resnick and Glaser (1976) state that long term memory (LTM) is searched for a routine encoded as relevant to the immediate problem solving goal. If such a routine is found, a

test is made to determine if the conditions required for carrying out the routine are present. If the answer is yes, the routine can be performed and tested for success in meeting the problem solving goal. If successful, the problem is "solved", but in fact it was not really a true problem to begin with since a routine was readily available in long term memory. If no routine is found relevant to the problem in long term memory, a problem is automatically recognized (Resnick & Glaser, 1976).

A problem is also defined when a possible solution may have been found in working or long term memory and the conditions for running it cannot be met or the action was not successful. In each case, a problem would be defined. This definition constitutes a new goal or a new encoding of the situation (Resnick & Glaser, 1976).

Feature Scanning

The second problem solving process in Resnick and Glaser's model is feature scanning. After a problem is detected and no immediate applicable or successful routine for the problem solving goal as initially represented is found, the problem solver begins to scan the environment searching for clues. This is an idea getting phase, a mapping of the environment, and a highly heuristic and partly random activity. It is often influenced by what first falls to hand or eye. Coupling with the scanning of the physical environment, there is frequently a questioning of the experimenter concerning the nature of the task requirements and restrictions on what can be done (Resnick & Glaser, 1976).

The problem solver notices a feature in the task environment which may be verbal, an object, a picture, or a symbol (Resnick & Glaser, 1976). Long term memory is scanned for any item that can be linked to the task environment feature. If a link is found in long term memory which has relevance to the problem solving goal, the solution is tested for applicability under present conditions and tested for success (Resnick & Glaser, 1976). There is a constant interplay between the problem detection phase and the feature scanning activities in problem solving. The task environment may be scanned many times before a link in long term memory is located. Typically, a partial solution is found rather than a full solution. The partial solution information is kept in mind or stored temporarily in working memory as processing continues (Resnick & Glaser, 1976).

Resnick and Glaser's model leaves the inner workings of many processes unspecified, but the model directs attention to many important characteristics of the problem solving process. First, the problem solving process is extremely sensitive to the task environment. An initially empty working memory is modified by a scanning of actual present objects or verbal instructions. What enters working memory in this way may vitally affect the outcome of continuing problem solving efforts. Second, the process is characterized by a working back and forth between the current task environment and previously acquired knowledge resting in long term memory (Resnick & Glaser, 1976). Feature detection leads to recall; recalled items are tested for relevance to the current situation. What actually enter working memory is the result of this interaction.

Finally, it is evident that the capacity of working memory will vitally affect the problem solving process, by limiting how much of the information noticed in the task environment or accessed in long term memory can be kept accessible. Selective rehearsal strategies of some kind are thus likely to be crucial to successful problem solution (Resnick & Glaser, 1976).

Goal Analysis

The third process in Resnick and Glaser's problem solving model is goal analysis. Success or failure in previously mentioned problem detection and feature scanning routines are dependent on finding an item in long term memory that matches the current definition of the problem. If the initial problem solving goal does not produce a match in long term memory, the problem must be redefined and a new problem solving goal created before feature scanning activities can be initiated. Feature scanning alone does not ensure finding a routine in long term memory. Further redefinitions of the problem may be needed before noted links or routines in the problem solver's long term memory can be recognized as relevant (Resnick & Glaser, 1976).

An important point concerning goal analysis is that goals are continually being redefined as a function either of memory search, usefulness of recalled routines, or noticed features of the environment (Resnick & Glaser, 1976). However a goal is generated, the contents of working memory will eventually be modified. In addition, the task environment itself may be modified if actions performed result in a physical change in the presented stimuli. Goal

analysis can be thought to yield a "restructured" problem that permits use of already accessed routines or redirects the search for appropriate routines (Resnick & Glaser, 1976).

Facilitating Problem Solving

According to Resnick and Ford (1981), problem solving can be facilitated through instruction. First, instruction can ensure the presence of well-structured knowledge in the student's long term memory. This means teaching as much knowledge as possible given the age and ability of the student. The more facts, procedures, and relations that characterize a person's knowledge structure, the more likely that person is to invent or discover needed connections in problem solving (Resnick & Ford, 1981).

Instruction can also emphasize the role of the task environment as the primary stimulus for problem solving. To help students perform as good problem solvers, the instructor may want to design optimal task environments or experiences (Resnick & Glaser, 1976). However, in the normal course of life the student will most likely have to solve a problem in a less than optimal task environment. The burden of detecting relevant features, analyzing problems, and establishing appropriate goals rests with the individual student in real life situations.

When designing a good task environment or experience for problem solving, the instructor may want to include pictures or diagrams with the problem statement to give the student practice in solving problems for varied task environments. Students can also be taught to freely scan for features in the problem solving environment and

consider the connections each feature calls up. Students can learn to draw pictures or write down their thoughts when detecting a problem to create a richer task environment for which they can build a problem representation (Resnick & Ford, 1981).

A Critique of Resnick and Glaser's Model

Resnick and Glaser admit that they have not followed their problem solving model completely through to the instructional stage. Resnick and Glaser have made implications for future research. Resnick and Glaser (1976) state that a job ahead is to devise means of instructing people in the processes they have hypothesized as general to problem solution, and to evaluate the effects of such instruction across a variety of task environments. Similar efforts with respect to teaching generalized strategies of problem detection and heuristics of feature scanning are also required next steps (Resnick & Glaser, 1976).

Flavell (1976) offers a critique of Resnick and Glaser's problem solving model. Flavell (1976) suggested that Resnick and Glaser follow their own prescriptions about how to solve problems. They should make their goals as clear and specific as possible and try to make each experiment tell them something they really want to know concerning these goals.

Flavell (1976) also suggested that Resnick and Glaser not be so exclusively oriented toward external behavior and external environments. Flavell further stated that the correspondence between Resnick and Glaser's information processing flow diagrams and

cognitive reality should not be overestimated. Lastly, Flavell (1976) recommended that Resnick and Glaser devise problem situations which are more naturalistic than the school type tasks they have been working with.

The Scientific Method Approach
to Problem Solving

The steps or stages of the scientific method vary from author to author. There is no one scientific method, however, there is what is considered to be a scientific approach to problem solving. The scientific approach is a systemized form of reflective thinking and inquiry (Kerlinger, 1986).

The scientific method approach to problem solving has evolved over time. The first systematic approach to reasoning, attributed to Aristotle and the Greeks, was the deductive method (Best, 1981). The categorical syllogism was one model of thinking that prevailed among early philosophers. Syllogistic reasoning established a logical relationship between a major premise, a minor premise, and a conclusion. A major premise is a self-evident assumption, previously established by metaphysical truth or dogma, concerning a relationship; a minor premise is a particular case related to the major premise. Given the logical relationship of these premises, it leads to an inescapable conclusion (Best, 1981). A typical Aristotelian categorical syllogism is as follows: Major Premise....All men are mortal. Minor Premise....Socrates is a man. Conclusion....Socrates is mortal (Best, 1981).

The deductive method, moving from the general assumption to the specific application, made an important contribution to the development of modern problem solving. The deductive method was not helpful to problem solvers in arriving at new truths (Best, 1981). The acceptance of incomplete or false major premises based on old dogmas or unreliable authority lead to error. Semantic difficulties often resulted from shifting definitions of the terms involved (Best, 1981).

Francis Bacon advocated the application of direct observation of phenomena, arriving at conclusions or generalizations through the evidence of many individual observations (Best, 1981). This inductive process of moving from specific observations to the generalization freed logic from some of the hazards and limitations of deductive thinking (Best, 1981).

The deductive method of Aristotle and the inductive method of Francis Bacon were fully integrated in the work of Charles Darwin in the nineteenth century (Best, 1981). The use of both deductive and inductive reasoning is characteristic of the scientific approach. The steps of the scientific approach are not neatly fixed. The problem solver may move back and forth between steps throughout the problem solving process.

John Dewey suggested a series of steps that are helpful in identifying the elements of a deductive-inductive process: 1) Identification and definition of the problem, 2) Formulation of a hypothesis, 3) Collection, organization, and analysis of data, 4) Formulation of conclusions, and 5) Verification, rejection, or modification of the hypothesis by the test of its consequences in a

specific situation (Dewey, 1933). Kerlinger (1986) describes the steps of the scientific method as follows: 1) Problem-Obstacle-Idea, 2) Hypothesis, 3) Reasoning-Deduction, and 4) Observation-Test-Experiment.

Killeffer (1969) offers another interpretation of the steps involved in the scientific method: 1) Consciousness of a problem, 2) Stating the problem, 3) Assembling the elements of a solution, 4) Choosing from these and combining them into a solution, and 5) Subjecting the solution to trial to prove whether or not it is a valid solution.

Killeffer's interpretation of the scientific method takes more of a problem solving approach and lends itself well to the discussion of problem solving models. Killeffer (1969) views the scientific method as an exercise in creative thinking. He further states that millions of everyday problems, great and small, cease to be problems when one applies creative thinking and imagination to them (Killeffer, 1969, p.1). According to Killeffer (1969), Socrates taught his disciples that creative thinking can only begin when and if the thinker senses and recognizes a problem, a stimulus, a "thorn in the mind", and then decides to do something about it. Where there is no problem, there is no incentive to think about it or to solve it. Only when a problem becomes irritating enough do we tackle its solution (Killeffer, 1969).

Once it is recognized a problem exists, the next step is to state the problem in such terms that one can handle it (Killeffer, 1969). An ambitious problem goal may baffle the problem solver and leave no reasonable problem to be tackled. The problem needs to be

further broken down so that the problem solver can grasp it clear enough to plan a way to achieve the desired result (Killeffer, 1969). The problem must be stated in such terms that one can solve it.

There are many resources that can be used to help the problem solver state the problem. According to Killeffer (1969) the problem solver can exercise his creative faculties: a) by drawing on his own experiences; b) by tapping the accumulated experiences that others have stored in books and papers in libraries; c) by observing events that happen around us and bearing upon the general field of the problem; d) by seeking out situations that are similar and have been solved; e) by conducting experiments of a kind that will give answers to some or all of the questions that arise in the problem solver's mind about the major problem; and f) by discussing all or parts of the major problem with others having experiences that will help along the way. Each added bit of information bearing on the search may allow the problem solver to restate the problem in new terms that will be a little easier to handle (Killeffer, 1969).

The next step in Killeffer's scientific method approach is to choose suitable bits of information from the resources available to the problem solver and assemble them in new combinations that solve the problem. The successive steps in the solution of any problem follow the pattern commonly described for promoting original thought. The steps are: 1) Accumulate all possible facts bearing upon the problem in hand. Study them and impress them on the mind; 2) Digest and synthesize these facts into a solution, either complete and final, or interim and representing a stage of progress toward the ultimate solution. Few problems can be solved at one trial and hence

piecemeal solution are the rule; 3) Repeat these steps alternately as often as necessary, with each repetition appropriately modifying the operation to take into account each bit of progress, however small, that has been made before (Killeffer, 1969).

At the very beginning, or at any stage in the search, one may be able to form a hypothesis, or a theory, about the problem and its solution that can become a road map to guide the way ahead (Killeffer, 1969). What one learns as they proceed may very well change their ideas about the problem and require the problem solver to revise or replace the road map that served well before (Killeffer, 1969).

The final step according to Killeffer's interpretation of the scientific method is testing the solution of the problem. Killeffer does not offer much instruction as to how to go about conducting a test of the problem solution. According to Kerlinger (1986), if the problem has been well stated, the hypothesis or hypotheses adequately formulated, and the implications of the hypotheses carefully deduced, the testing phase of the hypothesis or solution is almost automatic, assuming that the investigator is technically competent (Kerlinger, 1986).

The thinking part of the scientific method and its core is the methodical progression from a problem to a solution (Killeffer, 1969). The step-by-step confirmation or revision of thinking about the problem is the basis of the scientific method. It recognizes varying degrees of accuracy and of confirmation of ideas, and it revises and progressively narrows the hypothesis, or theory, to increase its value. Killeffer (1969) states that if one ignores or

neglects these basic concepts of the scientific method, then the methods of research become inscrutable. In the light of them, one can see significant patterns in the solution of problems, great and small (Killeffer, 1969).

The Workplace Skill Approach
to Problem Solving

Carnevale, Gainer, and Meltzer (1990) identified problem solving as a basic skill essential to the worker in order to succeed in the workplace. They have identified skills which can be developed in order to improve the problem solving abilities of students who will become workers.

Everyone, whether alone or as a member of a group, experiences problems at one time or another. According to Carnevale et al. (1990), a person realizes that a problem exists when he or she feels frustration, anger, fright, or anxiety about a situation. In the workplace, problems within groups are evident when output or productivity is not what it should be, when communication and cooperation seem to be lacking, or when conflict appears to be out of control (Carneval et al., 1990).

Carneval et al., (1990) state that there are three general ingredients of successful problem solving: skill in individual problem solving, skill in group problem solving, and practical ability in combining individual and group skills (Carnevale et al., 1990). Problem solving techniques are based on a variety of theoretical propositions that explain how individuals and groups

process information in the identification, analysis, and solution of problems (Carnevale et al., 1990).

Training techniques for improving individual problem solving capabilities usually involve: 1) building a person's awareness of his or her own problem solving style, 2) developing a person's awareness of the effect that individual style has on other people, and 3) applying techniques tailored to individual styles and capacities for improved problem solving ability (Carnevale et al., 1990).

Strategies for improving group problem solving capabilities are founded on individual skill building techniques (Carnevale et al., 1990). Such strategies also address the need to create group appreciation for the individual problem solving styles of others, examine group processes that inhibit problem solving, and encourage group acceptance and use of diverse problem solving styles (Carnevale et al., 1990).

Individual Problem Solving Skills

Some people are better problem solvers than others in part because of their superior ability to identify and analyze a problem's source (Carnevale et al., 1990). Carnevale et al. (1990) further state that in most cases, more experience is what makes a master problem solver out of a competent one. Experience provides informal learning in the art of problem solving and is not the most effective teacher. Unstructured learning is slow, haphazard, and constrained by a person's individual interaction with the daily environment and individual prior history (Carnevale et al., 1990).

Structured learning in a work related context takes advantage of a person's prior knowledge and experience to validate familiar processes as they are applied to new problems, but it is not constrained by them (Carnevale et al., 1990). Such learning is reproducible and consistent among many levels of learners and is systematic (Carnevale et al., 1990).

According to Carnevale et al. (1990) training for improved problem solving skills usually involves two skill categories: individual cognitive abilities and group interaction skills. Individual cognitive abilities are in a broad category of learned abilities that involve many essential skills and processes.

Carnevale et al. (1990) state that a problem solver needs to understand classification, the thinking skill of placing items in categories or classes on the following bases:

Order: understanding of the sequence or arrangement of things and ideas.

Structure: understanding of the interrelationships of parts of a whole.

Relation: understanding of how things affect one another (pp. 170-171).

A person also needs skills that relate to levels and points of view. Levels represent the ability to change the focus of analysis to increase one's depth of understanding. Points of view represent the ability to gain insight by experiencing alternative perspectives (Carnevale et al., 1990).

According to Carnevale et al. (1990) other essential problem solving skills involve the following:

Deductive Thinking: the process of drawing a specific conclusion from a set of general observations.

Inductive Thinking: the process of drawing a general conclusion from a set of specific facts.

Lateral Thinking: the formation of new relationships among existing ideas. This skill often requires the suspension of logic to facilitate new paths of analysis.

Dialectic Thinking: the ability to maintain different points of simultaneously. This skill requires a tolerance for ambiguity and the capacity to withhold judgement until all information is gathered and evaluate.

Unfreezing and Reframing: the ability to come to terms with the unsatisfactory aspects of a particular situation to free oneself to examine faulty assumptions, and the ability to create a situation. Reframing may involve a change in context, interpretation, a meaning, and so on - - to discover the validity and pertinence of their underlying assumptions.

Critical/ Reflective Thinking: individual effort to widen viewpoints and examine underlying assumptions that may be limiting (pp. 171-172).

Group Problem Solving Techniques

The second category of elements essential to the development of problem solving skills arises in group settings. Workplace productivity and product quality are related to the ability of both formal and informal work teams. Carnevale et al. (1990) recommend the following techniques for facilitating group problem solving:

Brainstorming: Encourages the generation and sharing of ideas and information in a nonthreatening atmosphere. Brainstorming helps uncover ideas and facts in situations where complexity or other restraints would ordinarily inhibit free discussion. The technique promotes people's free exploration of new ideas and possible solution without fear of criticism.

Synectics: Provides an environment that encourages creative but guided approaches to problem solving. Synectics is characterized by clearly defined roles for a leader, clients, and participants; techniques for detaching participants' minds from consciously thinking about a problem, thereby allowing their unconscious minds the freedom to explore possible solutions; and specific ways of reflecting on ideas.

Nominal Group Technique: Used in a structured problem solving process specifically designed for use in situations where a lone person is unlikely to be able to arrive at a solution. It quickly achieves results because it forces problem identification or a solution through the use of a quiet time for generating new ideas, followed by a force interaction period. The facilitator does not need extensive experience, and the technique provides an opportunity for each person to become involved because the leader encourages open discussion and clarification.

Systems Analysis: An excellent technique to use when a review of a problem's total context is called for, as opposed to times when a problem seems to be an isolated element.

Force Field Analysis: A process used to identify the dimensions of a problem and strategies for solving it. Two main sets of forces are identified: inhibiting forces that resist the problem's resolution and facilitating forces that push the problem toward resolution (pp. 173-174).

A Generic Problem Solving Model

Individual and group skills in problem solving are necessary but not sufficient for the successful practice of problem solving in the workplace. Both individuals and groups need a structure to follow in using their skills. There are many problem solving models. Most problem solving processes fit into a generic model that can be replicated with good results no matter what the problem is (Carnevale et al., 1990). As individuals and groups become more skillful in problem solving techniques, they may only need to carry out one or two of the generic models steps to manage a problem (Carnevale et al., 1990).

Carnevale et al. (1990) state that the first step in a generic problem solving model is problem analysis. A problem exists and it is necessary to define it accurately. Accurate problem

identification is often difficult because symptoms may be confused with causes. One way to improve problem identification skills is to emphasize the gathering of information that shows not only the existence of a problem but also its nature and extent (Carnevale et al., 1990).

The second step in the generic problem solving model is the discussion and analysis of assumptions (Carnevale et al., 1990). Each person brings a set of assumptions to each problem solving situation. The quality of the solutions generated is affected by the appropriateness of the assumptions. These assumptions may be structural assumptions related to the problems' context; personal assumptions unique to the individuals experience and personality; and problem assumptions related to such things as the problems' importance, its political implications, and ones' anticipation of management's acceptance or rejection of solutions (Carnevale et al., 1990).

The third step in the generic problem solving model is the identification of tentative alternative solutions. This is a repetitive process in which people are encouraged to identify and assess a wide range of solutions. Skills and techniques that come into play include skills for innovation, creativity, and brainstorming (Carnevale et al., 1990).

The fourth step in the generic problem solving model is alternative solution evaluation. Evaluating involves measuring against predetermined standards and criteria, the rationality, acceptability, and the reasonableness of the tentative solutions (Carnevale et al., 1990).

The fifth step in the generic problem solving model is selection, implementation, and feedback. One or more of the solutions may be selected for implementation. The two most important requirements for success at this point are: 1) management-employee commitment to implementation; and 2) continuation of the problem solving process to ensure desired results and to solve new problems that may arise (Carnevale et al., 1990).

Competency and Mastery in

Problem Solving

Carnevale et al. (1990) have identified a list which can be used to determine individual and group competency in problem solving.

Competency includes the ability to do the following:

Represent a problem (identify and define the problem in a way that allows for solution)

Apply logic (analyze a problem's structure in a way that allows appropriate data to be obtained)

Formulate a solution (devise a solution on the basis of available data)

Create a feedback mechanism (monitor a solution effectively to evaluate its implementation)

Provide summative evaluation (assess the final outcome in comparison with the original problem)

(p. 182)

Carnevale et al. (1990) have identified a list which can be used to determine individual and group mastery in problem solving.

Mastery includes the ability to do the following:

Redefine/reframe a problem (determine if the appropriate problem has been identified and addressed)

Analyze underlying assumptions (identify the underlying factors that affect framing of the problem and its possible resolution)

Suspend logic (consider counterintuitive approaches)

Put the problem in a systems perspective (project at each stage to the intermediate and final outcomes)

Provide formative evaluation [conduct ongoing evaluation of the process at each stage] (p. 182)

Carnevale, Gainer, and Meltzer's (1990) approach to problem solving stems from their research on basic skills needed by workers to succeed in the workplace. Problem solving is but one of the basic workplace skills Carnevale et al. (1990) have identified as an essential workplace skill.

The Cognitive Apprenticeship

Problem Solving Model

Cognitive apprenticeship is a rethinking of teaching and learning in school based on some of the concepts of traditional apprenticeship. Cognitive apprenticeship is aimed primarily at teaching the processes that experts use to handle complex tasks. The cognitive apprenticeship model is a good model for instructors to follow in order to develop problem solving skills in their students. In cognitive apprenticeship, conceptual and factual knowledge are exemplified and situated in the contexts of their use. According to Collins, Brown, and Newman (1989), conceptual and factual knowledge are learned in terms of their uses in a variety of contexts, encouraging both a deeper understanding of the meaning of the concepts and facts themselves and a web of memorable association between them and problem solving contexts (Collins, Brown, & Newman, 1989).

According to Collins et al. (1989), the term cognitive apprenticeship refers to the focus of the learning-through-guided-experience on cognitive and metacognitive, rather than physical, skills and processes. Applying apprenticeship methods to skills that are not always visually observable and are considered to be largely cognitive skills, means that ways have to be found to externalize processes that are usually carried out internally (Collins, et al, 1989).

In traditional pedagogical classroom instruction, teachers cannot make fine adjustments in students' application of skill and knowledge to problems and tasks, because they have no access to the students cognitive processes. By the same token, students do not usually have access to the cognitive problem solving processes of instructors as a basis for learning through observation and mimicry (Collins et al., 1989).

Berryman and Bailey (1992) state that the term cognitive should not be read to mean "academic". The cognitive apprenticeship model ignores the usual distinctions between academic and vocational education, in that its objective is to induct the novice into communities of expert practice, whether the practice is academic or vocational. The model presumes that learning is learning (Berryman & Bailey, 1992).

Collins et al. (1989) found that there are two major differences between traditional apprenticeship and cognitive apprenticeship. First, since traditional apprenticeship is set in the workplace, the problems and tasks that are given to learners arise not from pedagogical concerns but from the demands of the workplace.

Cognitive apprenticeship, differs in that the tasks and problems are chosen to illustrate the power of certain techniques or methods, to give students practice in applying these methods in diverse settings, and to increase the complexity of tasks slowly, so that component skills and models can be integrated. In short, tasks are sequenced to reflected the changing demands of learning. Letting the job demands select the tasks for students to practice is one of the great inefficiencies of traditional apprenticeship (Collins, Brown, & Newman, 1989).

The second difference between cognitive and traditional apprenticeship is the emphasis in cognitive apprenticeship on decontextualizing knowledge so that it can be used in many different setting (Collins et al., 1989). Traditional apprenticeship emphasizes teaching skills in the context of their use. Cognitive apprenticeship extends situated learning to diverse settings so that students learn how to apply their skills in varied contexts. Moreover, the abstract principles underlying the application of knowledge and skills in different settings should be articulated as full as possible by the teacher whenever they arise in different contexts (Collin et al., 1989).

The cognitive apprenticeship model has four dimensions which constitute the learning environment: content, method, sequence, and sociology. Within each of these dimensions is a set of characteristics that should be considered in constructing or evaluating learning and problem solving environments.

Content

The content dimension teaches strategic knowledge. This refers to the tacit knowledge that underlies an expert's ability to make use of concepts, facts, and procedures necessary to solve problems and carry out tasks. This kind of expert problem solving knowledge involves problem solving strategies and heuristics, and the strategies that control the problem solving process.

Within the content dimension are four types of knowledge which should be taught: domain knowledge, heuristic knowledge, control strategies, and learning strategies. Domain knowledge is the conceptual, factual, and procedural knowledge typically found in textbooks and other instructional materials. Heuristic knowledge is considered to be the "tricks of the trade" or "rules of thumb" that often help narrow solution paths. Control strategies are necessary in order for students to monitor and regulate their problem solving activity (Wilson & Cole, 1991). Control strategies contain monitoring, diagnostic, and remedial components. Control strategies are often referred to as metacognition. According to Flavell (1976) metacognition refers to one's own knowledge concerning ones' own cognitive processes and products. Many people define metacognition as "thinking about thinking". Learning strategies are strategies for learning domain knowledge, heuristic knowledge, or control strategies. Knowledge about how to learn ranges from general strategies for exploring a new domain to more local strategies for extending or restructuring knowledge as the need arises in solving problems or carrying out a complex task (Collins, et al., 1989; Berryman & Bailey, 1992).

Method

The second dimension in the cognitive apprenticeship model is method. Six teaching methods are recommended. Modeling, coaching, and scaffolding form the core of cognitive apprenticeship. These three methods help the student to acquire an integrated set of cognitive and metacognitive skills through processes of observation and of guided and supported practice. Articulation and reflection are methods designed to help students both focus their observations of expert problem solving and gain conscious access to and control of their own problem solving strategies. The final method, exploration, is aimed at encouraging learner autonomy, not only in carrying out expert problem solving processes, but also in defining or formulating the problems to be solved (Collins et al., 1989; Berryman & Bailey, 1992).

Modeling requires the expert to carry out a task so that students can observe and build a conceptual model of the processes that are required to accomplish the task. In cognitive domains a teacher would need to externalize usually internal processes and activities. The teacher would verbalize her thought processes to the students (Collins et al., 1989; Berryman & Bailey, 1992).

Coaching consists of observing students while they carry out a task and offering hints, scaffolding, feedback, modeling, reminders, and new tasks aimed at bringing their performance closer to expert performance. The content of the coaching interaction is immediately related to specific events or problems that arise as the student

attempts to carry out the target task (Collins et al., 1989; Berryman & Bailey, 1992).

Scaffolding refers to the supports the teacher provides to help the student carry out a task. When scaffolding is provided by a teacher, it requires the teacher to carry out parts of the overall task that the student cannot yet manage. It involves a kind of cooperative problem solving effort by teacher and student in which the express intention is for the student to assume as much of the task on his own as possible, as soon as possible (Collins et al., 1989; Berryman & Bailey, 1992).

Articulation is the method of getting students to articulate their knowledge, reasoning, or problem solving processes. Inquiry teaching is a strategy of questioning students to lead them to articulate, question, and refine their knowledge. Teachers should encourage students to articulate their thoughts as they carry out their problem solving. Teachers should also have the students assume the critic or monitor role in cooperative activities which lead the students to formulate and articulate their knowledge of problem solving and control processes (Collins et al., 1989; Berryman & Bailey, 1992).

Reflection enables students to compare their own problem solving processes with those of an expert, another student, and ultimately, an internal cognitive model of expertise. Reflection is enhanced by the use of various techniques for reproducing or replaying the performances of both expert and novice for comparison (Collins et al., 1989; Berryman & Bailey, 1992).

Exploration involves pushing students into a mode of problem solving on their own. Exploration as a method of teaching sets general goals for students and then encourages them to focus on particular subgoals of interest to them or even to revise the general goals as they come upon something more interesting to pursue. The goal is to find general tasks that students will find interesting and to turn them loose on them, after they have acquired some basic exploration skills (Collins et al., 1989; Berryman & Bailey, 1992).

Sequence

The third dimension of the cognitive apprenticeship model is sequence. Teachers need to recognize the changing learning needs of students at different stages of skill acquisition; and consequently, sequence and structure materials and activities for students appropriately for each of those stages. Proper sequencing of problem solving materials and activities includes increasing complexity, increasing diversity, and teaching global before local skills (Collins et al., 1989).

Increasing complexity refers to the construction of a sequence of tasks and task environments where more and more of the skills and concepts necessary for expert performance are required. There are likely to be jumps in complexity as students learn and integrate the interrelated set of skills or activities necessary to carry out a task but also to manage and direct these activities. There are two methods for helping students manage increasing complexity. First, efforts should be made to control task complexity. The second method is to use scaffolding. Scaffolding enables the student to handle

with the support of the teacher or other helper, the complex set of activities needed to carry out any interesting task (Collins et al., 1989).

Increasing diversity refers to the construction of a sequence of tasks in which a wider and wider variety of strategies or skills are required. As the skill becomes well learned, it is important that tasks requiring a diversity of skills and strategies be introduced so the student learns to distinguish the conditions under which specific skills and strategies apply. As students learn to apply skills to more diverse problems and problem situations, their strategies become freed from their contextual bindings (Collins et al., 1989).

Teaching global before local skills refers to the sequencing of activities which provides the learner with a conceptual model of how all of the pieces of a garment fit together before attempting to produce the pieces. Having a clear conceptual model of the overall activity both helps the learner make sense of the pieces that he is carrying out and provides a clear goal toward which to strive as he takes on and integrates more and more pieces. A clear conceptual model of the target task acts as a guide for the learner's performance, thus improving his ability to monitor his own progress and to develop self-correction skills (Collins et al., 1989).

Learning Environment

The fourth and final dimension of the cognitive apprenticeship model is the sociology of the learning environment. Collins et al. (1989) have identified five characteristics associated with the sociology of learning environment. Situated learning is the first

characteristic of the learning environment. In situated learning, students carry out tasks and solve problems in an environment that reflects the multiple uses to which their knowledge will be put in the future. Students understand the purposes or uses of the knowledge they are learning. Students learn by actively using knowledge rather than passively receiving it. Students learn the different conditions under which their knowledge can be applied. Learning in multiple contexts induces the abstraction of knowledge, so that students acquire knowledge in a dual form, both tied to the contexts of its uses and independent of any particular context. This unbinding of knowledge from a specific context fosters its transfer to new problems and new domains (Collins et al., 1989).

The second characteristic of the learning environment is a culture of expert practice. The students actively engage in the skills involved in expertise, where expertise is understood as the practice of solving problems and carrying out tasks in a domain. A culture of expert practice helps situate and support learning in several ways. The culture provides learners with readily available models of expertise-in-use which helps the learners to build and refine conceptual models of the task they are trying to carry out. If expert modeling is to be effective in helping students to internalize useful conceptual models, experts must be able to identify and represent to students the cognitive processes they engage in as they solve problems. The culture of expert practice for learning should include focused interactions among learners and experts for the purpose of solving problems and carrying out tasks (Collins et al., 1989).

Intrinsic motivation is the third characteristic associated with the sociology of the learning environment. Students should perform tasks because they are intrinsically related to an interesting or a coherent goal, rather than an extrinsic reason. Students should attempt to carry out realistic tasks in the spirit and for the purposes that characterize adult expert practice (Collins et al., 1989).

The fourth characteristic is facilitating cooperation. Students work together through cooperative problem solving. Students are often able to help each other grasp the rationale and distinguishing characteristics of some new concept or skill because they are closer to the problem of learning about it. Students may have a better internal model of other students' difficulties and know how to address them because they have recently had the same or a similar difficulty themselves. Cooperative learning helps foster the situated articulation of process and concepts, thus helping students to gain conscious access to and control of cognitive and metacognitive processes and the ways these employ conceptual and factual knowledge (Collins et al., 1989).

Collins et al. (1989) state that the fifth characteristic is encouraging competition. Students are given the same task to carry out and each student's work is compared. Comparison provides a focus for students' attention and efforts for improvement by revealing the source of strengths and weaknesses. For competition to be effective, comparisons must be made not between the products of student problem solving, but between the processes. Some people believe that competition encourages behavior and attitudes that are socially

undesirable and even unethical. Some of the ill effects of competition can be reduced by blending cooperation and competition. Individuals might work together in groups to compete with other groups.

General Problem Solver Model

Most people believe that through experience in learning, one gets better at learning (Larkin, 1989). This belief reflects the idea that, when one has acquired knowledge in one setting, it should save time and perhaps increase effectiveness for future learning in related settings. Transfer means applying old knowledge in a setting sufficiently novel that it also requires learning new knowledge (Larkin, 1989). If there were no transfer, then solving problems in a new domain would require totally mastering a set of necessary new knowledge. To the extent that transfer occurs, some of this necessary knowledge is transferred from earlier experience and need not be learned. Because necessary knowledge is transferred from earlier experience and need not be learned, the usual measure of transfer is the difference in time required to learn a new task for learners with certain prior experience as opposed to other learners who lack this experience (Larkin, 1989).

Thorndike demonstrated in many experiments during the early 1900's that transfer is much less broad in scope, that learning in one domain does not necessarily strengthen the mind for learning in any other domain (Larkin, 1989). He proposed a theory of identical elements for transfer, saying that learning time in a second domain

will be decreased only if this domain shares some common elements with the domain learned earlier (Larkin, 1989).

According to Simon (1989), Thorndike's research and other studies of the same genre did not prove transfer impossible nor did they make such claims. These studies simply showed that certain specific kinds of instruction do not produce transfer (Simon, 1989).

Simon (1989) further states that in the past half-century much has been learned about the conditions that could make transfer possible. First, transfer from Task A to Task B requires that some of the processes or knowledge used in Task B be essentially identical with some of the processes or knowledge that have been learned while acquiring skill in Task A. Second, to secure substantial transfer of skills acquired in the environment of one task, learners need to be made explicitly aware of these skills, abstracted from their specific task content (Simon, 1989).

If it is common elements that account for transfer, than perhaps a set of these elements might be viewed as general problems solving skills, independent of any particular subject domain (Larkin, 1989). This view lies behind research and thinking in both human and machine problem solving.

Ernst and Newell (1969) developed one of the earliest computer programs used to solve problems. They called their computer program a general problem solver (GPS) because it explicitly separated knowledge used to solve problems in a variety of domains from knowledge applicable in just one domain. They suggested that a program like GPS could potentially solve problems in a large number

of domains with the addition of only a moderate amount of domain specific knowledge (Larkin, 1989).

During the decade of the mid-1950's to mid-1960's there was, in artificial intelligence, a striving toward general programs capable of performing in a wide range of task environments (Langley, 1989). The general problem solver was a product of that decade. In this program, processes like means-ends analysis and recognition by means of discrimination nets were identified as possible invariants of human cognition (Langley, 1989). GPS is used as a basis for many computerized problem solving systems. GPS could solve problems in a collection of domains from algebra and geometry to chess and simple puzzles. According to Larkin (1989) what is general in GPS is the following strategy:

1. Identify the major differences between the current situation (state) and the desired or goal state.
2. Then pick an operator that will reduce one or more of those differences.
3. If there are several such operators, choose the one with conditions that most closely match the current state.
4. If you can't apply that operator, set as subgoals achieving the conditions that would let you apply it (p. 23).

According to Larkin (1989) GPS begins by noticing the major difference between the current state and goal. This difference leads GPS to choose operators according to what differences between the goal and the current state they will reduce, and if the conditions of the current operator are not satisfied, then choosing set subgoals to satisfy them. What is specific are the particular operators, differences, and the connections between them (Larkin, 1989).

The logic behind the GPS is the application of a means-ends analysis (Larkin, 1989). One has a certain situation, one wants a different situation. One detects a difference between the two situations, and one searches memory for an operator that is relevant for reducing differences of this kind. One applies the operator and examines the resulting expression to see if the difference has been removed (Larkin, 1989).

Strategies of Expert Problem Solvers

Johnson (1989) has used cognitive task analysis to study how novices and experts troubleshoot problems in industrial settings. Johnson found very definite differences between expert and novice troubleshooters. The differences were: 1) the experts obtained more information from the initial problem symptoms than did the novices, 2) the experts were better able to select information and hypothesis that were within the true problem space, 3) the experts selected hypotheses that brought them closer to the fault while the novices appeared to generate hypotheses on a random basis. In addition to having their knowledge better organized than novices, experts were able to use their knowledge to form mental and physical representations of situations or problems that confront them (Johnson, 1989).

Johnson (1989) further found that an approach in technical instruction in electronics is to use schematic and wiring diagrams to describe the function and operation of a technical device. When trainees did not have a sufficient background in electronics to fully understand the abstract diagrams, they were unable to develop the

conceptual understanding of the system because of the complex abstract nature of the diagrams (Johnson, 1989).

Expert problem solvers appear to possess two skills which facilitate the problem solving process. The first skill the worker must have is the ability to mentally or internally picture information. This requires abstract thought on the part of the problem solver. The second skill the problem solver must have is the ability to physically or externally represent information. The problem solver should be able to interpret and construct information in the form of tables, graphs, diagrams, electronic text, or other symbols.

A weakness that students have in solving problems is that they do not actively construct mentally or on paper a representation of ideas described in text when such a representation could help them in understanding the material (Lockhead & Whimley, 1987). In problem solving, a change in the way the information is presented may create a form that is more compatible with human information processing capabilities. A diagram or graph may be more suitable than a verbal or mathematical expression. A new representation can make it easier to identify features that were not apparent before the change or that were not easy to see in earlier presentations (Rubinstein & Firstenberg, 1987).

Sternberg's (1986) triarchic theory of intelligence identifies the internal mental mechanisms that are responsible for intelligent behavior. These mental mechanisms are referred to as information processing components. Sternberg's three components of his theory are metacomponents, performance components, and knowledge-acquisition

components. Metacomponents are executive processes responsible for figuring out how to do a particular task or set of tasks, and making sure that the tasks are done correctly (Sternberg, 1986).

One of Sternberg's (1986) metacomponent skills is that of selecting a mental representation for information. An important part of many kinds of problem solving is the way or ways that information is represented mentally. Such mental representation might be in the form of a pictorial image, a set of propositions, an algebraic equation, or some other format. Mental models are a person's internal picture of some phenomenon that enables the person to understand it.

The possession of well-developed mental models has been shown to improve performance in a variety of cognitive tasks (Winn, Li, & Schill, 1991). Problems that could be solved easily using one form of mental representation are often solved only with difficulty or not at all using another. The problem solver's choice of representation may critically affect whether or not he is able to solve given problems correctly (Sternberg, 1985). Cognitive psychologists have identified the most challenging task in problem solving as the creation of an internal representation of the problem-solving situation (Woods, 1987).

Senge (1990) states that mental models are powerful in affecting what we do because they affect what we see. Two people with different mental models can observe the same event and describe it differently, because they have looked at different details. Senge (1990) further states that our mental models determine not only how we make sense of the world, but how we take action.

Sometimes it is necessary to supplement a mental representation with an external representation of the information. Mental models often have spatial properties and can be represented as diagrams (Winn, Li, & Schill, 1991). When solving a mathematics problem it might be helpful to draw a diagram or to set up a series of equations that represent the terms of the problem. Such diagrams can then facilitate the problem solving, especially the way in which one proceeds to represent information about the problem in his head (Sternberg, 1986).

External or physical representations reduce the amount of searching through information required to solve problems. According to Winn, Li, and Schill (1991), diagrams in which conceptual relationships are expressed through spatial arrangement permit more rapid problem solving than equivalent texts. Diagrams of familiar material allow students to use existing knowledge to solve problems and do not require the computation of solutions from rules (Winn, Li, & Schill, 1991).

Sternberg (1986) identifies steps that can be taken to increase one's skills to mentally represent problems. The first step for the learner is to know his pattern of abilities. Problems can sometimes be solved in alternate ways. Knowing one's pattern of abilities can help one choose the kind of representation that is optimal. If one is better at spatial tasks than linguistic tasks, one should choose a spatial mental representation. Conversely, if one is better at linguistic tasks than spatial, one should choose a linguistic mental representation. If one is equally adept at both kinds of tasks he many choose either option depending on the problem, or choose a mixed

strategy that uses both spatial and linguistic elements. If the learner knows his pattern of abilities, he is in a better position to use the kind of mental representation that is most convenient (Sternberg, 1986).

Sternberg's (1986) second step to increasing the skills of mental representation is to use multiple representations whenever possible. The advantage of using multiple representations is that even if they are formally equivalent, they may not be equivalent psychologically. Sometimes, one can see aspects of a problem when representing it one way that are not obvious when representing the problem another way. Sternberg (1986) further states that seeing multiple forms of representation helps the learner to recognize more aspects of the nature of the problem.

Sternberg's (1986) third step to increasing the skills of mental representation is to use external representations. Many complicated problems can become much simpler if one does not rely totally on mental representations of the problem. For example, in a linear syllogism in which properties of various people or objects are compared, the problem is much simpler to solve if a little diagram is drawn representing the relations among people or objects. Using external representations of information reduces the load on the learner's internal processing capacities.

Cognitive science research indicates that expert problem solvers are able to process a large amount of information when solving problems while novices get "mentally bogged down" when confronted with lots of information (Johnson & Thomas, 1992). One way to reduce the load of working memories is through external memory or

diagraming. A diagram enables students to manipulate the information in external memory without having to store it in their minds (Johnson & Thomas, 1992).

Concept mapping is a form of external memory that helps student organize new information. Concept maps help students distinguish important concepts, arrange concepts in some meaningful order and establish meaningful relationships between concepts (Johnson & Thomas, 1992).

Concept mapping used as an instructional tool helps learners process information and evaluate their learning. Johnson and Thomas (1992) state that concept mapping has been shown to improve recall of main ideas, to help learners understand the "big picture", and to facilitate both learning and problem solving. Concept maps can also be provided by the instructor along with lecture material to help students mentally organize the information and visualize key concepts and relationships (Johnson & Thomas, 1992).

Case Study Research

Foundations of Case Study Research

According to Yin (1994, p. 13) a case study is an empirical inquiry that investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident. Yin (1994) further states that case study inquiry 1) copes with the technically distinctive situation in which there will be many more variables of interest than data points, 2) as one result relies on multiple sources of evidence, with data

needing to converge in a triangulating fashion, and 3) as another result benefits from the prior development of theoretical propositions to guide data collection and analysis (Yin, 1994).

Case study research occurs within a bounded system and has several purposes. It is an examination of a specific phenomenon such as a program, an event, a person, a process, an institution or a social group (Merriam, 1988). The purpose of a case study may be: to chronicle events; to render, depict, or characterize, to instruct; and to try out, prove, or test (Guba & Lincoln, 1981).

According to Merriam (1988) a case study has four characteristics. The case study is particularistic, descriptive, heuristic, and inductive. Particularistic means that the case study focuses on a particular situation, event, program, or phenomenon. The case itself is important for what it reveals about the phenomenon and for what it might represent. Descriptive means that the end product of a case study is a rich, thick description of the phenomenon under study. Heuristic means that case studies illuminate the reader's understanding of the phenomenon under study. They can bring about the discovery of new meaning, extend the reader's experience, or confirm what is known. Inductive means that case studies rely on inductive reasoning. Merriam (1988) further states that generalizations, concepts, or hypotheses emerge from an examination of data-data grounded in the context itself. Discovery of new relationships, concepts, and understanding, rather than verification of predetermined hypotheses, characterizes qualitative case studies (Merriam, 1988).

According to Stake (1981) knowledge learned from case study research is different from other research knowledge in four important ways: 1) Case study knowledge is more concrete; 2) Case study knowledge is enriched by one's own experience because it is more vivid, concrete, and sensory than abstract; and 3) Case study research is more contextual. This knowledge is distinguishable from the abstract, formal knowledge derived from other research designs; 4) Case study research is further developed by reader interpretation. Readers bring to a case study their own experience and understanding, which lead to generalizations. Stake (1981) considers these to be a part of the knowledge produced by case studies. Case study research is based more on reference populations determined by the reader. Thus, unlike traditional research, the reader participates in extending generalization to reference populations (Stake, 1981).

Case studies in education vary in terms of their end product (Merriam, 1988). Some are little more than intensive descriptions of a program, event, or process. Such descriptions are useful in learning about unique or innovative situations and may form a data base for future research. Case studies that go beyond description are interpretive in nature. The researcher uses the data to analyze, interpret, or theorize about the phenomenon. Finally, many case studies are evaluative in that they are undertaken to assess the merit of a particular practice or program. In reality, most case studies are a combination of description and interpretation, or description and evaluation (Merriam, 1988).

The Case Study Researcher

The demands of case study research on a person's intellect, ego, and emotions are far greater than those of any other research strategy (Yin, 1994). Yin (1994) further states that the skills required for collecting case study data are much more demanding than those from experiments and surveys. In a qualitative case study, the investigator is the primary instrument for gathering and analyzing data (Merriam, 1988). Certain personality characteristics and skills are needed by a case study researcher.

The case study researcher must have an enormous tolerance for ambiguity (Merriam, 1988). Adaptability and flexibility are needed by the researcher (Yinn, 1994). Throughout the case study process, from designing the study, to data collection, to data analysis, there are no set procedures or protocols that one follows step by step (Merriam, 1988). There are guidelines and the experience of others to help, but one must be able to recognize that the correct way to proceed will not always be obvious. The very lack of structure is what makes this type of research appealing to many, for it allows the researcher to adapt to unforeseen events and change direction in pursuit of meaning. The investigator's role in qualitative research has often been compared to that of a detective (Merriam, 1988).

Sensitivity is the second characteristic needed by a case study researcher. The researcher must be sensitive to the context and all the variables within it including the physical setting, the people, the overt and covert agendas, and nonverbal behavior (Merriam, 1988). One also needs to be sensitive to the information being gathered.

One must be aware of one's personal biases and how they may influence the investigation (Merriam, 1988).

The case study investigator must also be a good communicator. A good communicator empathizes with respondents, establishes rapport, asks good question, and listens intently. Empathy is the foundation for rapport. A researcher is better able to have a conversation with a purpose - an interview - in an atmosphere of trust (Merriam, 1988).

Another vital communication skill is being able to listen. The good qualitative researcher looks and listens everywhere (Guba & Lincoln, 1981). Being a good listener means being able to assimilate large amounts of new information without bias (Yin, 1994). Yin (1994) states that a good listener hears the exact words used by the interviewee, captures the mood and affective components, and understands the context from which the interviewee is perceiving the world. This type of skill needs to be applied to the inspection of documentary evidence, as well as, to making direct observations of real life situations (Yin, 1994) . In reviewing documents, a good question to ask is whether there is any important message between the lines. Poor listeners may not even realize that there can be information between the lines (Yin, 1994).

The Methodology of Triangulation

The use of several sources of data is termed triangulation. According to Yin (1994), the most important advantage presented by using multiple sources of evidence is the development of converging lines of inquiry, a process of triangulation. Any finding or conclusion in a case study is likely to be much more convincing and

accurate if it is based on several different sources of information (Yin, 1994). With triangulation, the potential problems of construct validity also can be addressed, because the multiple sources of evidence essentially provide multiple measures of the same phenomenon (Yin, 1994).

The three data collection methods used in the research study were document review, observation, and interview. Documents of all types can help the research uncover meaning, develop understanding, and discover insights relevant to the research problem (Merriam, 1988). The documents reviewed in the case study were course curriculum from five vocational programs which were observed.

According to Kerlinger (1986), methods of observation are systematic and standard procedures for obtaining data. Kerlinger (1986) states that the observer keeps detailed records of what occurs, including those things usually taken for granted.

The researcher in the case study was a passive participant. Spradly (1980) states that the passive participant is present at the scene of action but does not interact or participate. The researcher finds an observation post and assumes the role of a bystander or spectator (Spradly, 1980). The researcher conducted a series of classroom observations in five different occupational programs.

An interview is a useful way to get large amounts of data quickly (Jorgenson, 1989). Formal interviews use a structured schedule of questions. Jorgenson (1989) states that the researcher is able to ask specific questions in exactly the same way time after time among interviewees. Jorgenson (1989) further states that formal interviews produce a highly uniform set of data. The structured

interview requires the researcher to know what questions are relevant to the study. Formal interviewing is most appropriate during the later stages of field work (Jorgenson, 1989). The researcher interviewed course instructors of the observed classes from five different occupational programs.

Summary

The workplace continues to undergo changes caused by several factors. These factors are international competition, the customization of goods and services, the rapid pace of change, new technologies, and a general feeling of uncertainty (Berryman & Bailey, 1992; Carnevale, Gainer, & Meltzer, 1990; Wirth, 1992) . These factors have created the need for workers with more cognitive skills rather than physical skills.

A variety of workplace skills are advocated by educators, economists, and industry as being needed by the worker in order to find successful employment. The workplace skills and qualities which seem to set apart the average worker from the above average worker are: lifelong learning, collaboration, self-management, adaptability to change, abstraction, systems thinking, and problem solving. By examining these workplace skills, vocational educators may gain insight into the direction instruction should take in order to produce workers employers want to hire.

Problem solving is a process. The student engages in problem solving when he confronts a situation for which he has no immediate solution (Krulik & Rudnick, 1980). The student searches his memory to try and find previously acquired information which could be

reorganized and applied to the context of the new problem he has encountered. The problem solver integrates information from memory with new information gained from the problem environment (Rubinstein & Firstenberg, 1987).

Problem solving is the basis for all good teaching practice (Sellwood, 1989). Problem solving instruction can be incorporated in all subject matters at all levels of instruction. Problem solving skills practiced in a variety of contexts may facilitate the student's ability to solve problems as a worker in the workplace.

Intelligence may affect one's ability to engage in problem solving activities. Both fluid and crystallized intelligence affect one's ability to solve problems. Crystallized intelligence affects problems which call for judgement, knowledge, and experience (Cross, 1981). Fluid intelligence influences one's ability to perceive, remember, and adapt to new situations (Horn, 1982). Crystallized intelligence generally increases and remains stable over the adult years. Fluid intelligence peaks in early adolescence; however, researchers believe that fluid abilities may be partially regained through training and compensated by one's crystallized intelligence (Cross, 1981).

The human memory is an important component in the problem solving process. The human memory is divided into sensory memory, short-term memory, and long-term memory. Information in the human memory is encoded, retained and retrieved for later use. Previously acquired information must be retrieved from long-term storage when it is applied to a new problem (Rubinstein & Firstenberg, 1987).

Rubinstein and Firstenberg (1987) further state that the context in

which a problem is framed will influence the ability of the problem solver to retrieve a possible solution from memory.

There are a variety of problem solving models and approaches which have been developed. Polya's (1945) problem solving model is based on a questioning technique. Resnick and Glaser's (1976) problem solving model is based on an information processing approach. The scientific method uses both inductive and deducting reasoning to move back and forth between a series of problem solving steps (Killeffer, 1969). Carnevale, Gainer, and Meltzer (1990) identified approaches to be used which increase both individual and group problem solving skills in students in order to better prepare them for problem solving in the workplace. The focus of the cognitive apprenticeship problem solving model is based on learning through guided experience (Collins, Brown, & Newman, 1989). The cognitive apprenticeship model was developed from the cognitive science literature and traditional apprenticeship. The general problem solver was one of the earliest computer programs developed for problem solving (Ernst & Newell, 1969). The general problem solver serves as a framework for many problem solving computer programs available in today's market.

The researcher developed a matrix of the problem solving models presented in the review of literature (See Table 1). The matrix summarizes the key concepts unique to each model. The matrix provides the reader with a quick overview of the models and allows the reader to see similarities and differences among the models.

People considered to be expert problem solvers often use procedures not used by novice problem solvers. Expert

TABLE I
PROBLEM SOLVING MODEL MATRIX

	Polya's Model	Resnick and Glaser's Model	The Scientific Method	Workplace Skills	Cognitive Apprenticeship	General Problem Solver
Developers/ Researchers	George Polya	Lauren Resnick Robert Glaser	John Dewey D. Killeffer Charles Darwin	A. Carnevale Leila Gainer Ann Meltzer	Allan Collins John Brown Susan Newman	G.W. Ernst A. Newell
Theoretical Base/ Approach	Mathematics/ Questioning	Information Processing	Systemized Reflective Thinking	Vocational Education	Cognitive Science/ Apprenticeship	Information Processing/ Artificial Intelligence
Key Concepts	Teacher Questions & Suggestions	Memory/ Task Environment	Inductive & Deductive Reasoning Steps	Workplace Skills Competencies/ Mastery	Learning through guided experience/ Learning Environment	Computer Programs/ Artificial Intelligence
Individual or Group Emphasis	Individual	Individual	Individual	Individual & Group	Individual & Group	Individual

TABLE I (Continued)

	Polya's Model	Resnick and Glaser's Model	The Scientific Method	Workplace Skills	Cognitive Apprenticeship	General Problem Solver
Stages or Dimensions	1. Understanding the problem. 2. Devising a plan. 3. Carrying out the plan. 4. Looking Back	1. Problem Detection 2. Feature Scanning 3. Goal Analysis	1. Consciousness of a problem. 2. Stating the problem. 3. Assembling the elements of a solution. 4. Combining the elements of a solution. 5. Verifying a solution (Killeffer)	1. Represent a problem. 2. Apply logic. 3. Formulate a solution. 4. Create a feedback mechanism. 5. Provide summative evaluation. (competency)	1. Content Domain Knowledge Heuristic Knowledge Control Strategies Learning Strategies 2. Methods* 3. Sequence* 4. Sociology* * see next page	1. Identify difference between current and desired goal state. 2. Pick operator to reduce difference. 3. Choose operator that most closely matches current goal state if several choices. 4. If cannot apply operator, set subgoals.

TABLE I (Continued)

	Polya's Model	Resnick and Glaser's Model	The Scientific Method	Workplace Skills	Cognitive Apprenticeship	General Problem Solver
Methodology or Learning Techniques	<ol style="list-style-type: none"> 1. Questioning 2. Prompting using suggestions. 	<ol style="list-style-type: none"> 1. Emphasize task environment. 2. Ensure adequate knowledge base. 3. Planning ahead. 4. Verbalize goals & strategies. 5. Diagramming/drawing. 	Discovery/Teacher as facilitator	<p>Individual</p> <ol style="list-style-type: none"> 1. Build classification skills: order, structure, relation. 2. Increase understanding- Deductive thinking Inductive thinking Dialectic thinking Unfreezing/ Reframing Critical/ reflective thinking. <p>Group</p> <ol style="list-style-type: none"> 1. Brainstorming 2. Synectics 3. Nominal Group technique 4. Systems analysis 5. Force field analysis 	<p>Methods</p> <ol style="list-style-type: none"> 1. modeling 2. coaching 3. scaffolding/ fading 4. articulation 5. reflection 6. exploration <p>Sequence</p> <ol style="list-style-type: none"> 1. Increasing complexity 2. Increasing diversity 3. Global before local skills <p>Sociology</p> <ol style="list-style-type: none"> 1. Situated learning 2. Culture of expert practice 3. Intrinsic motivation 4. Exploiting cooperation 5. Exploiting competition 	Computer assisted instruction or artificial intelligence

solvers mentally picture the problem inside their head (Johnson, 1989; Sternberg, 1985). Expert problem solvers also construct diagrams, graphs, or other figures to explain the problem and work out a solution (Johnson, 1989; Sternberg, 1986; Winn, Li, & Schill, 1991). By mentally picturing the problem or constructing the problem physically on paper, the problem solver may identify features of the problem he had not noticed before which could lead to a solution.

Case study research provides an extensive description of the phenomenon under observation (Merriam, 1988). Merriam (1988) further states that case studies are characterized by the discovery of new relationships, concepts and understanding. Case studies allow the researcher to use multiple methodologies to collect the data. The case study is an appropriate approach to use when conducting research in the field of education.

CHAPTER III

RESEARCH PROCEDURES

Introduction

The purpose of the study was to explore problem solving instruction as it occurs within a vocational technical school. Data collected from the study provided insight as to how vocational educators go about teaching problem solving skills to students.

Research Design

The theory behind the case study was that problem solving skills can be taught or improved upon through instruction. A vocational technical school provided an appropriate environment in which to explore problem solving instruction. A case study can make a significant contribution to knowledge and theory building (Yin, 1994).

A case study may involve more than one unit of analysis. This occurs when, within a single case, attention also is given to a subunit or subunits (Yin, 1994). These embedded units can be selected through sampling or cluster techniques. The resulting design is called an embedded case study design. The subunits can often add significant opportunities for extensive analysis enhancing insight into the single case (Yin, 1994).

The research was a case study of a vocational technical school. The embedded subunits in the case study were five vocational programs each selected from a different occupational cluster within the vocational technical school.

Population and Sample Selection

The vocational technical school selected for the case study was located in central Oklahoma. The school was selected based on its reputation as being one of Oklahoma's more progressive area vocational technical schools, the variety of vocational programs offered at the school, and the school's availability to the researcher.

This school is part of a statewide network of 29 area vocational technical districts. Daytime classes began in August of 1982 at the school's current site. The vocational technical school currently enrolls more than 1,400 daytime students and offers more than 30 daytime vocational programs. The short-term enrollment for day and evening programs is more than 19,000 students annually. The vocational technical school is built on 80 acres of land, and the \$29 million vocational technical school is housed on over 257,000 square feet of space. Each instructional program is fully equipped with state-of-the-art equipment inventoried at over \$9.8 million.

The vocational technical school offered daytime programs to eleventh and twelfth grade high school students. The high school students attended part-time or three hours per day. The high school students eligible to attend the vocational technical school were from three urban school districts and two rural school districts.

Adult students were eligible to attend the daytime programs on a full-time basis of six hours per day or on a part-time basis of three hours per day. Adult students were also eligible to attend short-term programs held in the evenings and on weekends.

The vocational technical school offered more than 30 daytime programs. The daytime programs were divided among six broad occupational clusters. One of the occupational clusters was that of occupational services which was designed to meet the needs of special needs students and did not fit the overall design of this case study. The five remaining broad occupational clusters relevant for the case study were: advanced technology, business education, home economics, trade and industry, and health occupations.

The researcher selected one vocational program from each of the five broad occupational clusters. The five vocational programs selected represented the most popular as indicated by having the highest enrollment figure in the occupational cluster. The researcher selected the instrumentation control technician program from the advanced technology cluster. The applied accounting program was selected from the business education cluster. The practical nursing program was selected from the health occupations cluster. The child care program was selected from the home economics cluster. The engineering drafting program was selected from the trade and industry cluster.

Enrollment restrictions were placed on some of the vocational programs selected for the study by the vocational technical school. The instrumentation control technician program and the practical nursing program were open to adult students only. The applied

accounting, child care, and engineering drafting programs were open to high school and adult students.

Securing Permission to
Conduct the Research

The researcher spoke with an assistant superintendent of the vocational technical school by phone. During the phone conversation the researcher introduced herself and explained to the assistant superintendent the type of research to be conducted at the vocational technical school. The researcher gave the assistant superintendent a list of the vocational programs selected and informed the assistant superintendent of how the vocational programs had been selected.

The assistant superintendent explained to the researcher that each occupational cluster at the school had a different supervisor. The assistant superintendent said that she would contact each occupational cluster supervisor to see if they were willing to participate in the study. The supervisor would then in turn visit with the instructor of the vocational program from that occupational cluster to see if they were willing to participate in the study. The assistant superintendent said that she would send out the messages using electronic mail and call the researcher back in several days.

The assistant superintendent called the researcher two days later and told the researcher that all of the instructors were in agreement to participate in the study and would be happy to assist the researcher in any way possible. The assistant superintendent gave the researcher the names of the instructors from the five vocational programs and their phone numbers.

The researcher called each instructor to thank them for their willingness to participate in the study. The researcher advised each instructor regarding the study. The researcher told each instructor that she would need to observe in the classroom approximately nine hours or three classroom sessions. The researcher advised the instructor that she would need to conduct a thirty minute interview with the instructor concerning their opinions of problem solving in general and their strategies for teaching problem solving to students. The researcher also advised the instructor that she would need to obtain a sampling of their curriculum in order to examine it for evidence of problem solving instruction.

The researcher scheduled the classroom observations with the instructors. The researcher arrived early for the first observation of each program in order to discuss the research project in greater detail with each vocational program instructor. The researcher developed a research project information sheet which informed the instructor of the purpose of the research project, the data to be collected, and ensured the instructor of confidentiality. Each instructor was provided with a copy of the research project information sheet (Appendix A).

Data Collection

Triangulation

One strength of case study data collection is the opportunity to use many different sources of evidence (Yin, 1994). The use of several sources of data is termed triangulation. The three data

collection methods used in the case study by the researcher were classroom observation, instructor interview, and course curriculum review.

Observations

The researcher observed class instruction in each of the five vocational programs selected for the study. The classes at the vocational school were set up in three hour blocks of time. The researcher observed three, three hour classroom sessions in each of the five vocational programs. Approximately nine hours of classroom instruction was observed in each of the vocational programs.

The observations were conducted over an eight week period during the fall semester. The observations were prearranged with the instructor of each program. The researcher limited the observations to one per week. This allowed the instructor and students to proceed along in the program's curriculum. Further, it provided the researcher with a more accurate account of the content and activities covered during classroom instruction.

During the observations the researcher looked for evidence of problem solving instruction on the part of the instructor, and looked for student participation in problem solving activities. The researcher recorded problem solving incidents on an observation data instrument which was developed by the researcher (Appendix B). The researcher audio taped the observations, when quality recordings could be obtained, to ensure accurate data recording. The researcher felt that the audio tape recordings were less disruptive to the class than the use of a video camera.

Interviews

The researcher interviewed the instructor of each vocational program. The interviews were conducted after the researcher had completed the observations in the program. Delaying the interview allowed the researcher the opportunity to learn about the vocational program and gain insight into the context of the instructor's responses to the interview questions.

The researcher asked previously developed questions from a questionnaire (Appendix B). Each instructor answered the same questions. The questions were open-ended questions with no specific right or wrong answers. The researcher asked the instructors questions concerning problem solving in general and the strategies that the instructor might use to teach problem solving skills to students.

The interviews were audio tape recorded. The researcher took brief notes during the interview on the questionnaire which was developed by the researcher.

Curriculum Reviews

The school studied was unique. Rather than use a state-wide curriculum, the vocational programs in this school developed their own curriculum. The curriculum was the final data collected from each vocational program. The vocational instructors wanted assurance that the curriculum would not be passed along to anyone other than the researcher. Given that assurance, the researcher was able to obtain the curriculum from each of the five vocational programs.

All programs in the vocational technical school used self-paced, individualized instruction. The curriculum obtained from each of the vocational program was a series of learning activity packets commonly referred to as "LAPS". The students progressed through the LAPS at their own pace.

The LAPS were examined for evidence of problem solving instruction. The researcher reviewed each LAP for the following:

- 1) Course content likely to include problem solving instruction,
- 2) Course objectives related to problem solving, 3) Problem solving activities or tasks to be undertaken by the students, and
- 4) Instructional strategies used by the teacher.

The researcher recorded curriculum findings on the curriculum data management form (Appendix B). The criteria used to evaluate the curriculum for evidence of problem solving instruction were obtained from the problem solving models and problem solving strategies cited in the review of literature. The curriculum was produced prior to and independent of the research study. The learning activity packets were therefore, nonreactive and grounded in the context under study (Merriam, 1988)

Field Testing

A final preparation undertaken prior to the actual collection of the data was a field test. The field test was undertaken in order to help the researcher refine her data collection plans and skills in respect to the content of the data and the procedures to be followed. The field test was also helpful in revising data collection forms developed by the researcher.

The field test was conducted at a different vocational technical school other than the vocational technical school used for the actual case study. The researcher observed a specific class from a vocational program at the pilot school that was similar to one of the vocational programs selected for the actual case study. The researcher reviewed the curriculum for the class, observed a three hour classroom session, and conducted an interview with the program instructor.

The original observation data collection instrument was four pages in length. Two pages were devoted to the actions of the instructor and two pages were devoted to the actions of the students. Since essentially the same items were outlined on the instrument for both instructors and students, the researcher condensed the observation data collection instrument into two pages to make it more manageable.

Prior to the field test, the researcher's dissertation committee had suggested that the researcher try and assign some sort of level to the problem solving incidents being observed. The researcher developed a coding system which assigned a level to each problem solving incident observed. The coding system worked very well in recording the observations during the pilot study.

The researcher interviewed the instructor during the field test. The researcher asked the instructor previously developed questions from a questionnaire. The questions flowed smoothly and made sense to the instructor. The pilot study instructor felt that the questions were general enough for instructors from the different vocational programs in the actual case study to answer. The audio

taping of the interview was successful and provided the researcher the data for later analysis. The researcher used the questionnaire to make brief notes during the interview. One question, "Do you think that problem solving skills can be taught?" was added as a result of the field study interview.

The researcher examined the curriculum from the pilot study to determine if the curriculum data management form could be used to identify and sort evidence of problem solving instruction. The curriculum data management form worked well and needed no adjustments.

Recording the Data

Observations

The researcher used the observation data instrument to record the classroom observations. The observation data instrument contained a listing of previously identified problem solving characteristics, skills and methodologies. The researcher recorded observations every ten minutes. At the end of a ten minute time frame the researcher would note any problem solving incidents which occurred during the past ten minute time frame.

Each problem solving incident was assigned a level using a coding system. A "B" was recorded for a brief problem solving incident which lasted less than one minute of the past ten minute time frame. The letter "M" was recorded for a moderate problem solving incident which lasted from one minute up to five minutes of the past ten minute time frame. A "T" was recorded for a thorough

problem solving incident which lasted from five to ten minutes of the past ten minute time frame.

The researcher also took anecdotal records during the observations. The researcher took notes concerning the physical environment of the classroom, estimates of student ages, the classroom atmosphere, and any other information which would contribute to the case study. An audio tape recorder was used to record the classroom observations to ensure the notes taken by the researcher adequately described the observations.

Interviews

The researcher conducted an interview with the vocational program instructor using previously developed questions from a questionnaire. The researcher briefly noted the instructor's answers to the questions on the interview questionnaire and made any necessary comments. Additionally, the researcher audio taped the interview. The audio tape was the primary source of the interview data.

The researcher typed up a transcript of each interview from the audio tapes. Each transcribed interview was a verbatim account utilizing the questionnaire format which was in the researcher's computer. A hard copy of each interview was produced. Interviews lasted anywhere from twenty minutes to one hour and fifteen minutes. Instructors were allowed as much time as they wanted to respond to the questions.

Curriculum Reviews

The self-paced curriculum in each of the five vocational programs was comprised of learning activity packets or "LAPS". The researcher asked each instructor to provide the researcher with the LAPS that the students were working on during the researcher's observations. This procedure enabled the researcher to make connections between her classroom observations and the activities that the students had been working on in class. Since the students worked at their own pace and were at different levels in the vocational programs, this procedure provided a good representation of the vocational program's curriculum.

The researcher examined the LAPS from the vocational programs for the following: 1) Course content likely to include problem solving instruction, 2) Course objectives related to problem solving, 3) Problem solving activities to be undertaken by the students, and 4) Instructional strategies to be used by the teacher. The researcher recorded findings from the LAPS in any of the above four areas on the curriculum data management form.

Data Analysis

Observations

The researcher analyzed each vocational program individually. The researcher completed one observation data instrument during each session of classroom observation. The researcher spread the three observation data instruments from each program before her and examined them to see what problem solving incidents had occurred in

the vocational program. Interactions between the instructors and the students were infrequent in some of the vocational programs. The types of problem solving incidents recorded on the data collection instruments were consistent among the three observations. The levels of the problem solving incidents varied slightly.

The researcher determined the type of problem solving incidents which had occurred and then examined the other two observation data instruments to see if the same approach to problem solving had occurred during the other observations. The researcher then determined the levels at which the problem solving incident had occurred during the three observations.

The researcher wrote an individual anecdotal report on each vocational programs in the study. The researcher reported the type of problem solving incidents observed in the program and then proceeded to report the level of each type of problem solving incident during the three observations.

Interviews

The researcher reviewed the transcript from each interview. The researcher wrote an individual anecdotal report on each of the vocational programs included in the study. This report included the instructor's responses to all of the interview questions.

The researcher found it difficult to summarize some of the instructors' responses. Answers to some questions were reported verbatim when the answers were technical. Otherwise, responses were generally a summary of key points expressed by the instructor. The researcher compared the instructor's opinions concerning problem

solving instruction to the problem solving practiced during the classroom observations.

Curriculum Reviews

The researcher recorded evidence of problem solving instruction identified in the LAPS from each vocational program. One curriculum data management form was used for each vocational program. Each LAP was examined for content, objectives, activities, and instructional strategies which were likely to facilitate the student's problem solving skills.

When possible, the researcher added up the estimated hours spent on the LAPS which contained problem solving instruction. Using the number and types of problem solving activities in each LAP, the researcher estimated the percentage of time devoted to problem solving activities in the LAPS. The researcher reported the findings of the curriculum review in the individual case study for each vocational program.

CHAPTER IV

VOCATIONAL PROGRAM DATA

Introduction

The data were collected from each of the five vocational programs selected for study. The vocational programs selected were representative of occupational clusters within the area vocational technical school. The vocational programs studied were applied accounting from the business education cluster, engineering drafting from the trade and industry cluster, instrumentation and control technician from the advanced technology cluster, child care from the home economics cluster, and licensed practical nursing from the health occupations cluster.

The researcher used triangulated research methodologies which yielded data from observations, interviews and curriculum reviews. The data were sorted and analyzed according to each individual vocational program and by each research methodology.

The instructional orientation of the vocational technical school in which the study took place influenced the type and level of data collected. The vocational technical school believed that all instruction should be self-paced in order to accommodate the individual needs of the learner. The curriculum for each program in the vocational technical school centered around learning activity

these LAPS at their own pace. The instructors of the vocational programs had the mind set that they were to be facilitators or resource persons for the students rather than traditional instructors.

The researcher used the observation data instrument to record incidents of problem solving which occurred in the classroom. All of the observations were in three hour blocks except for the licensed practical nursing observations. Observations were recorded every ten minutes throughout the three hour block of time. The classes had a ten minute break midway between the three hour class period.

When a specific problem solving incident occurred during the past ten minutes, the researcher would record a "B", "M", or "T" by the specific type of incident. The letter "B" indicated that the problem solving incident involved a "brief" amount of time or less than one minute of the past ten minute time frame. The letter "M" indicated that the problem solving incident involved a "moderate" amount of time or from one up to five minutes of the past ten minute time frame. The letter "T" indicated that the problem solving incident involved a "thorough" amount of time or from five to ten minutes of the past ten minute time frame.

Coding each problem solving incident on the observation data instrument with a "B, M, or T" helped the researcher to assign a level to the problem solving incident being observed. For example, if the researcher recorded the letter "T" four times consecutively for the problem solving incident, drawing parts of a problem, the reader of the instrument could assume that the researcher observed students drawing parts of a problem from 20 to 40 minutes of a 40 minute time frame since the letter "T" means the incident occurred anywhere from

five to ten minutes in each ten minute time frame and there are four ten minute time frames represented by four "T's". Since the four "T's" were recorded consecutively, the reader could also assume that the problem solving incident was an ongoing activity.

The researcher also conducted an interview with the instructor of each vocational program studied. All instructors were asked the same questions using a structured questionnaire. The length of the interview took anywhere from twenty minutes to an hour depending on the instructor's responses to the interview questions. Questions were asked concerning the instructor's opinions of problem solving in general, and the ways the instructor goes about teaching problem solving in their class.

A review of the curriculum was conducted for each vocational program studied. The instructor was asked to gather the learning activity packets (LAPS) used by students during the researcher's observations which took place over an eight week time period. This procedure allowed the researcher to identify the problem solving activities that students might have been working on individually which she could not detect during her observations due to the nature of the self-paced instruction.

Applied Accounting Program

Applied Accounting Observations

The applied accounting program was selected from the business education occupational cluster. The researcher observed three, three hour classroom sessions for a total of nine hours. The classes were

held in a large open area which housed several classes. The large area was in the shape of a semi-circle. The open semi-circular room was sectioned off into nine pie shaped classrooms. Each classroom had approximately 20 computer stations. A waist high partition divided every two computer stations forming a cubicle effect. Computer stations were found along both sides of the classroom area. The instructor's desk was placed at the front of the classroom.

The applied accounting program is a 1200 hour program. Students may attend half days and complete the program in two years, or attend full days and complete the program in one year. Both high school students and adults may enroll in the program. Students who exit the program prior to completion receive a list of competencies attained rather than a certificate of attendance.

There were two sections of applied accounting; however, observations were limited to the one section taught by the instructor participating in the study. Students were assigned work stations. Each work station had a computer, videocassette player, head phones, an adding machine, and a printer. Students worked individually at their own pace at their work station. The classroom had an office atmosphere due to the cubicle effect created by the partitions between students.

The instructor was somewhat apprehensive about the researcher audio-recording the classroom activities and conversations initially because she felt that it might make the students uncomfortable. The instructor advised the researcher to wait awhile until the students were used to her being in the classroom.

The acoustics in the large open room were such that the audio-taping was not very successful. Sound did not travel well. The instructor was soft spoken and would lean over or sit by each student when they needed assistance. Conversations between the instructor and students could barely be heard unless the recorder was placed on the student's desk between the instructor and the student. The researcher felt that placing the audio-recorder on the student's desk was intimidating to the student. Since the intent of the study was not to study student behaviors, the researcher used the audio-recorder only occasionally when she could inconspicuously record activities or conversations.

The instructor would sometimes sit at her desk in the front of the room during the class. Students would periodically go up individually and ask her a question. Sometimes a student would raise their hand and the teacher would go to the student's station. Occasionally the instructor floated from student to student. The room was very quiet. Students rarely spoke or interacted with each other. Students worked individually on the LAPS at their own pace at their own stations.

The researcher found it difficult to observe problem solving activities going on in class since students worked quietly at their own stations, each on different things, and talking was at a minimum. The researcher observed the students individually engaging in several activities. Students read textbooks, worked on journals or ledger type accounting problems manually, worked at their computer, or sat with head phones on watching and listening to an instructional video.

The applied accounting program used instructional videos and computer assisted instruction extensively to teach content and application to the students. The teacher did not regularly provide instruction in a lecture format to the students. The lecture format was used by the instructor several times a year for specific topics. The students appeared to approach the teacher only when they were stuck, had a question, or needed to take a test. Students followed the directions in their LAPS, completed the necessary activities, checked their own answers, and then took the test to pass the unit. A unit of instruction usually consisted of several LAPS. The teacher checked the answers on each student's test before the student proceeded on to the next unit.

The purpose of the researcher's observations was to look for problem solving incidents which occurred in the classroom. Using the observation data collection instrument (Appendix B), the researcher recorded when the instructor facilitated problem solving or the student engaged in a problem solving activity. As stated before, the researcher found it difficult to determine that problem solving activities were occurring due to the nature of the self-paced instruction. The researcher was able to observe some characteristics of the classroom environment which are said to facilitate problem solving. The researcher was also able to observe several instructional methodologies which are said to facilitate problem solving.

During the first observation period of three hours, intrinsic motivation occurred a thorough amount of time for a two hours and 40 minute time frame. During the second observation period of three

hours, intrinsic motivation occurred again a thorough amount of time for two hours and 40 minutes. During the third observation period of three hours, intrinsic motivation occurred a thorough amount of time for two hours and 50 minutes (Table II). The use of the LAPS requires students to be intrinsically motivated in order to complete the program. This explains the observation that intrinsic motivation is ongoing. Intrinsic motivation is a characteristic of students who have the ability to problem solve. Students have to be very disciplined and intrinsically motivated to perform well in self-paced instruction.

Cooperation in problem solving was observed when two students would assist each other. The cooperation between students was sporadic. During the first observation of three hours, cooperation in problem solving was observed a thorough amount of time for one pair of students for two alternating time frames of ten minutes. Another pair of students were observed a thorough amount of time for 40 minutes. During the second, three hour observation period cooperation was observed a moderate amount of time for 20 minutes when one student asked another student to help him. During the third observation period of three hours, cooperation was observed a moderate amount of time intermittently for three, ten minute time frames and a thorough amount of time for ten minutes. Different pairs of students would help each other when one student had already completed the LAP that the other student was working on, or a student might offer advice if the teacher was otherwise occupied.

Computers, adding machines, and interactive videos were used by the students during all observation periods. The students used the

TABLE II
 LEVEL* AND TIME DEVOTED TO PROBLEM SOLVING BY CATEGORY
 DURING APPLIED ACCOUNTING OBSERVATIONS

Observation	Category		
	Intrinsic Motivation	Informal Cooperation	Using Technology
1-180 minutes	T-160 minutes	T-60 minutes	T-170 minutes
2-180 minutes	T-160 minutes	M-20 minutes	T-170 minutes
3-180 minutes	T-170 minutes	M-30 minutes T-10 minutes	T-170 minutes

*T = Thorough
 M = Moderate
 B = Brief

various technologies and machines a thorough amount of time for approximately two hours and 50 minutes of each three hour observation period or 94 percent of the time during each observation period. The use of these technologies or machines was an ongoing occurrence during each observation period. The ability to use different types of technologies is thought to contribute to the ability to problem solve.

The instructor used the methodology of questioning during the second observation period for a moderate amount of time when she worked with one student intermittently for 50 minutes. During the third, three hour observation period the instructor used questioning for a thorough amount of time for ten minutes with one student (Table III). The questioning technique was used with individual students and not with the class as a whole.

The teacher would sometimes spend part of the class at her desk working at her computer. She modeled the behavior of an accountant. During the first, three hour observation period she spent a thorough amount of time modeling behavior at her desk for 20 minutes. During the second, three hour observation period she also spent a thorough amount of time for 20 minutes modeling accounting behavior by setting up a disk of master files for students on her computer. During the third observation period the teacher was working on nine weeks grades at her desk on the computer. The modeling occurred a thorough amount of time for two hours, and a moderate amount of time for ten minutes.

The instructor coached various students by prompting, offering hints or feedback as the students attempted to carry out a task. During the first, three hour observation period, coaching occurred a thorough amount of time for two hours and 40 minutes while the

TABLE III
 LEVEL* AND TIME OF INSTRUCTIONAL STRATEGIES USED
 DURING APPLIED ACCOUNTING OBSERVATIONS

Observation	Category			
	Questioning	Modeling	Coaching	Scaffolding
1-180 minutes		T- 20 minutes	T-160 minutes	T-90 minutes
2-180 minutes	M-50 minutes	T- 20 minutes	T-150 minutes	T-30 minutes
3-180 minutes	T-10 minutes	M- 10 minutes T-120 minutes	B- 10 minutes M- 40 minutes T- 40 minutes	

*T = Thorough

M = Moderate

B = Brief

instructor helped a student set up Peach Tree accounting software into her computer. During the second, three hour observation period, coaching occurred a thorough amount of time for two hours and 30 minutes. During the third observation period, the instructor coached students once briefly over a ten minute time frame. She coached several different students individually a moderate amount of time for 40 minutes, and she coached several different students individually at their desk a thorough amount of time for 40 minutes.

The instructor used the instructional methodology of scaffolding. In scaffolding the teacher carries out a part of the overall task that the student cannot yet manage on his own. The student then takes over and completes the task. During the first, three hour observation period, scaffolding occurred a thorough amount of time for 90 minutes while the instructor installed Peach Tree software for a student. During the second, three hour observation period, the instructor used scaffolding a thorough amount of time for 30 minutes while sitting with a student and showing them how to begin an accounting task in a journal.

Applied Accounting Interview

An interview was conducted with the instructor of the applied accounting program. The researcher used a structured questionnaire (Appendix B). Questions were asked concerning problem solving in that occupational area. Questions were also asked about the way the instructor goes about teaching problem solving to students. The interview with the applied accounting instructor lasted approximately 20 minutes.

The instructor had been an instructor at a public high school, a part-time evening instructor at the vocational technical school, and

had held her current position as a full time vocational instructor for seven years.

The instructor felt that the basic skills needed in this occupation were good communication skills such as listening, reading, writing, and speaking, and also computer skills. The instructor stated that students needed to know how to work in an environment where they have to be a team player. The students also needed to have the special skills for their specific area of employment.

The instructor felt that the role of problem solving to future workers was very important, now more so than ever due to quality management. She felt that the individual employee must be a team player and do his own problem solving because the employee typically doesn't report a problem and wait for someone else to solve it.

According to the applied accounting instructor, the ability to solve problems in this occupational area is very important. On a 10 point scale, I would rate it an eight or a nine. Problem solving is important because this occupation requires a lot of interpretation and analyzing of different types of data for different purposes and reports.

When asked if she thought problem solving skills could be taught, the instructor replied

Yes I do, oh absolutely! I just don't think people are born with it. I conscientiously try to teach problem solving skills in class. I usually don't rush over and try to immediately solve their problems for them unless they are in a great frustration ball of worry. I try to be slow when I work with the students and then if I need to I might say, now what or where should you have gone to solve this problem? I might also say something like, how would you back track to look for this information?

One of the techniques the instructor uses to teach problem solving is to try and get the student to analyze the situation. She might ask them how they did and say something like:

Now Ms. Doe and I are not going to be there when you are in the work environment and you will have to be performing confident and competent.

This reminds the students how important their own problem solving is for successful employment.

When asked about any activities which were used to develop the student's ability to problem solve, the instructor stated that they constantly tried to teach and rationalize with the student about problem solving. She said that there was a little bit of problem solving in many of the learning activity packets. She said that she could probably go through and label something that was a problem solving application in everything that the students do.

She cited Lotus as a specific example of problem solving that the students work on in class. She said that the student may have to determine a formula to use on a worksheet for an accounting function, for example, coming up with an answer of a certain percent. The student has to problem solve and work out the feature of the worksheet. The instructor said that they also did trouble shooting LAPS in many areas such as WordPerfect, Lotus, or DOS. When asked what the instructor meant by trouble shooting she explained:

There are certain LAPS where the student has to go and look up resources. They might be given a scenario such as - Your printer will not print. What reference book would you go to and what content would you look under to find this information? The student would then go to the printer manual and look under the reference section and look for this error message. That is what we mean by trouble shooting.

Success in problem solving is measured by whether the student does the work, completes the LAPS, and the feedback from the test. The instructor said that they had a measurement scale for all of the above areas.

The instructor thought that some students were better than others at problem solving. She felt that some students just tolerated it while others students liked the challenge involved in problem solving.

The instructor had received some external evidence that made her believe that problem solving was taught in her class. She said that there was a state mandated follow-up that is done on all students in vocational education. Students are called on the job or at home to find out how things are going. She indicated that they also got some comments from employers.

The instructor stated that students who work in this occupation have to work in teams and that problem solving was a function of those teams. Her example of team problem solving was that of cross training in the workplace. When she was doing industry visits she noticed that it was important for workers to understand each other's positions.

The cross training factor just jumped right out at me. It used to be - this is my domain and if I'm gone don't touch a paper on my desk. That is not the way it is now. That desk cannot sit idle, production must go on, someone else has to be able to step into the position. That absolutely is teamwork!

Another example of teamwork given was compiling reports within departments and across departments.

When asked if students in this class ever had to work in teams, the instructor stated that the students worked in teams and did team building through their student organizations. The high school

students are required to join Future Business Leaders of America (FBLA). The adult students are not required to join Phi Beta Lambda (PBL), but the school has an active PBL chapter. According to the instructor,

it is really hard in our type of class environment to do a team simulation. We have talked about this many times. We have tried to do this through our student organization so that it is not disruptive to the class. The officers have to work as teams. They have to iron out all of the problems. The officers plan meetings and have to see each other's point of view. The officers plan agendas and plan activities. Last year the officers took a retreat where we presented quality control which involves using teamwork, problem solving, graphs, and an analytical approach. The officers set ground rules and made a mission statement. This year we are pulling in guest speakers to give this to all of our students. We realize we've got to get it to all of our students.

Applied Accounting Curriculum Review

Learning activity packets (LAPS) that were used as the course curriculum were obtained from the instructor. Since the observations took place during the first nine weeks of school, the instructor was asked to gather what she felt were the LAPS that the students in her class would have covered during the first nine weeks of class. This procedure was used so that the curriculum reviewed for the study would coincide with the researcher's observations.

The instructional strategies used by the teacher to teach the course curriculum also influenced the researcher's ability to detect problem solving instruction in the class. The instructional strategies used by the teacher were self-paced instruction, instructional videotapes, computer assisted instruction, and hands-on

experiences with electronic calculators, computers, and an accounting practice set.

A variety of content was covered in the LAPS during the weeks of observation. The instructor gave the researcher 14 LAPS to review. Each LAP varied in the amount of credit hours given and in the amount of time necessary to complete the LAP. LAPS ranged from one to twenty hours of credit upon completion. The time it took to complete a LAP ranged from one to 30 hours.

Using the curriculum data management form (Appendix B), the researcher examined the LAPS for instructional strategies used by the teacher, course content likely to include problem solving, course objectives related to problem solving, and problem solving activities to be undertaken by the students.

Ten of the fourteen LAPS contained evidence of problem solving. The course content or LAPS covered during the researcher's observations period which included problem solving instruction were LAPS with the following titles: Features of the Sharp Electronic Calculator, Solving Business Problems on the Electronic Calculator, Analyzing Business Transactions, Analyzing Business Transactions Using T Accounts, The General Journal and the General Ledger, Adjustments and Worksheets, Closing Entries and the Post-Closing Trial Balance, a Mini-Practice Set for a Service Business Accounting Cycle, Accounting for Sales and Accounts Receivable, and Accounting for Purchases and Accounts Payable.

Some of the LAP objectives related to problem solving were as follows: (1) Adjust and perform routine maintenance on the Sharp Electronic Calculator, (2) Perform basic operations of addition,

subtraction, multiplication and division, (3) Perform calculations with fractions, decimals, and percents, (4) Analyze business transactions, (5) Use T accounts, (6) Use the general journal and general ledger, (7) Complete and use the worksheet, (8) Complete the accounting cycle by showing how the books are closed before a new financial period is begun, (9) Apply your knowledge of accounting principles and procedures by handling all the accounting work of Arrow Accounting Services for the month of January 1994, (10) Use the sales journal, and (11) Use a three column purchase journal. The estimated time given to complete the LAPS with the above objectives was 95 hours.

The researcher estimated that approximately 50 hours of the 95 hours allotted to complete the above LAP objectives were spent on problem solving activities. Some of the problem solving activities to be undertaken by the students were as follows: (1) Replace the ink ribbon and paper on an electronic calculator, (2) Solve problems with mixed operations on an electronic calculator, (3) Solve word problems using a percentage formula, (4) Analyze the effects of business transactions and enter them into the accounts affected, (5) Set up T accounts, (6) Prepare, use, and interpret various financial statements, journals and ledgers, and (7) Use a practice set and handle all accounting work for a fictitious company for one month.

Summary of the AppliedAccounting Program

The triangulated research methodologies of observation, interview, and curriculum review were used to determine if problem solving instruction was occurring in the applied accounting program. The researcher found that problem solving instruction did occur in the applied accounting program.

The researcher wanted to find out if the vocational instructor addressed specific problem solving skills in her instruction. The vocational instructor facilitated several problem solving skills in her class. The use of the LAPS required the students to have intrinsic motivation in order to complete the program. Intrinsic motivation is a characteristic of students who are able to problem solve. The students were free to cooperate in problem solving; however, this did not occur frequently. The students used different types of technology extensively in the program. The ability to use many types of technology is thought to enhance one's ability to problem solve.

The researcher did not observe the students working on any group or team projects in class. The instructor stated that group problem solving was conducted through their student organizations. The officers of the student organization did group problem solving activities. The researcher found that unless a student was an officer in the student organization, the student had minimal or no exposure to group problem solving.

The researcher wanted to find out what instructional strategies the instructor used to teach problem solving. Several instructional

strategies were used by the instructor to facilitate problem solving. The instructor questioned students individually and asked them to analyze situations or rethink their steps. The instructor sometimes modeled the behavior of an accountant by working at her desk on her computer. The instructor coached the students individual at their desks by prompting, offering hints, or feedback. The instructor used the methodology of scaffolding by showing the student how to carry out part of a task and letting the student complete the task.

The learning activity packets encouraged the students to problem solve individually. Ten of the fourteen laps reviewed contained problem solving content, objectives, and activities. The use of self-paced instruction appeared to prevent the instructor from using group problem solving activities in class.

Engineering Drafting Program

Engineering Drafting Observations

The engineering drafting program was selected from the trade and industry occupational cluster of the area vocational technical school. The engineering drafting course overlaps both the trade and industry occupational cluster and the advanced technology occupational cluster. Students may take the engineering drafting course which consists of thirteen laps or they can take the course as a part of the Computer Aided Design and Drafting/ Computer Aided Manufacturing Specialist Program (CADD/CAM) which is a three year, 2000 hour, program considered to be a part of the advanced technology occupational cluster.

The class observed consisted of high school students and adults equally. Students in the class were working in different areas. The high school students were mostly working on CADD math and engineering drafting. The adult students were working on technical math, introduction to CADD, computer applications, 3-D modeling, and application classes such as mechanical drafting or architectural drawing.

Twenty-five students were enrolled in the class. The atmosphere of the classroom was relaxed. Each student's station was equipped with a computer and digitizer, a videocassette player, and head phones. Music from a rock and roll station was playing lowly over the sound system. The music was not distracting and contributed to the relaxed atmosphere of the classroom. The students were very focused on what they were doing. The relaxed atmosphere seemed to foster collaboration between the students.

The students did not hesitate to ask the instructor for help and sought him out continually. The instructor rarely sat down. He floated from student to student during the entire class period. The instructor gave the students positive support and occasionally patted them on the shoulder. He checked with all students during the class to see how they were doing. A second instructor was also available to assist the students.

Three, three hour observations were conducted for a total of nine hours of classroom observation. A fifteen minute break occurred midway between each three hour class period. The researcher audio taped the observation periods, but due to the acoustics of the large room and the music playing overhead, not all of the conversations were

adequately recorded. The observations took place over an eight week time period.

Learning Activity Packets (LAPS) were used in the class. Students worked individually at their own pace. Students watched instructional videos, sketched, read, made blueprints, or worked at their computer.

During the first observation period of three hours, intrinsic motivation occurred a thorough amount of time for two hours and thirty minutes. During the second observation period of three hours, intrinsic motivation occurred again a thorough amount of time for two hours and thirty minutes. During the third observation period of three hours, intrinsic motivation occurred a thorough amount of time for two hours and twenty minutes, and a moderate amount of time for ten minutes (Table IV). The students were very focused on what they were doing and intrinsic motivation was an ongoing occurrence. Intrinsic motivation is a characteristic of students who have the ability to problem solve. Students also have to be intrinsically motivated to perform well in a self-paced instructional format.

Cooperation in problem solving was observed when two or more students would assist each other. During the first observation period of three hours, two students worked together on a LAP a thorough amount of time for 30 minutes. During the second observation period of three hours, two students were sitting across from each other and working on the same project. This occurred a moderate amount of time for ten minutes and a thorough amount of time for ten minutes. One

TABLE IV
 LEVEL* AND TIME DEVOTED TO PROBLEM SOLVING BY CATEGORY
 DURING ENGINEERING DRAFTING OBSERVATIONS

Observation	Category				
	Intrinsic Motivation	Informal Cooperation	Diagramming	Using Technology	Creativity
1-180 minutes	T-150 minutes	T- 30 minutes	T-150 minutes	T-150 minutes	T-150 minutes
2-180 minutes	T-150 minutes	M- 10 minutes T- 40 minutes	T-150 minutes	T-150 minutes	T-150 minutes
3-180 minutes	M- 10 minutes T-140 minutes	T- 40 minutes T- 50 minutes	M- 10 minutes T-140 minutes	M- 10 minutes T-150 minutes	M- 10 minutes T-150 minutes

*T = Thorough

M = Moderate

B = Brief

student was sitting with another who was drafting on his computer and was helping him analyze what he was doing wrong. This occurred a thorough amount of time for thirty minutes. During the third, three hour observation period, cooperation in problem solving occurred a moderate amount of time for ten minutes and a thorough amount of time for 50 minutes when two students were helping a third student solve a design problem for a home project.

The ability to diagram or draw parts of a problem is a skill which enhances one's ability to problem solve. The students would often have to sketch or draw when doing exercises in their LAPS or taking performance tests. This skill is an integral part of engineering drafting so it occurred throughout all observation periods. During the first, three hour observation period, the students drew a thorough amount of time for two hours and thirty minutes. During the second, three hour observation period the students drew a thorough amount of time again for two hours and thirty minutes. During the third, three hour observation period the students drew a thorough amount of time for two hours and twenty minutes and a moderate amount of time for ten minutes. During the last ten minutes of the class students would usually start putting away their sketches and clean up their work stations. Drawing was an ongoing activity.

The ability to use different types of technology and machinery enhances one's ability to problem solve. Computers, video cassette players, and a blue print machine were available for all students to use during each three hour class period. Students involved in sketching would also use various drafting tools such as a drafting table, "T" square, a scale, and drafting media. Students would use the

above technologies and drafting tools as needed throughout each three hour observation period. During the first observation period, the use of technology and drafting tools occurred a thorough amount of time for two hours and thirty minutes. During the second observation period, the use of technology and drafting tools occurred a thorough amount of time again for two hours and thirty minutes. During the third observation period, the use of technology or drafting tools occurred a thorough amount of time for two hours and thirty minutes, and a moderate amount of time for ten minutes at the end of class when students started cleaning up their work stations.

Many times a problem can be solved in several different ways. Two people may approach a problem differently but both come up with a solution that works. The ability to create or design is a skill that enhances one's ability to solve problems. According to the drafting engineering instructor, students are often encouraged to be creative and come up with their own designs which may or may not look like another student's as long as their design fits the specifications and works. Students created sketches or drawings during all observation periods and it was an ongoing activity. During the first, three hour observation period, some of the students in the class created or designed a thorough amount of time for two hours and thirty minutes. During the second, three hour observation period, some of the students in the class created or designed a thorough amount of time again for two hours and thirty minutes. During the third, three hour observation period, some of the students in the class created or designed a thorough amount of time for two hours and thirty, and a moderate amount of time for ten minutes at the end of class when they

started putting away their sketches. Creating or designing was an ongoing activity.

The instructor facilitated problem solving by questioning students individually. During the third, three hour observation period, the instructor questioned students a brief amount of time during two separate ten minute time frames.

The instructor floated from student to student and coached them on their assignments. The instructor would often prompt, offer hints, and feedback to the students. During the first, three hour observation period, coaching occurred a thorough amount of time for two hours and twenty minutes and a moderate amount of time for ten minutes. During the second, three hour observation period, coaching occurred a thorough amount of time for two hours and twenty minutes and a moderate amount of time for ten minutes. Coaching during the first and second observation periods was an ongoing activity as the instructor moved from student to student. During the third, three hour observation period, coaching occurred a moderate amount of time for forty minutes and a thorough amount of time for an hour and twenty minutes (Table V). These incidents of coaching were separated by time frames when no coaching occurred during the third observation period.

Scaffolding occurs when the instructor does part of a task for the student that the student is not yet ready to manage on his own and then allows the student to carry out the rest of the task. This enables the students to see how the parts of a task fit together. Scaffolding is an instructional technique that facilitates problem solving. During the second, three hour observation period, scaffolding occurred a thorough amount of time for one ten minute time

TABLE V
 LEVEL* AND TIME OF INSTRUCTIONAL STRATEGIES USED
 DURING ENGINEERING DRAFTING OBSERVATIONS

Observation	Questioning	Coaching	Scaffolding
1-180 minutes		M- 10 minutes T-140 minutes	
2-180 minutes		M- 10 minutes T-140 minutes	M- 10 minutes T- 10 minutes
3-180 minutes	B- 20 minutes	M- 40 minutes T- 80 minutes	M- 10 minutes

*T = Thorough

M = Moderate

B = Brief

frame while the instructor showed a student how to make a blueprint of his design, and a moderate amount of time for ten minutes when the instructor sketched part of a design for a student to show him where he had gone wrong. During the third observation period, scaffolding occurred a moderate amount of time for a ten minute time frame when the instructor again sketched part of a student's design.

Engineering Drafting Interview

An interview was conducted with the instructor of the engineering drafting class using a structured questionnaire. Questions were asked concerning problem solving in that occupational area. Questions were also asked concerning the way the instructor goes about teaching problem solving. The interview was approximately twenty minutes in length.

The instructor had twelve years of mechanical drafting experience in industry. He had taught two years at a previous vocational technical school and then one year at another vocational technical school before coming to the present vocational technical school under study. This was his first year at the present vocational technical school.

According to the instructor, the skills that entry level workers need to have in this occupation are good math skills, critical thinking skills, and people skills. The instructor said that people skills were important in order for the worker to be able to relate to fellow workers, be a good team member, show up for work everyday on time, not have any excuses for why a job did not get finished, etc. The ability to negotiate and take care of things as they come up or

problem solve was also cited by the instructor as a skill needed by entry level workers. In addition, the worker must have the CADD skills. The students will have those skills when they complete the CADD/CAM specialist program.

When asked what the instructor thought the role of problem solving was to future workers he replied,

It is extremely important. It used to be that the worker didn't do anything without someone else telling them what to do. It just isn't that way anymore. Companies are downsizing. They expect people to do more with less. A lot of companies are going to work teams where the work teams make decisions instead of the great and glorious supervisor who sees all and makes all decisions.

The instructor thought that the ability to solve problems was extremely important to entry level workers because there are typically more workers than there are jobs. He felt that workers who could not solve problems would be replaced by other workers.

The instructor believed that problem solving skills could be taught. He taught problem solving skills in class. When asked to describe the techniques or methodologies he used to teach problem solving he replied,

Well a lot of our instruction is self-paced. We allow the student a lot of freedom in how to approach things in the units of instruction. We don't tell them the answers. We don't tell them that there is necessarily one right or wrong answer. We just expect them to be able to defend their decision and the answer they came up with; but sometimes there are definitely right or wrong answers. This lends itself well to letting the student make decisions on their own and solve some problems on their own without having to tell them every little thing to do.

Other activities the students work on to develop their ability to problem solve occur through their student organization. According to the instructor, the students run the organization themselves.

Their American Design and Drafting Association (ADDA) chapter was the national chapter of the year winner last year and the students did the work themselves.

The instructor cited performance tests and design projects as examples of problem solving that students work on in class. The program works with companies that have some small projects and put a student on the problem. All students take performance tests and defend their work.

When asked how he measures success in problem solving the instructor said,

If there is a problem with no right or wrong answer, the student can show me how they arrived at their answer. If it makes sense and is logical and it works, we would probably describe that as being successful. We could have two people work on the same project and come up with different answers, but both of the answers could be correct.

The instructor felt that some students were better at solving problems because of environment, personality and handicaps. In some cases the designer needs to look at the bottom of something and a disability might interfere with his ability to do so. The instructor felt that some people want to be told everything and they don't want to solve problems.

When asked if he had any external evidence that made him believe that students learned problem solving in his class the instructor said,

A guy who owned a company had this knee pad and he could only make twelve a day. The knee pad was used by construction workers and other people who have to work on their knees. He wanted to redesign the knee pad, so we put one of our students on the project. The student redesigned the knee pad and now the company can make 100 a day. It helped the company's profit margin quite a bit.

That is the most tangible example that I can give, of course, I haven't been here very long.

The instructor said that workers in this occupational area have to work in teams and they solve problems as a function of these teams. The instructor cited Mercruiser, Ditch Witch, and Armstrong Flooring as companies that use a team approach to problem solving. He said that instead of having all of the machinists together, all of the welders together, all of the drafters together and all of the designers together, the company will put a member from each area on a team. Each team member is responsible for a function or a process. The team works together on the process. The team may also make decisions concerning who gets raises, who they hire, and who they fire. The team decisions are based on input from all team members.

The instructor indicated that students in his class worked in teams and engaged in problem solving as a function of those teams. The instructor gave the following example:

We have design projects where we have more than one student working on a process or a piece of material that is going to be manufactured. The students spend a lot of time deciding what the best approach is to the problem. We make the students split up the work and document what each person did so that one student doesn't do all of the work.

Engineering Drafting Curriculum Review

Learning activity packets (LAPS) that were used as the course curriculum were obtained from the instructor. The instructor was asked to identify the LAPS that the students worked on during the period of time covering the researcher's observations.

The instructional strategies used by the instructor influenced the researcher's ability to detect problem solving instruction in the

class. The instructional strategies used by the instructor were self-paced instruction or LAPS, instructional videos, computer assisted instruction, hands-on experiences with computers, drafting tools, machinery, and performance tests.

A variety of content was covered in the LAPS during the researcher's observations. The instructor gave the researcher seven LAPS to review. The time to complete the laps ranged from three to ten hours. The estimated time to complete all seven of the LAPS was 40 hours.

Using the curriculum data management form (Appendix B), the researcher examined the LAPS for instructional strategies used by the teacher, course content likely to include problem solving, course objectives related to problem solving, and problem solving activities to be undertaken by the students.

Three of the seven LAPS contained evidence of problem solving. Four of the seven LAPS contained mainly theory. The course content or LAPS covered during the researcher's observations which was likely to include problem solving instruction were LAPS with the following titles: Lettering and Sketching Techniques, Reproduction and Drawing Sheet Layout, and Dimensioning.

Some of the LAP objectives related to problem solving were as follows: (1) Draw Gothic letters using guidelines, (2) Create technical sketches based on industry standards, (3) Properly run a dry diazo blueprint machine, (4) Describe appropriate drawing sheet layout, and (5) Dimension various objects using a variety of dimensioning techniques. The estimated time given to complete the LAPS with the above objectives was 19 hours.

The researcher estimated that approximately 13 hours of the 19 hours allotted to complete the above LAP objectives were spent on problem solving activities. Some of the problem solving activities to be undertaken by the students were as follows: (1) Demonstrate standard Gothic lettering, (2) Create technical sketches based on industry standards, (3) Demonstrate the proper operation of a dry diazo blueprint machine, (4) Sketch a standard drawing sheet, (5) Demonstrate different ways of applying dimensions, and (6) Dimension various types of geometry.

Summary of the Engineering

Drafting Program

The triangulated research methodologies of observation, interview, and curriculum review were used to determine if problem solving instruction was occurring in the engineering drafting program. The researcher found that problem solving instruction did occur in the engineering drafting program.

The researcher wanted to find out if specific problem solving skills were taught. The vocational instructor facilitated problem solving by using self-paced instruction which required the students to be intrinsically motivated in order to complete the program. Intrinsic motivation is a characteristic of good problem solvers.

The relaxed atmosphere of the classroom encouraged students to work collaboratively on some of the assignments. The instructor stated that students also worked on group projects in class. The students were given a problem scenario and as a group must decide what approach to take and each work on different parts of the project. The

group documents which students did what and explains their decisions in a report to the instructor.

The students also work in groups through their student organization.

Students were taught how to draw or sketch assignments. The ability to diagram or draw parts of a problem is a skill that good problem solvers possess. The ability to diagram enables a student to see parts of a problem from different view points or angles. Many times several different students working on the same problem can come up with different designs and both are correct. Creativity is a characteristic of good problem solvers. Creativity is necessary in designing and drafting.

The ability to use different technologies is a skill that good problem solvers possess. Students used different types of technology and drafting tools extensively during the classes.

The researcher wanted to find out what instructional strategies the instructor used to teach problem solving. The instructor provided much positive support to the students. The instructor primarily used the methodology of coaching. The instructor offered suggestions and gave feedback to the students. The instructor floated from student to student during all three, three hour observation periods and rarely sat down. The instructor tried to visit with all of students during each class to check their progress. The instructor also questioned several students briefly while discussing their assignments with them. The instructor also used the methodology of scaffolding by showing students how to complete parts of a drawing or showing them how to get started making a blueprint.

The instructor used self-paced instruction or LAPS, instructional videos, and computer assisted instruction, and hand-on experiences to teach problem solving skills in addition to the above strategies. The instructor also use drawing assignments, group projects, and performance tests.

Three of the seven LAPS contained evidence of problem solving. The remaining four LAPS contained theoretical material. The students who were further along in their LAPS did more drawing assignments and had to take a performance test which required them to do some drafting.

Instrumentation and Control

Technician Program

Instrumentation and Control

Technician Observations

The instrumentation and control technician program was selected from the advanced technology occupational cluster of the vocational technical school. The first instrumentation and control technician (ICT) course takes approximately 100 clock hours to complete. Students may also receive 3 hours of college credit while enrolled in the course.

Students in the first ICT course learn ICT terminology and how to demonstrate systems operations by using the proper measurement and control techniques of flow, pressure, temperature, and level within a system. Technicians from the program go to work in places such as power plants, petro-chemical plants, breweries and food processing plants.

The students in the ICT class were adult students ranging in age from nineteen to fifty-eight years old. Some of the students were part-time and some of the students were full time. Some of the students in the classroom were just starting the program while other students in the classroom were getting ready to finish the program. Several of the students had worked before in industry.

The classroom was also used as a laboratory. A large conference table was set up at the front of the room. Students would often sit at this table and read or visit. Along the side wall of the classroom were individual desks where the students could watch instructional videos or work on their LAPS without being distracted. Throughout the rest of the large room were many different types of instrument controls and machines for the students to work on. The ICT laboratory had just been moved to this room during the summer and many of the control instruments were not working properly. Some parts of the instruments had gotten misplaced during the move.

The atmosphere of the laboratory was very relaxed. Students spent quite a bit of time visiting with each other. The course used self-paced instruction or learning activity packets (LAPS). The majority of the students were working on LAPS from the first instrumentation and control technician course.

The instructor of the course was new to the vocational technical school. The instructor viewed his role as that of a resource person or facilitator. He spent much time at his desk grading tests. The students typically worked on their own and usually asked for the instructor's help only when they were stumped.

The observations were conducted over a four week period. Three, three hour observations were conducted. Each three hour observation period had a fifteen minute break midway between the class. The researcher audio-taped the observations. Since there was not much discussion or interaction between the instructor and the students that could be recorded, the instructor suggested that the researcher seek out some of the students and visit with them to find out what they were working on.

The purpose of the classroom observations was to look for problem solving incidents which occurred in the classroom and strategies that the instructor used to teach problem solving skills. During the first observation period twelve students were present. During the second observation period, eight students were present. During the third observation period, no more than seven students were present in the classroom at one time. Depending on the student's schedule, students might come in for only half of the three hour class period. Some of the students would stay the full three hours. Both the morning and afternoon class periods were broken into two shifts with a fifteen minute break occurring between each shift of students.

The students, when focused, appeared to spend a great deal of time reading, studying for a test, or taking a test. The students worked on the actual control instruments in the laboratory a minimum amount of time during the researcher's observations. The large conference table at the front of the room provided a tempting place for the students to sit and visit. The researcher observed that the talking students were sometimes distracting to the students who were trying to work.

During the first, three-hour observation period the researcher observed that about half of the students were motivated to work on their LAPS and the other half of the students sat and visited. One student was observed napping at a desk toward the back of the laboratory. The students that were working were focused on their tasks and several did not even stop during the class break. The researcher observed that half of the class was intrinsically motivated a thorough amount of time for three hours. During the second, three hour observation period fifty percent of the students were working on their LAPS. Intrinsic motivation occurred a moderate amount of time for ten minutes and a thorough amount of time for two hours and forty minutes. During the third, three hour observations period most of the students were working on their LAPS and intrinsic motivation was observed a thorough amount of time for two hours and fifty minutes. (Table VI). Intrinsic motivation is a characteristic of good problem solvers.

The students often went to two of the more advanced students for assistance. One older student in particular was called upon by several students for help. During the first, three hour observation period cooperation in problem solving was observed between students on three different occasions. The first incident of cooperation occurred a thorough amount of time for forty minutes. The second incident of cooperation occurred a thorough amount of time for thirty minutes. The third incident of cooperation occurred a thorough amount of time for ten minutes. During the second, three hour observation period cooperation occurred a moderate amount of time for ten minutes and a thorough amount of time for ten minutes. During the third, three hour

TABLE VI
 LEVEL* AND TIME DEVOTED TO PROBLEM SOLVING BY CATEGORY
 DURING INSTRUMENTATION AND CONTROL
 TECHNICIAN OBSERVATIONS

Observation	Category					
	Intrinsic Motivation	Informal Cooperation	Diagramming	Using Technology	Trouble Shooting	Creativity
1-180 minutes	T-180 minutes	T- 80 minutes		T-100 minutes	T-100 minutes	
2-180 minutes	M- 10 minutes T-160 minutes	M- 10 minutes T- 10 minutes		T- 80 minutes		
3-180 minutes	T-170 minutes	M- 20 minutes	T-170 minutes	T-170 minutes	T-170 minutes	T-170 minutes

*T = Thorough
 M = Moderate
 B = Brief

observation period cooperation between students occurred a moderate amount of time for ten minutes on two separate occasions.

Students who have the ability to diagram or draw parts of a problem are said to be better at problem solving. Diagramming was not observed during the first and second observation period. During the third, three hour observation period, one student was working on a project. The student was trying to create a system to control the fluid levels in an automatic photo developer using a programmable logic controller. The student was having to diagram the switches that he used in his system and indicate if the switches were open or closed. The student was developing his project using trial and error. The researcher observed this student diagramming a thorough amount of time for two hours and fifty minutes while he worked on his project.

The ability to use different types of technology and machinery enhances one's ability to solve problem. The laboratory contained many instruments and gauges which the students used while progressing through the LAPS. A computer was available for the students to use to write programs. During the first, three hour observation period, an advanced student was repairing a piece of equipment with the help of the instructor. Another student was working on adjusting a pressure gauge for a LAP. The students worked at their tasks for a thorough amount of time for one hour and forty minutes. During the second observation, several students were working on the programmable logic controllers or writing a program at the computer, this occurred a thorough amount of time on three separate incidents. The first incident was for 20 minutes. The second incident was for 30 minutes and the last incident was for 30 minutes. During the third

observation period of three hours, one student worked on a programmable logic controller and at the computer, three other students were working on programmable logic controllers. All four students worked a thorough amount of time for two hours and fifty minutes.

Good problem solvers have the ability to troubleshoot. Troubleshooting is an investigative process. The student looks for the cause of a problem and tries to correct it. During the first, three hour observation period, one student was helping the instructor fix a piece of equipment. Troubleshooting occurred a thorough amount of time for one hour and fifty minutes. Troubleshooting was not observed during the second observation period. During the third, three hour observation period, one student was trying to write a program on the computer and could not get the computer to accept one of his commands. The printer was also not printing the program the way the student desired. This student troubleshooted a thorough amount of time for two hours and fifty minutes.

Creativity is a characteristic of good problem solvers. Students in the ICT class have projects which require them to create or design a control system. During the third, three hour observation period. One student was creating a control system for an automatic photo developer. The researcher observed this student a thorough amount of time for two hours and fifty minutes. Creativity was not observed during the first and second observation periods.

During the first, three-hour observation period the researcher observed the instructor question a student working on a gauge a

thorough amount of time for ten minutes (Table VII). Questioning was not observed during the second and third observations periods.

Modeling is a strategy that instructors use to show a desired behavior to the students. During the first observation period, the instructor tried to repair equipment a thorough amount of time for one hour and ten minutes. During this same episode the instructor had one of the advanced students working with him. The instructor coached the student by offering suggestions and feedback to the student a thorough amount of time for one hour and fifty minutes. The instructor also used the instructional strategy of scaffolding during this incident. The instructor would carry out parts of the repair job and let the student continue the job.

The ability to articulate one's thought processes is a skill of good problem solvers. During the first, three hour observation period the instructor had a student working on adjusting a control instrument. The student explained his reasoning to the instructor a thorough amount of time for ten minutes.

Exploration is an instructional strategy which lets the student learn to solve problems on his own often in a trial and error manner. The ICT program encourages the student to learn problem solving by trial and error. During the first, three hour observation period exploration was observed a thorough amount of time for one hour while the instructor and a students tried to repair a piece of equipment that would not work. During the third, three hour observation period, exploration occurred a thorough amount of time for two hours and fifty minutes while one student developed a control system using a

TABLE VII

LEVEL* AND TIME OF INSTRUCTIONAL STRATEGIES USED DURING
INSTRUMENTATION AND CONTROL TECHNICIAN OBSERVATIONS

Observation	Questioning	Modeling	Coaching	Scaffolding	Articulation	Exploration
1-180 minutes	T- 10 minutes	T- 70 minutes	T-110 minutes	T-110 minutes	T-10 minutes	T- 60 minutes
2-180 minutes						
3-180 minutes						T-170 minutes

*T = Thorough
M = Moderate
B = Brief

programmable logic controller. The student used trial and error to figure out how to make the control system work properly.

Instrumentation and Control

Technician Interview

An interview was conducted with the instrumentation and control technician instructor using a structure questionnaire. Questions were asked concerning problem solving in that occupational area. Questions were also asked concerning strategies the instructor uses to teach problem solving. The interview was approximately one hour and fifteen minutes in length.

The instructor had taught instrumentation and control for technicians in power plants in industry. He was asked to serve on a task force which conducted a task analysis of the ICT curriculum for this program. He was invited by this program to also serve on its advisory committee. When the previous instructor took another position, he was invited to come and interview for the instructor's position. This is his first year at the vocational technical school.

When asked what skills entry level workers currently need to have in this occupation, the instructor replied:

They have to be 'supertechs' (jokingly). Probably what I would consider the primary skills are a very sound understanding of industrial electronics, computers, digital communications, applied physics, and industrial electricity. In addition, they need to have above average critical thinking skills and an analytical mind. They should also have good motor skills.

According to the instructor, the role of problem solving to

future workers is as follows:

The trend right now is that large companies are downsizing. That basically translates into an increased workload which means workers' skills are becoming more diverse, much more so than the assembly line workers of the 1970's. We are talking about people who have to have a very broad skill set. In order for workers too obtain these skills, companies are investing large dollars in training. These workers have to be able to pick that up and apply it. Employers cannot typically teach troubleshooting in a training environment in a corporate setting. It is much more long term. If workers are not good problem solvers, during company reorganizations, these workers will be filtered into positions where they will eventually move out the door. To hold down a really fulfilling job these days is a real challenge. You have to have an above average interest in your job to be successful. Of course, the team atmosphere is invading everywhere. It is really being thrust upon some workers. Some workers embrace it, some don't.

The instructor said that the ability to solve problems was important to entry level instrumentation and control technicians.

According to the instructor,

Troubleshooting, a.k.a. problem solving, is about 90 -95 percent of what industrial process instrumentation control technicians are expected to do. Again with the thrust on minimizing your maintenance crews, technicians are being asked to solve problems more rapidly. They are being asked to assimilate new equipment and systems. The revolution in computerized process control equipment is at such a pace that virtually no one can keep up with the developments. The systems are so complex that what technicians used to be able to pick up from on the job training experience now requires eight to ten weeks of training at the vendor's school; and that only prepares the worker to come back and basically recognize the system and a minimum of the features that are available to them in troubleshooting and maintaining the system. Typically you are looking at five years to master one of the modern control systems such as the Honeywell Distributive Control System. Part of this is because the exposure to the system is infrequent because the system is very reliable. Overall, these systems still require five to ten hours a week just for routine maintenance. Routine maintenance would be things like making changes to human factors work on the display screen, trouble shooting some of the control loops where the distributive control system itself may not be at fault, but the instruments in the field are

and you have to go through the engineering work stations. Intuitive thinking used to be able to get the worker by when the systems were largely pneumatic or mechanical in nature. Empirical observations allowed you to troubleshoot a lot of these systems. Now with it all being inside a computer case, you can't visualize what is taking place so your critical thinking and your reasoning skills have to be very keen. Your problem solving skills, of course, go hand in hand with that.

The instructor believes that problem solving skills can be taught. The instructor does not personally teach problem solving skills, but he believes that problem solving skills are a by product of the program's teaching methods. According to the instructor,

As far as I'm aware with me being a new instructor and not having an in-depth knowledge of all the curriculum, what I am seeing is a lack of questions that ask the students to critically think and reason in some of the exercises. That is an area that I would like to improve, and I have started doing that. In some of the later courses in control systems and in programmable logic controller interfacing, the student is working strictly from a vendor's handbook and the student has to interpret and reason. I believe that becomes part of the problem solving skills that we are talking about. It teaches the students to be resourceful in finding information and solving their own problems. There is not a lot of assistance given to the student. The student knows what the objectives are and they are clearly stated. Much like in the workplace, the students are being pushed to take care of business. The students don't get much help out of me, because I'm not an Allen Bradley trained person which is our vendor for the programmable logic controllers. I am trained on a different system. I get a lot of questions; and I give the students a lot of head nods and tell the students to go after it. So far, we haven't had anyone who has gotten thoroughly frustrated.

When asked to describe his techniques or methodologies to teach problem solving, the instructor stated,

By being an individualized self-paced program, the encouragement and expectation is already there that the student not ask questions of the instructor until they have exhausted all of what they believe to be their resources. Usually, what I end up doing in answering a question is pointing out where some of the information can be found or interpreting some of the curriculum due to semantics and set the students back on the right path.

Some of the activities which are used in the course to develop the student's ability to problem solve are as follows:

The student is asked to wire up a specific brand of a programmable logic controller (PLC) that they may never have seen before. They are working from crude diagrams of where to connect wires. If they make a mistake with their programming and enter it in under a certain protocol, the system comes up and says you have a problem. The system is not very definitive in telling the student what the problem is. The student then has to study the vendor's manual and study their programming and draw their own conclusions and try to correct their mistakes.

After students have completed thirteen LAPS on the programmable logic controller (PLC), they are asked to utilize the cumulative knowledge that they have gained in designing and implementing a working program for that particular type of PLC. They can choose whatever design within the limitations of this type of PLC. We have had individuals do reactor water feed pumps, automated washing machines, golf course sprinkler systems, automatic garage door openers and cereal box fillers. I ask the students to research what field devices they are using in order to find out the information necessary to control the process.

The instructor felt that they did not have a very good tool or "yardstick" for measuring problem solving right now. When he worked in industry, they used performance tests as a measuring device. The performance test was a "go or no go type of situation". If the worker could not pass the performance test, the worker continued to work with senior workers until he could pass the test. The performance tests in industry have very specific criteria. The final project that students worked on in class could be considered as a type of performance test, but the instructor felt that it was very subjective.

The instructor felt that intelligence and analytical abilities made some students better than others at problem solving; however, he felt that those abilities could be offset by interest. The instructor felt that if the situation or problem was relevant to the individual,

they were going to be a better problem solver. If the problem is real or relevant to the student, they will stay after it longer until they come up with a solution.

The instructor had external evidence that made him believe that students learned problem solving skills in class.

We get a lot of feedback from our advisory committee members who have employed some of our students on a part-time basis. We have also had feedback from the students themselves. They mentioned that they were well prepared in some areas. They can do the problem solving and troubleshooting, but in other areas they were totally unprepared. It becomes really difficult to separate whether it is the work environment that is affecting that or whether it was a deficiency in our program. Some students have gone to work on an internship usually after they graduated. In an internship in this industry there is no expectation that the student will be employed after it is over. It is strictly an internship program to gain some experience for our best and brightest students. The students understand going in that there is no guarantee of a permanent job offer.

The instructor said that workers in this occupational field worked in teams and problem solving was a function of those teams. The workers not only worked in teams within their own work area, but also in teams with people from other crafts. The instrumentation control technicians are the troubleshooters for the plant. The technician may have to help troubleshoot a system because the mechanic, electricians, or operators may be struggling to solve the problem. There is sometimes finger pointing between the crafts because one craft may not be able to figure out the problem and thinks it is another craft's problem. Sometimes the technician must prove or disprove a craft's assertions.

When asked if the students ever worked in teams in class, the

instructor said,

Yes, but it is real informal. Some of the students are usually traveling within a few LAPS of each other. The students will work together much like these two gentlemen working over here on an atmospheric pressure lab. So, they sort of travel in packs which makes it rough on the instructor sometimes (jokingly). One of the things that is forthcoming is a new simulator that will allow the students to be able to use their creativity in teams to go in and write the program and make the system work. They will probably do this in teams of two or three when practical. This open entry/ open exit around here makes it kind of tough to do some team problem solving. We will probably have one person doing programming, one person doing logistics, and one person doing the hands on using a meter, troubleshooting, and giving feedback. The students will probably trade roles. That is how I envision the simulator situation working. We did this type of thing in industry training.

The instructor said that group problem solving was inhibited in their classroom environment. He felt that group problem solving took place through their student organization which was the Instrumentation Society of America (ISA). Students are not required to join ISA. He thought that the officers did 60 percent of the planning and problem solving for the group. The students worked on fundraising, organized tours, encouraged group participation and set up booths at exhibitions.

Instrumentation and Control

Curriculum Review

Learning activity packets (LAPS) used as the course curriculum were obtained from the instructor. The instructor was asked to identify the LAPS the students in the instrumentation and control classroom and laboratory were working on during the researcher's observations.

The instructional strategies used by the instructor were self-paced instruction or LAPS, instructional videos, hands-on experiences adjusting instruments for pressure, level, temperature, and flow, and programming instruments.

The instructor gave the researcher eight LAPS from the first level of instrumentation and control to review. The estimated time given to complete the eight LAPS was 23 hours.

The instructor also gave the researcher five LAPS from the programmable logic controller interfacing section of the instrumentation and control technician curriculum. There was not a time limit for completing these LAPS. Some of the students in the ICT laboratory during the researcher's observations were working on these LAPS.

Using the curriculum data management form (Appendix B), the researcher examined the LAPS for instructional strategies used by the teacher, course content likely to include problem solving, course objectives related to problem solving, and problem solving activities to be undertaken by the students.

Six of the eight ICT level I LAPS contained evidence of problem solving. The course content covered in the six LAPS which included problem solving were LAPS with the following titles: (1) Piping and Instrument Diagrams, (2) Process Concepts, (3) Measuring Atmospheric Pressure, (4) Instrumentation Test Instruments, (5) Pneumatic Deadweight Tester, and (6) Instrumentation Test Instruments - Part 2.

The LAP objectives related to problem solving were as follows:

(1) Demonstrate how to read and interpret piping and instrumentation

diagrams, (2) Use principles of physical science to calculate and measure flow, pressure, level, temperature and mechanical energy, (3) Measure atmospheric pressure using a Fortin type barometer, an absolute pressure gauge and a diaphragm resistance bridge transducer, (4) Describe the purpose, operation and maintenance for pneumatic and hydraulic deadweight testers, (5) Calibrate a gauge using a pneumatic deadweight tester, and (6) Describe the hydraulic comparator, test gauges, manometers and pneumatic calibrator for the purpose of calibration.

The researcher estimated that approximately thirteen hours of the nineteen hours allotted to complete the six LAPS were devoted to problem solving activities. The problem solving activities identified in the six LAPS were as follows: (1) Demonstrate how to use a piping and instrumentation diagram to troubleshoot a malfunctioning system, (2) Demonstrate the use of unique components to orient a system, (3) Draw a simple piping and instrumentation diagram for a home heating system, (4) Convert Celsius readings to Fahrenheit, (5) Measure atmospheric pressure with a Fortin type mercurial barometer, (6) Correct the reading for instrument influences, (7) Measure atmospheric pressure with a bourdon tube absolute pressure gauge, (8) Measure atmospheric pressure with a strain gauge electronic transducer, (9) Describe three factors that affect the accuracy of deadweight testers, (10) Calculate the area of the piston of a hydraulic deadweight tester, (11) Describe the function of the Verner piston on the hydraulic deadweight tester, (12) Set up a pneumatic deadweight tester, (13) Calculate calibration corrections, (14) Plot calibration curves for three pressure measuring devices, (15) Describe

how to determine the accuracy rating of a test gauge to be used as a standard on the pressure comparator, (16) Describe how to measure pressure/ vacuum using a "U" tube manometer, (17) Describe how to read a slant tube manometer, and (18) Explain when "Red 0.1" would usually be used in manometers. Many of the activities that asked the student to describe a procedure were activities which presented the student with a problem scenario and asked the student to analyze the situation and interpret various diagrams.

All five of the five ICT Programmable Logic Controller Interfacing LAPS contained evidence of problem solving. The LAPS had the following titles: (1) SLC 500 Introduction to Programming and Interfacing, (2) SLC 500 Motor/ Positioner/ Limit Switches, (3) SLC 500 Up Counters, (4) SLC 500 Interlocking Outputs, and (5) Two-cycle Positioning Application.

The objectives related to problem solving from the five ICT Programmable Logic Controller (PLC) Interfacing LAPS were as follows: (1) Program a ladder logic program into a SLC 500 PLC, (2) Program and interface a linear positioner, motor, and limit switches to a SLC 500 PLC, (3) Program and confirm an up counter in a positioning application, (4) Program and confirm a retentive timer in a positioning application, and (5) Program and confirm a two-cycle positioning program with manual stop. A time estimation was not given for completing the PLC LAPS.

The researcher felt that 100% of the student's time was spent on problem solving activities in each the five PLC LAPS. The problem solving activities from the PLC LAPS are as follows: (1) Wire a SLC 500 PLC, (2) Understand the addressing structure of the SLC 500,

(3) Program a start/ stop station, (4) Program a seal-in circuit, (5) Program using examine-if-closed and examine-if-open bits, (6) Connect motor/ positioner module to the relay coil outputs and SLC 500, (7) Connect limit switches for indicating position, (8) Program and confirm a positioning program, (9) Program an up counter in a positioning application, (10) Confirm a positioning application program, (11) Program a retentitive timer into a positioning application, (12) Confirm a positioning application program, (13) Wire two NC switches to SLC 500 inputs, (14) Program two-cycle application into the SLC 500, and (15) Demonstrate and confirm the two-cycle positioning application program.

Instrumentation and Control

Technician Summary

The Triangulated research methodologies of observation, interview, and curriculum review were used to determine if problem solving instruction was occurring in the instrumentation control technician program.

The researcher wanted to find out if specific problem solving skills were taught. Self-paced instruction was used which required students to be intrinsically motivated to complete the program. Intrinsic motivation is also a characteristic of good problem solvers. Some of the students appeared to lack the motivation necessary in a self-paced program. This was frustrating to the instructor. Some of the students would procrastinate for several days and then work intensely on other days to catch up in their LAPS. The instructor, who was new to the school, was trying to think of a way to prevent

this from happening. Apparently the instructor was not aware that some of the other vocational programs at the school gave daily grades or points based on a student's daily productivity.

Students would often ask other students in the class for assistance on an informal basis. Two students in particular were called upon more than others to help out. Group projects were currently not used as a part of the course instruction. The instructor felt that the classroom environment inhibited group problem solving.

The ability to diagram or draw parts of a problem is a skill of good problem solvers. The LAPS used in the course often asked the students to interpret diagrams of systems or to draw symbols and diagrams of systems. The students in the class were required to become very proficient at reading various control systems diagrams.

The students learned to use various types of instruments and gauges in the class. Students wrote various programs for different types of technology. The ability to use different types of technology enables a student to be a better problem solver.

According to the program orientation LAP, troubleshooting, problem solving, and critical thinking are important characteristics of a good instrumentation and control technician. Students were encouraged to find the solutions to problems encountered by trying on their own and retrying until the problem was solved.

The course allowed the students to exercise their creativity. Some of the LAPS asked the students to design control systems. Creativity is an attribute of good problem solvers.

The researcher wanted to find out what instructional strategies the instructor used to teach problem solving. The instructor felt that he personally did not teach problem solving, but felt that the LAPS taught the students to problem solve. The instructor thought that the students should come to him only when they have exhausted what they believed to be all of their resources in dealing with a problem. The instructor allowed the students to explore problem solving on their own through trial and error.

When students asked the instructor for assistance, the instructor might respond with leading questions. These questions might make the student rethink a process, design or part of a control system. The instructor might coach a student through a procedure by giving the student feedback. The instructor also asked the student to explain or articulate their thought processes to him.

Occasionally, the instructor might model the behavior of an instrumentation control technician when he was called upon to install, repair or troubleshoot equipment in the classroom. The instructor would also use the methodology of scaffolding. In scaffolding, the instructor completes part of a task such as repairing a piece of equipment and then asks a student to finish out the project.

The instructor used self-paced instruction (LAPS), instructional videos, and hands-on experiences with control systems to teach problem solving to the students. The instructor felt that performance based skills tests needed to be developed to assess the student's competencies.

Six of the eight instrumentation and control technician level one LAPS contained evidence of problem solving. Approximately 68

percent of the student's time while completing these six LAPS was devoting to problem solving activities. All five of the programmable logic controller interfacing LAPS contained evidence of problem solving. Virtually 100 percent of the student's time involved in completing the programmable logic controller interfacing LAPS was devoted to problem solving activities.

Child Care Program

Child Care Observations

The child care program was selected from the home economics occupational cluster of the vocational technical school. The researcher observed three, three hour classroom sessions for a total of nine hours of observation. The students spend their time in a regular classroom working on learning activity packets (LAPS) and also rotate out in groups of four into the child development laboratory. The child care program operates a licensed child care facility that is staffed with full time child care teachers. The children who attend the child development center are preschool age children.

When the students rotate out into the child development laboratory, they spend the entire week in the center. Three of the students that rotate out into the lab are assigned to the teachers in the center. The fourth student is assigned the job of being the kitchen foreman. The kitchen foreman is responsible for getting the food from the school's food service personnel and setting up each meal service for the children. The kitchen foreman also is responsible for

cleaning up after each meal service, washing dishes, and cleaning up the kitchen.

All students report at the beginning of each class to the regular classroom. The instructor takes attendance and makes announcements to the class. The students who are scheduled to work in the child development lab leave the classroom. The remaining students sit at their desks in groups of four and work on their LAPS. The teacher begins the class by asking each student what they are working on that day. This gives the instructor an idea of how each student is progressing and prevents the students from procrastinating their work.

Students may enroll in the child care program as part-time or full-time students. The program contains 130 LAPS. Part-time students usually complete the program in two years. The students range from high school juniors to adults. The class selected for observation consisted almost completely of high school juniors who were first year level students in the child care program. The instructor felt that these students were more challenging than the adult students and high school students in her other class.

The researcher divided the observations between the classroom and the child development lab. The first, three hour observation period was spent watching students in the classroom. The second, three hour observation was spent watching the four students who were scheduled to work in the child development lab. The first one and a half hours of the third, three hour observation period was spent watching students in the classroom. The last one and a half hours was spent watching the four students scheduled to work in the child development lab.

Classroom Observations

The students in the classroom worked on their (LAPS). The students talked quite a bit with each other. Some of the students worked more intently than others. Self-paced instruction requires intrinsic motivation on the part of the students. Intrinsic motivation is a characteristic of good problem solvers. During the first, three hour observation intrinsic motivation was observed a thorough amount of time for 20 minutes prior to the break midway in the class and a thorough amount of time for 70 minutes after the break. During the third, one and a half hour observation, intrinsic motivation was observed a thorough amount of time for forty minutes and for 20 minutes (Table VIII). The researcher observed students working cooperatively on LAPS a brief amount of time for ten minutes during the first observation period.

Everyday at 8:45 in the morning all students in the classroom would go over to the child development center for group time. All of the children in the center sat on a carpet and the students from the classroom would sit with the children. This daily event was called group time. One of the students from the classroom was responsible for leading the students and children in songs. The classroom instructor and usually one teacher from the lab also sat with the children. During group time the students were given the opportunity to put the theory that they had learned in their LAPS into practice with the children. During the first and third observation periods

TABLE VIII
 LEVEL* AND TIME DEVOTED TO PROBLEM SOLVING BY
 CATEGORY DURING CHILD CARE OBSERVATIONS

Observation	Category			
	Intrinsic Motivation	Informal Cooperation	Using Multiple Contexts	Creativity
<u>Class</u> 1-180 minutes	T-90 minutes	B- 10 minutes	T- 30 minutes	
<u>Lab</u> 2-180 minutes		T- 40 minutes	T-160 minutes	
<u>Class</u> 3- 90 minutes	T-60 minutes		T- 30 minutes	T- 40 minutes
<u>Lab</u> 90 minutes			T- 60 minutes	

*T = Thorough
 M = Moderate
 B = Brief

students used multiple contexts of the learning environment a thorough amount of time for thirty minutes in each observation period.

The students had the opportunity during the group time with the children to also interact with the teachers in the child development lab. The opportunity to learn by interacting with experts facilitates the student's problem solving abilities. The researcher observed the classroom students interacting with the teachers in the lab a thorough amount of time for thirty minutes in both the first observation period and the third observation period.

During the third, one and a half hour observation period, the researcher observed the students creating bulletin boards, making games, and making art activities for the children in the lab. Creativity is a quality of good problem solvers. Creativity was observed a thorough amount of time for thirty minutes before group time and a thorough amount of time for ten minutes after group time.

The instructor of the classroom modeled the behavior of a child caregiver when she sat with the children and students during group time. Modeling was observed a thorough amount of time for thirty minutes during both the first and third observation periods (Table IX). The instructor questioned individual students a moderate amount of time for ten minutes during the first observation period, and a thorough amount of time for ten minutes during the third observation period.

The instructor coached the students by prompting or giving feedback. The instructor worked individually with the students. During the first observation period, coaching occurred a moderate amount of time for twenty minutes, and a thorough amount of time for a

TABLE IX
 LEVEL* AND TIME OF INSTRUCTIONAL STRATEGIES USED
 DURING CHILD CARE OBSERVATIONS

Observation	Category			
	Questioning	Modeling	Coaching	Interacting with Experts
<u>Class</u>				
1-180 minutes	M-10 minutes	T- 30 minutes	M- 60 minutes T- 40 minutes	T- 30 minutes
<u>Lab</u>				
2-180 minutes		T-160 minutes	M- 20 minutes T- 40 minutes	T-160 minutes
<u>Class</u>				
3- 90 minutes	T-10 minutes	T- 30 minutes	T- 70 minutes	
<u>Lab</u>				
90 minutes		T- 60 minutes	M- 30 minutes	T- 60 minutes
*T = Thorough				
M = Moderate				
B = Brief				

thirty minute incident before the midway break. After the break, coaching occurred a moderate amount of time for forty minutes, and a thorough amount of time for ten minutes. During the third observation period, coaching occurred a thorough amount of time for fifty minutes and a thorough amount of time for twenty minutes.

Child Development Laboratory Observations

When students were working in the child development lab they used multiple contexts of the learning environment. The use of multiple contexts of the learning environment helps students to be able to transfer their knowledge to real life problems which they may encounter. The students worked in the kitchen, in the outdoor play area, in the indoor activity centers, and in the bathroom area. The students were observed preparing the tables for meal services, clearing away the tables after meal services, setting up specific toys for activities planned by the teachers, assisting the children with games and art projects, supervising the children in the outdoor play area, preparing cots for nap time, and supervising the children in the bathroom area. The students used multiple contexts of the learning environment a thorough amount of time for two hours and forty minutes during the second observation period. During the third observation period, multiple contexts of the learning environment were used a thorough amount of time for sixty minutes.

The students working in the lab were assigned to assist the teachers who worked full time in the child development center. This gave the students the opportunity to interact with experts in their field of practice. During the second, three hour observation period,

the students interacted with the teachers a thorough amount of time for two hours and forty minutes. During the third, one and a half hour observation period, the students interacted with the teachers thorough amount of time for sixty minutes.

During the second, three hour observation period, several students from the child care classroom came over to the kitchen to make playdough as required by one of the LAPS. The students worked cooperatively a thorough amount of time for thirty minutes. The students scheduled to work in the lab worked cooperatively a thorough amount of time for ten minutes while they served breakfast to the children.

The teachers in the child development center modeled the behavior of caregivers a thorough amount of time for two hours and forty minutes during the second, three hour observation period. During the third, one and a half hour observation period, modeling occurred a thorough amount of time for one hour.

Coaching occurred when the teachers in the child development center gave students assigned to work with them suggestions or feedback. During the second, three hour observation period, the child development teachers coached the students a thorough amount of time for thirty minutes during one incident, a thorough amount of time for ten minutes during another incident, and a moderate amount of time for twenty minutes while the students prepared the tables for lunch. During the third, one and a half hour observation period, coaching occurred a moderate amount of time for thirty minutes.

Child Care Interview

An interview was conducted with the instructor of the child care program. The researcher used a structured questionnaire. Questions were asked concerning problem solving in that occupational area. Questions were also asked about problem solving instruction in the child care program and the strategies the instructor used to teach problem solving skills to students. The interview was approximately 35 minutes in length.

The instructor had worked for a Head Start program as the education coordinator for eleven years. She was responsible for staff training and on-site center training. While working for that program she was on the advisory committee for the child care program at this vocational technical school. She also taught some night courses at a junior college. She took the position because she was interested in the teaching aspect of the job. She said that she was really enthusiastic about coming to work for the school, but she was not quite ready for the high school students. She felt that the high school students were more of a challenge than the adult students.

The instructor said that entry level workers in this occupation need to be able to read and write and have a high school diploma. In order to get a full time job, the worker must be eighteen years of age. They must have first aid, cardiopulmonary resuscitation training, and fire extinguisher training. Child care workers must have a tuberculosis test. The workers are required to update their

skills each year by completing six hours of training which may be through conferences or taking night courses.

When asked what she thought the role of problem solving was to future workers, she replied,

To work in this field, they have to be able to solve basic simple problems. For example if a child wets their pants, the student has to know what to do first, second, third, and fourth. Some of those steps involve sanitation skills or locating extra clothing if the child has none. Another example could be that food service didn't show up a with food item that the children were supposed to have at lunch. The worker has to be able to solve a problem when something doesn't occur as it is expected to in their every day routine. Most of it is basic problem solving. The problem solving could get more in depth depending on what position the worker holds in the child care facility. For a lead teacher, a problem might be that a parent did not pay their child care tuition on time and the parent tells you he doesn't have the money. Another problem solving example is how do you deal with children who have learning problems that you don't have training to deal with. That would require some research, having a parent conference, having a specialist evaluate the child, then sitting down and writing an individual education plan (IEP) for that child.

The instructor indicated that the ability to solve problems was very important in this occupation. She said that some of the students had to come and ask her on every step of a procedure when the answer is in the LAP. The students don't take the time to go back and read their LAPS. She said that some of the students are going to have a lot of problems in a child care facility if they do not stop and think. She said that she tried to be patient with the students but doubted that many supervisors in the work arena would be as patient.

The instructor said that the most critical problem solving areas of the child care curriculum were safety, nutrition, and child development. Guidance is included in the safety area. She further stated that if students do not have these three areas down, the

students will not last very long on the job. She has found that many of her students do not have good behavior and guidance techniques because they have grown up in a life where they have gotten spanked and their parents have told them 'not what to do'. Such students do not understand positive guidance and time outs.

The instructor thought that problem solving skills could be taught. She said that the focus now was on critical thinking skills. In the past, she felt that people did not see the significance of critical thinking skills. She thought that problem solving was vital in the child care area because the worker has to have initiative and not ask about each little item. She said that if a worker waits for somebody to tell them what to do, that worker could not function in this job.

The instructor felt like problem solving was taught in her class. According to the instructor,

the LAPS allow the students to check themselves. I think that solves the problem of how to do the work. I think the self-paced instruction has problem solving set up in it. I take it a step further. When a student asks me a question, I will turn around and ask them a question to answer their question to see if they really know the answer.

Some of the techniques she uses to teach problem solving in class are LAPS, a checklist on the LAPS, group support, and hands-on experiences. In hand-on experiences she said that the students actually see something taking place that they didn't know before. This solves their curiosity rather than just reading about it. She thought that many students do not grasp a concept from just reading about it. Hands-on experiences make more of a difference than some of the paper work.

The instructor cited making playdough as one example of a problem solving activity that students work on in class. Many students have never cooked and do not know how the playdough is supposed to turn out. If the student goes through the process and makes the play dough and it flops, sometimes they can still tell the instructor why the play dough did not work. The students do some science projects that involve problem solving. Each student must also be responsible for leading the children in the child development center during group time. She said that some of the students are able to see what they have done wrong and evaluate their projects. She felt that evaluation was a part of problem solving.

When asked how she measures success in teaching problem solving, the instructor said,

The students evaluate themselves on every LAP - play dough, bulletin board, homemade game usability. The students are not used to evaluating themselves. Some of the students rate themselves higher than I would rate them. If I don't think their item will turn out when they use it in the child development center, I ask them to redo it so it will not be a total flop. In some cases I have a stubborn student who won't redo the project, so I let them go use it in the child development center and flop. For example, musical chairs is a school age activity that these students think they can use with the preschool children in the child development center. The students do not realize that preschool children do not have the comprehension to understand the concept of losing a game. The students will think that the musical chairs went alright, but the children in the center will ask later why they lost because their feelings got hurt. I think the students finally understand when they do their student teaching. The more experience the students have, the more they understand preschool children.

The instructor felt that some students were better than others at problem solving because they took their time on their LAPS. Taking their time on the LAPS helps them to understand the capabilities of

each age group in the child development center. She said that she can really tell a difference in the students who have grasped basic child development from those students who have not grasped it when the students go out and try an activity in the child development center with the children. Some of the students have to go back and repeat LAPS. She does not give a grade on each LAP, but gives them a check mark if their answers are adequate. If their answers do not make sense, the students are asked to repeat the LAP. The students have to complete 13 LAPS minimum each nine weeks. Several LAPS make up a unit of instruction. The students take a test over a unit of instruction.

The instructor has external evidence that makes her believe that the students in her class learn problem solving skills. People on her advisory committee from three specific child care centers have hired many of the students. With the students themselves, the evidence is them keeping the job, having the abilities to do the job, and being successful at the job. She also gets some feedback from nanny placements. Parents who are satisfied will tell their friends and she gets many calls. She has also gotten a couple of really nice letters out of the blue from employers who have been satisfied with the students that they hired from her class. One of the employers sent a letter to the superintendent of the vocational technical school.

Workers in the occupational area of child care sometimes work in teams. The teacher said that the workers have to be flexible because they may be moved from room to room. Workers have to adjust their hours to fill in for absent teachers. Sometimes a substitute is put with a more experienced teacher. The workers also work in teams when they are working on the National Association of Young Children

accreditation, on child care facility licensing standards, or on the Child and Adult Care Food Program. The workers do quite a bit of training in teams.

Workers in child care facilities may be called upon to solve problems in teams. The child care teachers have to evaluate another staff member in accreditation. The teachers must also evaluate themselves in their area and evaluate their equipment. The instructor said that the process of accreditation gives the child care center the chance to look at who they are, what they are, and where they are, and where they want to be.

When asked if the students in her class ever worked in teams and engaged in problem solving in those teams, the instructor replied,

I think so. That is why I have the classroom set up in groups of four desks facing each other. The students rotate out into the child care center in groups of four. Nine high schools feed into this vocational school. I think that is frightening to some of the high school students and scares them off because they think that when they get out here they don't have any support. I think it helps to have their desks facing each other. The students can help each other out with questions on the LAPS. Peer discussion is sometimes just as effective as teacher discussion. That is a big part of this class and a neat part of it. I learn from the students. I learn where their thoughts are and I try and take them as far as they can go or want to achieve. That is my main goal in this class. I think the students learn how to get along with each other doing group work. The students also do resumes and portfolios. Many of the things we do will directly feed back into their job.

Child Care Curriculum Review

Learning activity packets (LAPS) that the students were working on during the researcher's observations were obtained from the child care instructor. The LAPS require the students to do a variety of

activities such as reading reference materials, viewing films, completing assignment sheets, performing a job or task, demonstrating a skill, making an object, using the computer, or any other activity suitable for a particular lesson.

The instructional strategies used by the teacher included self-paced instruction (LAPS) and hands-on experiences. The students worked on their LAPS in a classroom. Each week a group of four students worked in the child development lab for the entire week. The students received hands-on experiences in the management of a child development center and in dealing with children and their parents.

The instructor gave the researcher fifteen LAPS to review. The LAPS varied in the amount of time estimated for completion. Some of the LAPS did not have an estimated time limit for completion.

Using the curriculum data management form, the researcher examined the LAPS for instructional strategies used by the teacher, course content likely to include problem solving, course objectives related to problem solving, and problem solving activities to be undertaken by the students.

Eleven of the fifteen LAPS contained evidence of problem solving instruction. The course content covered during the researcher's observations which was likely to include problem solving instruction were LAPS with the following titles: (1) Kitchen Responsibilities, (2) Job Hunting, (3) Special Needs Children, (4) What is Behavior and Guidance?, (5) Types of Guidance Techniques, (6) Behavior Problems and Children with Special Needs, (7) Group Times, (8) Mixing Up Some Fun, (9) Teacher Made Games and Activities, (10) Developing and Displaying Bulletin Boards, and (11) Writing Weekly Lesson Plans.

Some of the LAP objectives related to problem solving were as follows: (1) Organize and clean dishes, prepare the dishes and food for serving, and maintain a safe, sanitary, kitchen area, (2) Compile a resume and list the different methods of seeking employment, (3) Write examples of positive guidance, (4) Know ways to guide the behavior of young children, (5) Develop effective rules for the classroom, (6) Assist children with behavior problems, (7) Plan and implement a group time for young children, (8) Prepare paint and playdough, (9) Design and construct an appropriate game or activity for use with young children, (10) Design and display a bulletin board appropriate for young children, and (11) Develop and implement a weekly lesson plan.

The researcher estimated that a minimum of 20 percent of the student's time was devoted to problem solving activities in each of the eleven LAPS with the above objectives. The researcher also estimated that five of the eleven LAPS devoted 75 percent of the student's time to problem solving activities. Some of the problem solving activities to be undertaken by the student were as follows: (1) Demonstrate correct kitchen procedures, (2) Complete your resume', (3) Compute a salary range on which you could live, (4) Write examples of positive guidance, (5) Describe ways in which caregivers can guide the behavior of young children, (6) Develop rules for use with young children from a case study, (7) Identify common behavior problems in given scenarios, (8) Describe positive ways to assist children with special needs in given scenarios, (9) Plan and conduct a group time with children, (10) Evaluate your group time plan, (11) Prepare

tempera paint, (12) Make cooked playdough, (13) Plan and evaluate a game or activity, (14) Create materials for the game or activity, (15) Construct the game and if applicable, laminate, (16) Present the game to the children (evaluate), (17) Create materials for a bulletin board display, (18) Display bulletin board in the child development center, and (19) Develop, implement, and evaluate a weekly lesson plan.

Summary of the Child Care Program

The triangulated research methodologies of observation, interview, and curriculum review were used to determine if problem solving instruction was occurring in the child care program. The researcher found that problem solving instruction did occur in the child care program. The problems encountered were not technical in nature, but were likely to be problems in areas such as child guidance and behavior.

The researcher wanted to find out if problem solving skills were taught in the child care program. The instructor facilitated individual problem solving by using self-paced instruction or LAPS which required the students to be intrinsically motivated.

The classroom was arranged in desks of four which encouraged the student to work cooperatively on the LAPS. The research did not observe much cooperation in working on the LAPS in the classroom, but did observe cooperation on the part of the students working in the child development lab. The students working in the lab would often help each other with a task such as preparing for a meal service.

The students were allowed to exercise their creativity in some of the LAPS. Students created games, activities, bulletin boards, and lesson plans. Creativity is a quality of good problem solvers.

The researcher wanted to find out what strategies the instructor used to teach problem solving. The instructor facilitated the transfer of the students' knowledge by using multiple contexts of the learning environment. Students learned both in the classroom and in the child development lab. The child development lab contained several different areas in which the students could develop their problem solving skills.

Students were given the opportunity to interact with experts in their profession when they worked in the child development lab. Students were assigned to assist the full time teachers or were assigned as the kitchen foreman. Both the classroom instructor and the teachers in the child development center modeled the behavior of a caregiver. Students who are given the opportunity to work with and observe experts in their chosen field are able to learn tricks of the trade which enable them to be better problem solvers.

The instructor used the methodologies of questioning and coaching when working individually with the students. When a student asked the instructor a question she indicated that she would often answer the question with another question. The researcher observed the instructor coaching the students when they worked on their LAPS by offering suggestions and feedback to the students when they asked her a question or wanted her opinion.

Licensed Practical Nursing Program

Licensed Practical Nursing Observations

The part-time licensed practical nursing program was selected from the health occupations cluster of the vocational technical school. Licensed practical nurses (LPN'S) provide nursing care under the supervision or direction of a registered nurse, licensed physician or dentist. According to the instructor of the program, an LPN is responsible for the bedside nursing of the patient. The students consisted of adult students only. The part-time licensed practical nursing program takes a maximum of 24 months to complete. The students must spend an average of 20 hours each week in the nursing program. Students spend their twenty hours working on learning activity packets (LAPS), skills, tests, and participating in clinical rotations at a nursing home, local hospital, or a doctor's office.

The instructor conducts one lecture each week. The researcher observed two lecture sessions conducted by the instructor. The first lecture was one hour in length. The second lecture was one hour and thirty minutes in length.

The students were also in the process of conducting clinical rotations at a large local hospital. The instructor invited the researcher to accompany them on the clinical rounds because the students gained much problem solving experience through this avenue of instruction. The researcher conducted two clinical observations. The first clinical observation was two and one half hours. The second clinical observation was four and one half hours.

Lecture Observations

The observation data instrument was used to record the observations. The lectures were also audio-taped. The students actively participated in the lectures by asking questions, relating experiences, and role playing.

The first lecture was one hour in length. The instructor began the lecture by making announcements. The students brainstormed about selling jumbo cups as a fund raiser for their student organization. The students went through some problem solving steps while thinking through the idea a thorough amount of time for ten minutes. The students discussed the following problem solving steps:

(1) Describe what currently exists, (2) State the problem, (3) Recall past experiences, (4) Identify new knowledge, and (5) Consider alternative solutions.

During the discussion of the fund raising idea, the students used a group process called brainstorming a thorough amount of time for ten minutes (Table X). Brainstorming is a cooperative process.

The instructor discussed the importance of communication between the doctor and the nurse. Students role played a situation where a doctor was taking out his anger and frustration on a nurse. Students also articulated some of their own experiences in communicating with doctors, nurses, and patients a moderate amount of time for ten minutes and a thorough amount of time for ten minutes. During this episode the instructor instilled domain and heuristic knowledge or "tricks of the trade" to the students a thorough amount of time for twenty minutes. The instructor informed the students of the nurse's rights and responsibilities in the above situation, and how she

TABLE X

LEVEL* AND TIME DEVOTED TO PROBLEM SOLVING BY CATEGORY
DURING LICENSED PRACTICAL NURSING OBSERVATIONS

Observation	Category				
	Using Problem Solving Steps	Group Activities	Informal Cooperation	Creativity	Using Technology
<u>Lectures</u>					
1-60 minutes	T-10 minutes	T-10 minutes	T-10 minutes		
2-90 minutes	T-70 minutes	T-50 minutes	T-90 minutes		
<u>Clinical Rotations</u>					
1-150 minutes	Yes	Yes	Yes	Yes	Yes
2-270 minutes	Yes	Yes	Yes	Yes	Yes

*T = Thorough

M = Moderate

B = Brief

personally would handle such a situation. The instructor modeled the appropriate behavior for a nurse caught in the above situation a moderate amount of time for ten minutes.

The instructor went on to lecture on the proper way to prepare a sterile field. The instructor demonstrated the proper way to prepare a sterile field. The instructor instilled domain and heuristic knowledge to the students a thorough amount of time for thirty minutes. While lecturing the instructor modeled setting up a sterile field for thirty minutes. The instructor asked two students to role play the procedure while she gave them directions. The instructor coached the students through the procedure a thorough amount of time for ten minutes and a moderate amount of time for ten minutes. The instructor used the methodology of scaffolding by helping the two students carry out part of the task of preparing a sterile field a moderate amount of time for ten minutes. The instructor used the instructional methodology of exploration by allowing two students who had never prepared a sterile field to role play the procedure. This exploration occurred a thorough amount of time for ten minutes (Table XI).

The second lecture was one hour and thirty minutes in length. The instructor began the lecture with announcements. The topic of the lecture was ethical decision making. The instructor went through the nursing process which is a problem solving process that nursing students are taught to use when solving problems and making decisions. The instructor posed questions and situations for the students to consider in making ethical decisions. Students shared ethical dilemmas that they had encountered. The instructor broke the students

TABLE XI
 LEVEL* AND TIME OF INSTRUCTIONAL STRATEGIES USED DURING
 LICENSED PRACTICAL NURSING OBSERVATIONS

Observation	Questioning	Modeling	Coaching	Scaffolding	Exploration	Articulation	Reflection
<u>Lecture</u>							
1-60 minutes		M- 10 minutes T- 10 minutes		M-10 minutes	T-10 minutes	M-10 minutes T-10 minutes	
2-90 minutes	T- 70 minutes		T- 70 minutes			T-80 minutes	T-80 minutes
<u>Clinical Rotations</u>							
1-150 minutes	Yes	Yes	Yes	Yes	No	Yes	Yes
2-270 minutes	Yes	Yes	Yes	Yes	No	Yes	Yes

*T = Thorough
 M = Moderate
 B = Brief

up into groups and gave them five ethical problem scenarios. Each group used the nursing process to come up with a solution to the ethical problem.

The instructor and the students went through some of the problem solving steps a thorough amount of time for 70 minutes. The problem solving steps discussed in each of the five scenarios were: (1) Describe what currently exists, (2) State the problem, (3) State the plan, (4) Recall past experiences, (5) Identify new knowledge, (6) Collect pertinent information, (7) Scan task environment for clues, (8) Consider alternative goals, (9) Restate the problem, (10) Adjust the plan, and (11) Conduct a trial run of the solution.

The students were very involved in sharing ideas and experiences with the instructor and with each other. Cooperation was observed a thorough amount of time for 90 minutes. The students worked in groups to come up with solutions to the ethical dilemmas a thorough amount of time for fifty minutes. The students engaged in a decision making process.

The instructor facilitated problem solving by making sure she instilled an adequate knowledge base in the students. The instructor provided domain knowledge to the students a thorough amount of time for 80 minutes while she explained the legalities and rights of patients in ethical dilemmas. The instructor simultaneously provided heuristic knowledge a thorough amount of time for 80 minutes while she explained how she personally might handle some of the different scenarios that the students worked on.

The instructor tried to use the experiences of the nursing students to reinforce the lecture material. The instructor questioned

the students about their personal experiences or their group's reasons for handling a scenario in a specific way. The instructor questioned the students a thorough amount of time for 70 minutes. The instructor also coached or prompted individuals and the groups to share more information about the ethical decisions that they had made and their reasoning behind those decisions. The instructor coached a thorough amount of time for 70 minutes.

The instructor encouraged the students to articulate their experiences in ethical dilemmas and their reasons for their actions. The students articulated their thoughts and actions to the other students and to the instructor. The students engaged in articulating their thoughts a thorough amount of time for 80 minutes.

The instructor wanted the students to reflect upon their actions and to appreciate the other students' perspectives in handling ethical dilemmas. The instructor encouraged the students to recognize value differences among people which influence ethical decision making. The students reflected on their experiences and the given scenarios a thorough amount of time for 80 minutes.

Clinical Observations

The researcher had intended to use the observation data instrument to record the clinical observations; however, this method was not possible due to the nature of the clinical rounds. During the clinical rounds the researcher shadowed the instructor as she worked with each student individually. The researcher was allowed to ask questions of the instructor and the students in order to better

understand the nursing program and the procedures that the nursing students were undertaking.

The instructor spent part of the time stationed in a lounge area waiting for the nursing students to report back to her after they completed their tasks. The instructor also went with some of the students to their patient's room to watch the nursing student complete a procedure or help the nursing student carry out a procedure.

The students worked on the orthopedics floor of the hospital. Each student was assigned to two patients. Three students were present during the first clinical observation. The day before the clinical round the instructor makes patient assignments to the students. The students are required to develop a care plan for each patient assigned to them so that they will be prepared to work with the patients the next morning. The nursing students come to the hospital the day before their clinical round and visit their assigned patients in order to write the care plans that night. The patient's care plan must include the patient's problems, appropriate nursing interventions, patient lab work, and patient drug treatments. The students must also research the disease process as part of their care plan for the patient.

The clinical round begins at 6:45 a.m. The instructor collects the nursing student's care plans for their patients. The students get a report from the nursing staff at the hospital on their assigned patients. The nursing students do a head to toe assessment of each patient including vital signs. The students help pass out breakfast trays and assist any patients who need help eating their breakfast. The nursing students then administer patient medications, give morning

care treatments, change dressings, give baths, and change beds. The students are allowed a thirty minute lunch break around 11:00 a.m. The students return to the orthopedics floor to help pass out lunch trays and assist any patients who need help eating lunch. The nursing students leave the hospital floor at 2:00 p.m. and meet downstairs for a post-conference. At the post-conference the instructor and nursing students discuss how their day went and what they learned.

A large part of the student's clinical rounds is spent learning how to properly administer medication to the patients. The instructor has high standards and expects the students to be extremely knowledgeable about each medication and dosage. Prior to administering medications, the nursing students go get the patient's medication orders from the staff nurse. The student nurses read the medication orders and go pick up their patient's medications. Before administering the medication to the patient, the student nurse must go before the instructor who questions the student nurse about the medication. The instructor asks the student nurse the medication's name, the doctor's prescribed dosage, the medication's recommended dosage, the medication's side effects to look for, what the medication was probably being prescribed for, any drug interactions the medication might cause, and how the student nurse could determine if their patient was getting an overdose of that medication, and how the nursing student planned to administer that medicine.

The first hour of the observation was spent listening to the instructor question the students on their medication administration. The instructor was very skilled at questioning the students. If the students did not know the answer to her question, the instructor would

rephrase or ask a different leading question which would start the students along the right path to answering the original question. Since many of the patients were taking multiple medications, the nursing students would have to stop and think and explain to the instructor why each specific medication was probably being prescribed and how these medications would effect each other. The students would also have to explain to the instructor what they would look for to determine if the dosage was too strong for the patient.

Some of the patients on the floor were older patients and often had difficulty swallowing pills. There were some patients who also had intravenous tubes and feeding tubes. The instructor would ask the nursing student how they planned to administer the drug to the patient. The nursing student often had to problem solve to figure out a way to get the medication into the patient. Sometimes this required the nursing students to break the pill in half, grind them and mix them with applesauce, or mix the medication with water so that it could be put into a feeding tube, or put the medication in an intravenous tube.

The instructor spent a great deal of time explaining different medications to the students. When students had difficulty remembering the different aspects of the medications that the instructor asked for, the instructor would slow the student down and tell them to think through the process. One student was having trouble remembering the information about the medications. The instructor advised the students to mentally picture someone she knew who had taken the drug or a patient she had who was taking the drug. The instructor told the student to find some quirky image or personality that she could

associated with the drug in order to help her remember the drug. The instructor often gave such heuristic knowledge or "tricks of the trade" to help students to learn the material. The instructor said that she evaluated each student's learning styles when they began the nursing program. The instructor was cognizant of each student's style of learning and tried to help the student find better ways of retaining the information.

One student came to the instructor and told her that she thought her patients wound dressing needing changing. The instructor asked the student how she could tell if the dressing needed changing. The nursing student told her why she thought the dressing needed changing and the instructor also gave the student some other things to look for to determine if the dressing needed changing. The student decided that she needed to change the wound dressing. The instructor had the student state her plan of action and recite the procedure. After stating an acceptable plan, the instructor observed the student changing the wound dressing since the student had never changed this type of wound dressing. Once the students had been observed administering a specific procedure successfully, the instructor usually allowed the student to do the procedure alone the next time unless they needed assistance.

The instructor pushed her students to be autonomous and independent thinkers. The instructor would automatically ask the students, "What are you going to do?, How are you going to do it?, When are you going to do it?, or What is your plan?" The students used a problem solving process called the nursing process. The students would assess a situation, examine their choices, come up with

their plan, carry out their plan, and determine the success or result of their plan. The students used the nursing process in practically every situation that they were confronted with and were very proficient at articulating their thought processes to the instructor.

The students cooperated in problem solving. Sometimes there was a shortage of wheel chairs or a particular type of bed needed to take a person to surgery. It often took several people to assess the available resources and find a solution. The instructor told of an experience that she had one time in the hospital. She came upon six people trying to take care of a simple need which was to find a bed to take a woman down to surgery. Some of the nursing procedures took more than one person to carry out. Students were required to team up together when lifting patients or changing beds.

During the second clinical observation six students were present. The students worked on the orthopedics floor and the labor and delivery floor of the hospital. The students were at different levels in the program. The different program levels require a different number of clinical hours to be completed by the students.

The students brought their patient medications before the instructor prior to administering the medication. The instructor questioned the students on each medication and its procedure for administration.

Students must demonstrate a skill and be checked off on the skill at the school before they are allowed to try the procedure at the hospital. One student needed to draw a urine specimen from a patient and asked the instructor if she needed to watch the procedure.

The instructor had already witnessed the student administering this procedure before and did not need to observe the student again.

A student informed the instructor about one of her patients who was worried about her young son who had been admitted to the hospital in the patient's home town. The instructor asked the nursing student what she could do to help the patient's mental and emotional state. The student said that she could call the other hospital and let the patient talk to her son. The instructor also suggested that the patient might want to send her son a card. The instructor advised the student that the patient probably needed a "good ear" today. The instructor encouraged her students to be empathetic to the patient's situation and do what ever they could do to help relieve any patient anxiety.

The instructor worked with her students to build their confidence level so that they could be assertive and independent. The instructor felt that half of nursing was interpersonal skills. The instructor indicated that she worked with the students on being professional and being able to communicate effectively with patients, nurses and doctors.

A nursing student expressed frustration over working with a staff nurse who would not really let the student do anything and acted like she really did not want to bother with the student nurse. The instructor asked the student what she wanted to do about the situation. The student wanted to find another nurse to work with. The student explained to the instructor how she could go about relieving the current nurse of working with her. The nursing student who was one of the advanced students went and talked to the nurse and

came back and reported her results to the instructor. The instructor pointed out that most of the first and second level nurses would not have had the confidence yet to be as assertive as her third level students. The instructor thought that it was a good sign when the nursing students started taking charge of situations on their own.

One student was getting ready to perform a heparin lock procedure on a patient. The instructor had the student run through the steps of the procedure. The instructor went to observe the student perform the procedure. The patient had other hospital staff in her room, therefore, the student nurse could not perform the heparin lock procedure. The instructor showed the student nurse a way to tape the cap on the syringe so that she could still use the same syringe later when the staff left the room. The instructor told the student to put the syringe in her pocket and never to lay down syringes anywhere because the person who might find them would have no idea what medication was in the syringe.

Students on the birth and delivery floor were involved in assisting with patients getting ready to deliver a baby. An expectant father fainted while his wife was given an epidural. The nursing student helped to monitor the father's vital signs and blood sugar until he regained consciousness. The nursing student then took the father to another room to be checked out by hospital staff. The father sent the student nurse back to his wife's room to video the birth of his child in case he missed it.

Students were able to watch vaginal births. The students assisted by "buffing" the babies after they were born. After the

vernix is wiped off of the baby, the student nurse helps to rub the baby to warm them and stimulate their circulation.

During the last part of the second observation, the hospital had a code three drill. This was a drill that the entire hospital participated in once a year. The drill was for a major outside disaster such as a plane crash with 200 wounded people. The drill was to see how long it would take the hospital to get geared up to receive the incoming wounded from such a disaster. The hospital even had people acting like they were wounded.

The students' part in the disaster drill was to let the head nurse on the floor know that they were available to assist. The nurses had to figure out how many beds they could have available and who could be possibly sent home early if their bed space was needed. The staff had to call people at home to see how long it would take them to get to the hospital in the event of such an emergency. In the event of a real disaster, the nurse's job would probably be calling doctors to get their orders for the patients who could be sent home and helping patients who could be released early get their things together so that their room could be used for the plane crash victims.

Licensed Practical Nursing Interview

An interview was conducted with the instructor of the licensed practical nursing program. The researcher used a structured questionnaire. Questions were asked concerning problem solving in that occupational area. Questions were also asked concerning problem solving instruction in the licensed practical nursing program and concerning the instructional strategies utilized by the instructor to

teach problem solving skills to the students. The interview lasted approximately 25 minutes.

The instructor had held a management position at a large local hospital. She has held her current position at the vocational technical school for twelve years. The instructor is a register nurse and holds a master of education degree.

The instructor said that there were three pages of basic skills which entry level workers currently needed to have in this occupation. Workers also needed to have basic drug administration skills, patient care skills, tracheostomy care skills, dressing change skills, math skills, and psychomotor skills.

According to the instructor, problem solving skills are the support system for future workers. If workers can problem solve, they can handle almost anything that comes along. She further stated that if workers are given the parameters in which to make decisions they can deal with things effectively. In this day and age, changes occur so rapidly that workers are going to have to be able to problem solve.

When asked how important to entry level workers the ability to solve problems was in this occupation, the instructor replied,

Really important. Most of the job is problem solving. A patient presents symptoms and complications. The nurse has to figure out what to take care of first and how to take care of their symptoms. The nurse needs to find the answer to what is going on with the patient. So I feel that problem solving is real important.

The instructor thought that problem solving skills could be taught. She has had several students who did not have the ability to think through the whole process when they first started the nursing program. These students were always looking for somebody to give them

the answers. During the clinical rounds the students were given situations and some examples of how to problem solve and come up with good solutions.

The instructor teaches problem solving in her class by using questioning techniques. She often asks the student, "What would you do in this situation?, What resources do you have? or What do you think you should do?" If the students cannot come up with a solution to the problem she will direct the student using questioning techniques.

The instructor uses clinical experiences and actual situations or scenarios to develop a student's ability to solve problems. The instructor cited an example of problem solving that students might work on in class.

A patient's blood pressure is 250 over 120 and the student was trying to decide what type of action she should take. I asked the student what she felt she should do about it. The student thought she should get some type of medication on board to get the pressure down and talk with the staff nurse. The student developed her plan of what she wanted to do. We carried out her plan and we were able to get the medicine on board, talk to the staff nurse, and get the patient's blood pressure back down into a normal range.

When asked how she measured success in problem solving, the instructor replied,

It is hard to give a quantitative measurement for this. I feel that I have been successful when I don't have to answer a lot of questions. The students start coming to me and using me as a sounding board. The students have come to the right conclusion and all I have to say is 'Yes, you are right, now go do it'. When the students work through the problem before they even get to me, then I know that they have reached that goal.

The instructor felt that some students were better than others at problem solving. According to the instructor,

I think that self-confidence enters into it. If the students feel like they know the material and they know a good solution, they are more likely to express that. If the students are not as self-confident as other students, they are hesitant to express those answers that are probably right, but they just don't have the guts to say it. More experience with problem solving helps. I don't expect someone in the first level to be as proficient as someone getting ready to graduate. Also, in our situation, willingness for me to allow the students to problem solve. Some of the instructors may not allow the students that much autonomy to make decisions.

The instructor had external evidence that made her believe that she taught problem solving skills in her class. The instructor cited the following example:

I had a student who graduated a few weeks before this incident happened. She was taking care of a patient who was giving blood. We had talked in class about patients who have a reaction to blood transfusions, but this was not really in the scope of her practice. She is supposed to monitor everything as a licensed practical nurse but doesn't really have to know everything that a registered nurse would know. She felt that the patient was having a reaction that was life threatening and she took the appropriate action. She stopped the blood, hung a new IV, got the registered nurse down there and sure enough the patient was having a blood reaction. I don't know if it saved the patient's life, but is sure expedited his treatment for that problem. The student sized up the situation and took action and got a good result. One of my students is in a management position at one of the Oklahoma City clinics so her problem solving skills have got to be excellent.

The instructor said the licensed practical nurses worked in teams and solved problems as a function of those teams. The licensed practical nurse (LPN) actually works under a registered nurse (RN) or doctor. The LPN depends on the RN for guidance and suggestions. The LPN goes to the RN if there are things that they cannot deal with or need support with.

The instructor indicated that students in her class worked in teams. During clinical rounds, the students often paired up to get tasks finished such as lifting patients, changing beds, or taking patients down for a procedure. The instructor further stated that many of the nursing skills took two people. The students engage in problem solving while working in teams. The instructor said that the nurse has to make an assessment and figure out a plan of action. An example of a problem solving activity is making sure the nurse knows the time of a patient's procedure so that the patient is not gotten out of bed twice within a certain length of time, finding a wheel chair for the patient, and calling the appropriate people.

Licensed Practical Nursing Curriculum Review

The licensed practical nursing program student handbook was used as a reference for the curriculum review. In order to keep the vocational technical school in which the study took place anonymous, it is not possible to cite this source nor include it in the dissertation bibliography.

According to the licensed practical nursing program student handbook, the licensed practical nursing curriculum is based upon the needs of the community, the client, and the students. Within this context, the nursing faculty selected necessary content, organized it into levels of instruction and determined learning experiences within the curriculum.

The licensed practical nursing program handbook further states that the theoretical concepts and threads that are integrated throughout the curriculum provide direction to the teaching-learning

process. There are three major concepts that are the foundation of the curriculum: Nursing Process, Nursing Skills, and Body Systems. The three main threads that are integrated to provide continuity are: Health, Human Needs, and Professionalism. The focus of the curriculum is the client.

The nursing process is a theoretical concept that is introduced and expanded upon throughout the curriculum. The delivery of nursing care is facilitated by utilizing the nursing process, which is a method of planning care to provide for individualized client needs. This ongoing process has five steps which are: assessment, analysis, planning, implementation and evaluation. The nursing process is a problem solving process.

The concept of nursing skills is the cognitive, psychomotor, and affective competencies that are required in the role of the practical nurse. These competencies are needed to implement the nursing process in order to provide quality care. Classroom, laboratory and clinical learning experiences are provided to acquire nursing skills.

Body systems is a major theoretical concept which is comprised of two subconcepts: normal body structure and function, and the study of disease and disorders. Knowledge of normal body structure and function is necessary for the nurse to assist the client in promotion and maintenance of health. Knowledge of disease and disorders is necessary in the prevention of illness and restoration of health.

The curriculum for the part-time practical nursing program is divided into three levels of instruction. The level objectives are based upon program objectives and build upon one another from simple to complex. These objectives reflect what students should achieve

before progressing to the next level. Objectives include the cognitive, psychomotor, and affective domains for both instruction and clinical aspects of the program.

The Oklahoma Department of Vocational Technical Education Practical Nursing Curriculum is used as a foundation for course content. The curriculum is supplemented with textbooks, learning activity packets, professional journals, audiovisual resources, and medical equipment.

A variety of teaching methods are utilized. These methodologies include lectures, demonstration, group discussion, student teaching, case studies, independent learning activities, computer assisted instruction, individualized tutoring, field trips, student and professional organization activities, patient centered conferences, laboratory simulations, and supervised clinical experience.

The instructor advised the researcher that the majority of the curriculum's problem solving instruction could be found in the program's clinical LAPS rather than in the theoretical LAPS. When nursing students begin the program the first two LAPS they must complete are on learning skills and critical thinking skills which contribute to problem solving abilities. The researcher felt that this was evidence of the program's belief that problem solving skills are part of the student's foundation in nursing. Since the majority of the time during the researcher's observations was spent observing students in a clinical setting, the researcher examined the clinical LAPS for evidence of problem solving.

According to the licensed practical nursing programs clinical handbook, during the clinical experience the student has the

opportunity to repeatedly perform nursing skills that build upon the principles and skills taught in the classroom and laboratory settings. The major portion of clinical experience was in three areas: medical-surgical, geriatrics, and obstetrics. Limited clinical experiences were provided in the operating room, surgicare unit, home health agency, and a pediatric doctor's office.

The instructor gave the researcher all of the clinical LAPS which represented the program's three levels of instruction. Students have approximated 24 months to complete the three levels of instruction. The instructor gave the researcher five clinical LAPS which totaled 480 hours. The level three leadership clinical LAP did not indicate a time range for completion.

The researcher examined the LAPS for instructional strategies used by the teacher, course content likely to include problem solving, course objectives related to problem solving, and problem solving activities to be undertaken by the students.

The content covered in the level one clinical LAP was basic nursing. The time allotted to complete this LAP was 192 hours. The objective of the LAP was for the nursing student to use the nursing process to plan and perform nursing care in the hospital setting and a long-term care facility.

The researcher estimated that approximately 80 percent of the student's time was spent on problem solving activities during the level one clinical rotation. The problem solving activities undertaken by the students were as follows: (1) Utilize the nursing process to provide for basic human needs, (2) Utilize safety practices in the workplace, (3) Utilize methods of infectious control,

(4) Apply knowledge of basic nursing principles and skills in delivery of patient care, (5) Demonstrate behaviors that support client's rights, (6) Demonstrate behaviors that reflect an understanding of legal and ethical responsibilities of nursing, and (7) Portray the role of the nurse assistant in the long-term care setting.

The instructor gave the researcher two, level two clinical LAPS to be reviewed. The content covered in the clinical LAPS was medical-surgical clinical rotation and gerontology rotation. The objective of the medical surgical clinical LAP was for the student to be able to deliver patient care under the supervision of a registered nurse in a medical-surgical hospital unit. The time allotted to complete the level two medical-surgical clinical rotation was 144 hours.

The researcher estimated that approximately 80 percent of the level two student's time was spent on problem solving activities in the medical-surgical clinical rotation. Some of the problem solving activities undertaken by the level two students were as follows:

(1) Utilize the nursing process to provide care for the medical-surgical clients according to their priority human needs, (2) Utilize the nursing process to develop a teaching plan based on the client and family's needs, (3) Apply knowledge of nursing principles and skills in the delivery of patient care in increasingly complex situations, (4) Relate basic knowledge of medication classification, action, use, and side effects to nursing care of the client, (5) Administer medications in a safe and accurate manner, (6) Begin to assist with monitoring/ maintenance of intravenous therapy, (7) Apply safety principles specific to needs of clients in various age groups, (8) Communicate effectively with the client, family and members of the

health care team, and (9) Demonstrate behaviors that reflect professional accountability during independent learning opportunities in selected clinical rotations.

The objective of the level two geriatric clinical rotation LAP was for the student to be able to identify the holistic needs of the older adult in an extended care facility and relate nursing intervention that assist in promotion and maintenance of normal structure and function for these patients. The student must also be able to differentiate between normal aging and abnormal deviations from structure and function of body systems and implement nursing management of these disorders. The time allotted to complete the geriatric clinical rotation was 64 hours.

The researcher estimated the 80 percent of the student's time allotted to complete the geriatric LAP involved problem solving activities. Some of the problem solving activities undertaken by the level two students were as follows: (1) Incorporate nursing interventions that assist in promotion and maintenance of normal structure and function for the older adult in an extended care facility, (2) Identify and report deviations from normal structure and function of body systems in the older adult, (3) Demonstrate safe application of nursing principles and skills in caring for the older adult, (4) Communicate therapeutically and establish effective relationships with clients, family, and other members of the health care system, and (5) Administer and document medications accurately and safely.

The instructor gave the researcher two, level three clinical rotation LAPS to review for problem solving instruction. The content

covered in the level three LAPS was advanced medical-surgical hospital care, and leadership. The objective of the level three medical surgical LAP was for the student to be able to discuss the responsibilities of the practical nurse on the medical surgical unit and provide care for medical-surgical patients. The time allotted to complete the level three medical surgical LAP was 80 hours.

The researcher estimated again that approximately 80 percent of the student's time to complete the LAP was spent on problem solving activities. Some of the problem solving activities in the level three medical-surgical rotation were as follows: (1) Utilize the nursing process to provide care for medical-surgical clients increasingly complex situations, (2) Implement a teaching plan based on client and family needs, (3) Continue to apply nursing principles and skills in delivering patient care in complex situations, (4) Demonstrate increasing independence in safely administering medications, (5) Assist with monitoring/ maintenance of intravenous therapy, (6) Utilize knowledge of body structure and function to identify deviations in health in increasingly complex situations, (7) Incorporate safety principles in assisting the client in adaptation to self-care deficits, (8) Apply knowledge of developmental tasks in caring for clients throughout the life span, (9) Incorporate nutritional principles in assessing dietary needs of clients, and (10) Portray behaviors that reflect respect and the dignity and right of the client.

The objective of the level three leadership clinical rotation LAP was for the student to demonstrate the responsibilities of the LPN in the assigned facility. There was no specific time frame specified

for the completion of this LAP. Some of the problem solving activities to be undertaken by the students were as follows:

(1) Practice problem solving skills and initiate appropriate nursing measures, (2) Work with peers in planning and implementing of nursing care, and (3) Evaluate self and peers.

Summary of the Licensed Practical

Nursing Program

The triangulated research methodologies of observation, interview, and curriculum review were used to determine if problem solving instruction was occurring in the part-time practical nursing program. The researcher found that indeed problem solving instruction did occur in the practical nursing program.

The researcher wanted to find out if the instructor taught specific problem solving skills in her class. The use of the theoretical LAPS required intrinsic motivation on the part of the students. The students worked cooperatively and brainstormed for solutions to problems in groups. Students also routinely worked in pairs to perform some of the procedures during clinical rotations such as lifting, changing beds, and locating beds to take patients down to surgery.

The students were taught a problem solving process called the nursing process which was used extensively as a part of instruction and was an integral part of the program's curriculum. The nursing process is an ongoing process which has five problem solving steps. The five steps to the nursing process are assessment, analysis, planning, implementation, and evaluation.

The students were proficient at articulating their thought processes to the instructor. The students were aware of their learning styles and learned the instructional material sometimes by using mental pictures to retain the information.

The students were taught to respect other student's opinions and were open to looking at different points of view. Students were able to reflect upon their actions and appreciate the action of others and other's perspectives.

Students learned to think independently. Students used the nursing process to figure out a plan of action and followed through on their plans. Students were able to evaluate the results of their plans and determine if they had made good choices.

Students were allowed to exercise creativity. Students often had to be creative in administering medication to patients and performing routine procedures. Students had to be able to adapt to new and challenging situations which were influenced by their patient's personality, illness, and sometimes circumstances beyond the student nurse's control.

The researcher wanted to find out what strategies the instructor used to teach problem solving skills to the students. The instructor used lecture, demonstration, role playing, scenarios, personal experiences and group activities. The instructor often told the students how she might handle a particular situation and often gave the students tricks of the trade.

The instructor was very skilled at questioning the students. The instructor questioned students to get them to think through an

entire process. The instructor also used questioning as a way of getting the students to articulate the reasoning behind their actions.

The students learned skills in the laboratory at the vocational technical school and were checked on those skills by the instructor. Students were required to perform most of those skills during the clinical rotations.

The instructor used clinical rotations as an arena in which the students could exercise their problem solving abilities. The instructor often coached students through a procedure or assisted a student when help was needed.

The clinical rotations were used to give the students the experiences of working with experts in their chosen field. The clinical rotations were a type of on the job training for the student. Students were assigned to patients and performed the appropriate nursing care for their patients.

The instructor pushed her students to be autonomous and independent thinkers. The students used the nursing process automatically when faced with various situations. The instructor felt that it was crucial for the students to be able to problem solve on their own in order to be a successful licensed practical nurse.

Summary of the Five Vocational Programs

The five vocational programs observed encouraged the development of problem solving abilities in students. Informal cooperation was observed in all five of the programs (Table XII). Intrinsic motivation, using technology, and creativity were observed in four of

TABLE XII
 THE OCCURRENCE OF PROBLEM SOLVING BY CATEGORY BASED ON
 OBSERVATIONS IN FIVE VOCATIONAL PROGRAMS

Program	Category							
	Intrinsic Motivation	Informal Cooperation	Group Activities	Using Technology	Diagramming	Creativity	Trouble Shooting	Using Problem Solving Steps
Applied Accounting	X	X		X				
Engineering Drafting	X	X		X	X	X		
ICT Technician	X	X		X	X	X	X	
Child Care	X	X				X		
Nursing		X	X	X		X		X

the five vocational programs. Group problem solving was observed in only one program.

The five vocational programs observed used a variety of instructional strategies to teach problem solving skills to students. The instructional strategies of questioning and coaching were used in all five of the vocational programs (Table XIII). Four of the five vocational programs used the instructional strategies of modeling and scaffolding. The instructional strategies of articulation and exploration were used in only two of the vocational programs.

TABLE XIII
 THE USE OF INSTRUCTIONAL STRATEGIES BASED ON
 OBSERVATIONS IN FIVE VOCATIONAL PROGRAMS

Program	Category							Reflection
	Questioning	Coaching	Modeling	Scaffolding	Articulation	Exploration	Interaction with Experts	
Applied Accounting	X	X	X	X				
Engineering Drafting	X	X		X				
ICT Technician	X	X	X	X	X	X		
Child Care	X	X	X				X	
Nursing	X	X	X	X	X	X		X

CHAPTER V

FINDINGS, CONCLUSIONS, RECOMMENDATIONS, AND IMPLICATIONS FOR PRACTICE

Summary

Demographic, economic, and technical forces indicate a need for workers who are able to engage in problem solving (Carnevale, Gainer, & Meltzer, 1990). Problem solving has been identified as a workplace skill that entry level workers need to have in order to find and maintain successful employment. Deficiencies in problem solving skills have been reported by employers and documented by many researchers (Berryman & Bailey, 1992; Brock, 1991; Carnevale, Gainer, & Meltzer, 1988; 1990; Feuer, 1987; Reich, 1991; Wirth, 1993; Zuboff, 1988). The problem central to this study was that entry level workers lack sufficient problem solving abilities.

Vocational education prepares people for work. Vocational educators are in the position to provide problem solving instruction to future workers. It is currently not clear the extent that problem solving is taught in vocational education programs. If problem solving is taught in vocational education programs, it is not known how it is accomplished. The purpose of the research was to investigate through a case study the problem solving instruction occurring in an area vocational technical school in Oklahoma.

According to Woods (1987) problem solving skills can be facilitated through instruction. Sellwood (1989) states that problem solving is the basis for all good teaching practices. The theory

behind the study was that problem solving skills can be taught or improved upon through instruction. Instructional strategies and problem solving models have been developed which could be used by vocational educators to facilitate the problem solving abilities of students.

Problem solving is a process. Intelligence is a component of the problem solving process. Crystallized intelligence affects the problem solver's ability to solve problems which call for judgement, knowledge, and experience (Cross, 1981). Horn (1982) states that fluid intelligence influence's the problem solver's ability to perceive, remember, and adapt to new situations.

Memory is a second component of the problem solving process. Information in the human memory is encoded, retained and retrieved for later use. According to Rubinstein & Firstenberg (1987) previously acquired information must be retrieved from long-term storage when it is applied to a new problem. Rubinstein & Firstenberg (1987) further state that the context in which a problem is framed will influence the ability of the problem solver to retrieve a possible solution from memory.

A variety of problem solving models have been developed by researchers and practitioners. A review of the literature provides insight into the following problem solving models: Polya's (1945) problem solving model, Resnick and Glaser's (1976) problem solving model, the scientific method (Killeffer, 1969), the workplace skills approach (Carnevale, Gainer, & Meltzer, 1990), the cognitive apprenticeship approach (Collins, Brown, & Newman, 1989), and the general problem solver (Ernst & Newell, 1969). Each of the models has a theoretical base, stages or dimensions, and recommended instructional methodologies. A matrix which summarizes the key points

of each of the problem solving models is presented in the summary of the review of literature.

Expert problem solvers use different skills and procedures in problem solving than novice problem solvers. Expert problem solvers are capable of mentally picturing the problem in their head (Johnson, 1989; Lockhead & Whimley, 1987; Senge, 1990; Sternberg, 1986). Expert problem solvers also use diagrams, graphs, or other figures to explain a problem and work out a solution (Johnson, 1989; Sternberg, 1986; Winn, Li, & Schill, 1991).

Case study research is an examination of a specific phenomenon such as a program, an event, a person, a process, an institution or a social group (Merriam, 1988). Case study research is an acceptable approach to use when conducting research in the field of education

Since the purpose of vocational education is to prepare people for the workplace, a vocational technical school provided an appropriate environment in which to conduct the case study. The researcher wanted to find out if the vocational education programs within the vocational school were providing problem solving instruction to students. Vocational educators are in a position to facilitate student problem solving abilities in order to adequately prepare the students to solve problems in the workplace.

The vocational technical school selected for the study was located in central Oklahoma. The school was selected based on its reputation as being a progressive vocational school, and the variety of vocational programs available to students. There were five broad occupational clusters in the school that were relevant for the case study. The five occupational clusters were business education, trade and industry, advanced technology, home economics, and health occupations. The researcher selected the vocational program from each occupational cluster which had the highest enrollment. Programs in

the case study included: the applied accounting program from the business education occupational cluster; the engineering drafting program from the trade and industry occupational cluster; the instrumentation and control technician program from the advanced technology occupational cluster; the child care program from the home economics occupational cluster; and the part-time licensed practical nursing program from the health occupations cluster.

The researcher used triangulated research methodologies to conduct the research study. The three data collection methods used in the study were classroom observation, instructor interview, and course curriculum review. During the classroom observations the researcher looked for evidence of problem solving instruction on the part of the instructor, and looked for student participation in problem solving activities. The researcher observed three, three hour blocks of classroom instruction in each program over an eight week period with the exception of the practical nursing program in which the both classroom instruction and clinical rotations were observed.

In the interview process, the researcher asked each instructor previously developed questions from a structured questionnaire. Interview questions were asked concerning the instructor's opinions on problem solving in general and methodologies or techniques the instructor might use to teach problem solving skills to students.

The curriculum for each vocational program consisted of learning activity packets commonly referred to as "LAPS". The instructor was asked to identify the learning activity packets which the students worked on during the researcher's observations. The learning activity packets were examined for course content, course objectives, and student activities which included problem solving instruction. The learning activity packets were also examined for instructional

strategies used by the teacher which might facilitate problem solving instruction.

Research Objectives and Findings

The researcher identified three research objectives for the study. The findings were reported for each of the research objectives. The first research objective was:

1. To determine the occurrence of problem solving instruction in a selected area vocational technical school in Oklahoma.

The finding was:

A. Problem solving instruction occurred in all five of the vocational programs selected for the study from the vocational technical school.

The second research objective was:

2. When problem solving is taught, to determine if vocational educators addressed specific problem solving skills through instruction or are such skills an incidental outcome of the curriculum?

The findings were:

A. All five of the vocational educators addressed problem solving skills through instruction. Problem solving instruction was a planned part of instruction. The types of problem solving skills addressed by the instructors varied among the five vocational programs.

B. The instructors facilitated the following problem solving skills: using problem solving steps, diagramming/drawing parts of a problem, participation in group problem solving, using different technologies, and troubleshooting.

C. The instructors encouraged the following characteristics of good problem solvers: intrinsic motivation, cooperation, and creativity.

D. Problem solving instruction was incorporated into the course curriculum of each vocational program. Problem solving content, objectives, activities, and strategies were purposefully designed into the self-paced instructional learning activity packets which were used as the curriculum for all vocational programs.

The third research objective was:

3. To identify instructional strategies that appear to be used by vocational educators to teach problem solving skills to students.

The findings were:

A. The researcher identified common instructional strategies used to teach problem solving skills. The researcher also identified instructional strategies used to teach problem solving skills which were specific to individual instructors.

B. Domain and heuristic knowledge was instilled into the students in order to give students an adequate knowledge base to solve problems.

C. Instructors used the following methodologies to facilitate student problem solving abilities: questioning, coaching, scaffolding, modeling, articulation, exploration, and reflection.

D. The rigid structure of self-paced instruction inhibits formal group problem solving activities.

E. Student organizations provide group problem solving opportunities for only a portion of the students enrolled in a vocational education program.

F. Self-paced instructional materials can be used to teach problem solving skills.

G. Instructors do not always incorporate into their classroom what they believe to be important in the workplace.

Discussion of the Findings

The findings of the study support the theoretical construct identified earlier in the study. The theoretical construct for the study was that problem solving skills can be taught or improved upon through instruction (Woods, 1987). Instructors taught problem solving skills to students and used a variety of instructional strategies.

In response to the first research objective, problem solving instruction occurred in all five of the vocational programs selected for the study. The researcher used the triangulated methodologies of observation, interview, and curriculum review to determine if problem solving instruction occurred in each of the vocational programs. Through classroom observation the researcher identified student problem solving skills and activities which were known to enhance student problem solving abilities and instructional strategies used to facilitate student problem solving. Through the interview process the researcher identified additional problem solving activities and instructional strategies incorporated into program instruction which did not occur during the researcher's classroom observations. The review of the curriculum for each vocational program provided further documented evidence of planned problem solving instruction.

In response to the second research objective, the researcher found through observation that each vocational instructor taught problem solving skills and encouraged the development of certain qualities which are believed to be characteristics of good problem solvers. Through the interview process the researcher was able to identify each vocational educators' support for teaching problem

solving together with their views regarding the importance of problem solving. The interview process also allowed the instructors to identify instructional methodologies or techniques which they might use in class to facilitate problem solving instruction and which may not have been observed at the time of the researcher's classroom observations. The curriculum review of the learning activity packets in each program provided the researcher with evidence of program specific problem solving content and problem solving activities which were to be undertaken by the students as they progressed through the learning activity packets. The problem solving activities ranged from simple to complex. Problem solving activities in the child care program were likely to be practical everyday problems in child care. Problem solving activities in the drafting engineering program and the instrumentation and control technician program were likely to be very technical in nature. Problem solving activities in the licensed practical nursing program were problems which affected the status of patient health and well being.

The researcher sought to identify specific problem solving skills which instructors taught to the students. The review of the literature identified a number of characteristics or qualities that good problem solvers possess. It was noted during program observations that teachers encouraged or facilitated some of these problem solving abilities.

Each instructor encouraged students in the development of their intrinsic motivation. The researcher found that the students possessed intrinsic motivation in all of the programs selected for the study. The design of the learning activity packets encouraged intrinsic motivation. In order to successfully complete the vocational program, the students were required to progress through the learning activity packets on their own. The researcher found that

some of the students were more motivated than others to work daily on the learning activity packets. Some of the instructors used various classroom management techniques such as assigning a daily grade or points to prevent the students from procrastinating or not progressing in a timely manner.

Another characteristic of good problem solvers which the researcher observed was that of cooperation. The cooperation observed between the students was of an informal nature and not a formally organized group activity. The cooperation was typically in the form of one student answering another student's question or one student helping another on a learning activity packet. Instructors encouraged cooperation by setting an appropriate physical and psychological environment for student cooperation. Classrooms which had partitions between student computer stations versus desk groupings and large tables appeared to limit the amount of cooperation between students. Programs which had music piped in overhead appeared to foster cooperation among the students. Programs in which students were allowed to call the instructor by their first name had more of a relaxed atmosphere which encouraged informal cooperation among the students and teachers.

Instructors encouraged student creativity. The instructors facilitated their students' creativity by have the students develop or design projects. In some of the vocational programs the students were allowed to approach a project from different viewpoints with there being no right or wrong answer to the project. The students were given the opportunity to be creative, but also, had to come up with a project solution that was logical and worked.

The researcher was able to identify specific problem solving skills being taught by the instructors; however, two of the instructors felt that problem solving was built into the self-paced

curriculum. The instructors in all five of the programs thought of themselves as facilitators rather than traditional instructors due to the nature of the self-paced curriculum. The researcher noted that several of the instructors were more actively involved with the students than others.

Instructors taught steps in problem solving. The way specific problem solving steps are stated vary from author to author, but some general problem solving steps are as follows: 1) Identify the problem, 2) Collect the data or information/ Develop a plan of solution, 3) Implement the plan, 4) Monitor feedback/ Adjust the plan if necessary, and 5) Evaluate the Plan. The researcher found through the review of the curriculum that the students went through part or all of the problem solving steps when doing some of their LAP activities. It was apparent from the curriculum and the researcher's observations that when students progressed through these problem solving steps, it was usually an internal process which was not articulated to the instructor or to other students. An exception was the students in the licensed practical nursing program who routinely had to state their thoughts as they used the problem solving steps labeled "the nursing process". The nursing process, a problem solving model, was used extensively by the nursing students to assess situations and make appropriate decisions. The researcher observed that the beginning nursing students gained further insight and experience in problem solving by listening to the advanced nursing students orally state their assessment of a problem situation, a plan of action, and an evaluation of the plan.

A problem solving skill that was taught to the students was the ability to diagram or draw parts of a problem. The vocational instructors from the technical programs taught this problem solving skill. By diagramming or drawing parts of a problem, the student can

learn to take problems apart and approach problems from different angles. The student who can diagram or draw parts of a problem has the skill to take a mental picture in their head and put that picture on paper to be further analyzed by themselves and other students.

Two of the vocational educators taught organized group problem solving skills to their students as a part of the classroom instruction. One instructor used brain storming techniques during classroom discussion and also had the students solve problem scenarios in teams. Students in the nursing program were required to work in teams when performing specific clinical procedures. In the engineering drafting program, the instructor required the students to work on a group design project much like the work team projects in industry.

Students who are adept at using different types of technology including computers and machinery have an advantage in problem solving over students who are not adept at using different types of technology (Berryman & Bailey, 1992). The ability to use different types of technology was a problem solving skill taught in all five of the vocational programs. When using different technologies, a problem solver has access to additional resources which may allow the student to approach a problem from different perspectives and gain additional information about the problem which may not be available without the technology.

Students were given opportunities to develop the problem solving skill of troubleshooting. When troubleshooting, the problem solver looks for the cause of the problem and tries to correct it. The researcher observed students in one of the technical programs troubleshooting equipment which was not properly working and trying to repair the equipment. Another of the vocational programs had learning

activity packets on troubleshooting which students typically worked toward the end of the vocational program.

In response to the third research objective, the researcher identified instructional strategies that vocational educators used to teach problem solving skills to students. From the review of the literature the researcher was able to determine instructional strategies which an instructor could use to facilitate problem solving in the classroom.

The researcher observed one instructor instilling domain and heuristic knowledge or "tricks of the trade" during her weekly lectures. In order for the student to adequately solve problems, the student must first have an adequate knowledge base from which to approach the problem. Instructors did not lecture to the students during the researcher's observations with the exception of this one instructor. Some of the instructors interpreted their role in self-paced instruction as being restrictive in their interaction with students. Students in all five of the vocational programs learned domain knowledge by following the steps outlined in the learning activity packets.

All five of the vocational instructors used the instructional methodologies of questioning and coaching. The instructors used questioning techniques when they wanted the students to further analyze a problem or situation. Some of the instructors would often ask leading questions or answer a student's question with another question, in order to get the student to rethink a situation. The instructors used the methodology of coaching by offering suggestions or hints to the students.

Scaffolding was an instructional strategy used by most of the instructors. In scaffolding, the instructor would usually begin a task and let the student complete the task, or the instructor would

complete part of a task that the student was not yet capable of handling on their own. Scaffolding lets the student to see how parts of a task may fit together, and allows the student to view the entire task being completed.

The instructional strategy of modeling was used by many of the vocational instructors. In modeling, the instructor models or portrays the behavior of a worker in that particular occupation. The instructional strategy of modeling gives the student an example that they can emulate. Instructors who continually model problem solving behavior show their students appropriate ways to go about solving problems.

The researcher observed the instructional strategy of articulation being used by two of the vocational instructors. Students were asked to articulate or verbally state their thought processes to the instructor when solving problems. In one of those programs, the instructor also had the students explain their reasoning to other students in the class. It is very helpful for students to hear how their classmates go about solving problems. Students can often explain a problem and its solution to their classmates in a way that make the problem easier for the classmates to understand.

Two of the instructors used the instructional strategy of exploration. One of the technical programs approached problem solving instruction by have the students solve problems by trial and error. The students explored the problem on their own and figured out the solution by trial and error with minimal or no help from the instructor. This vocational program felt that the trial and error method worked well because workers in that occupational field typically solved problems in the workplace through trial and error. Another instructor used the instructional strategy of exploration by

having students role play workplace procedures in class before trying the procedures in a workplace setting.

The instructional strategy of reflection was used by one of the vocational instructors. Students were taught to reflect upon their own actions and appreciate the actions and perspectives of fellow students. The instructor felt that by encouraging her students to reflect on their actions and evaluate themselves, she was teaching her students to be autonomous and independent thinkers which were important qualities for a worker in that particular vocation to possess.

The rigid structure of the self-paced instruction inhibited organized group problem solving instruction. The learning activity packets were organized in such a way that the students progressed in a very structured step by step manner. While self-paced instruction allows for individual learner differences, it limits the amount of interaction between students in organized group problem solving activities. Some of the instructors were locked into the practice of students learning in isolation.

Student organizations provide problem solving opportunities to some of the vocational education students. The instructors indicated that student organizations were used to supplement classroom experiences. Some of the instructors specifically stated that group problem solving was taught solely through their student organization.

The instructors went on to say that the student organization officers engaged in group problem solving activities. Since not all students join a student organization, and of those students that join not all can be officers, student organizations alone do not provide adequate group problem solving experiences for all students enrolled in a vocational program.

The use of self-paced instruction for problem solving presents special challenges to the instructor. Some students may have difficulty in adjusting to a self-paced instructional approach to learning. Instructors need to be knowledgeable of classroom instructional and management techniques that work well in a self-paced classroom environment. Teachers who use self-paced instruction should have special preparation.

Instructors did not always incorporate into their classroom instruction what they believed to be important in the workplace. During the interview process the instructors stressed how important the team concept was in today's workplace, yet several of the instructors failed to include any type of organized group problem solving activity in their classroom instruction. Some of the instructors felt that self-paced instruction did not allow for formal organized group problem solving experiences.

Conclusions

Several conclusions were developed as a result of the data collection and analyses, and the review of the literature. Since the research study was a case study, the conclusions should not be generalized to all vocational programs; however, the conclusions are offered to the reader for consideration. The conclusions were:

1. Students who complete vocational programs as represented by those included in this study will, as workers, have problem solving skills.

2. When self-paced instruction is a major component of classroom instruction, specific problem solving elements need to be made interactive in a vocational program that seeks to develop student problem solving. These elements are formal organized group problem solving activities, experiences in which students regularly explain

and discuss their reasoning with the instructor and other students, and problem solving activities which require a variety of approaches on the part of the student.

3. These vocational education programs provided excellent opportunities for facilitating student problem solving abilities in order to meet the problem solving demands placed on workers in the workplace.

4. These vocational education programs should focus on the development of collaborative problem solving skills.

Recommendations for Research and Practice

As a result of the study, the following three recommendations are made to vocational educators for further research.

1. Future research needs to be conducted which measures the effectiveness of different types of problem solving instruction on student problem solving abilities.

2. Research needs to be conducted which develops a good observation instrument which can be used to identify problem solving activities in both educational and work settings.

3. Research could be conducted concerning the effectiveness of self-paced instruction from the instructor's perspective and the student's perspective.

As a result of the study, the following recommendations are made to vocational educators for practice.

1. Organized group problem solving activities need to be incorporated into classroom instruction.

2. Instructors should not rely on student organizations as the only means of providing group problem solving instruction to students.

3. Vocational instructors housed in the same instructional facility should meet regularly to discuss issues concerning classroom management and instruction.

4. Vocational programs which seek to develop problem solving abilities of students need to have the following interactive elements: formal organized group problem solving activities, opportunities for students to articulate their problem solving thought processes to fellow students and the instructor, and exposure to situations which require the students to use a variety of problem solving approaches.

Discussion of Recommendations and Implications for Practice

Problem solving instruction needs to be one of the most important goals of vocational educators. Problem solving occurs in the workplace both individually and in teams. Vocational educators need to develop the student's individual problem solving abilities, as well as, the student's ability to participate effectively in a group problem solving process.

In response to the first recommendation, informal cooperation between students is no substitute for formal organized group activities. The instructor needs to provide activities which allow the students to actively interact with each other. Instructors cannot assume that students are equipped to participate as a member of a work team in the workplace environment. The instructors need to incorporate team activities or projects into the classroom. These planned group problem solving activities should mirror problems the students will encounter in the workplace.

In response to the second recommendation, all vocational students need access to organized group problem solving experiences in order to develop good group problem solving skills and interpersonal

order to develop good group problem solving skills and interpersonal skills. Student organization experiences cannot replace learning experiences in the classroom. Vocational instructors should not rely solely on student organizations for teaching group problem solving skills.

In response to the third recommendation, vocational instructors do not appear to be aware of how other vocational instructors approach classroom challenges in using self-paced instruction. Vocational instructors should meet with instructors outside of their occupational cluster. Such meetings would allow instructors to exchange ideas and learn successful instructional techniques from their peers.

Vocational educators using self-paced instruction may have to alter their instructional strategies in order to incorporate formal organized group problem solving instruction. Vocational educators should not use self-paced instruction as an excuse to not include group problem solving activities. Vocational educators need to follow the leads of other vocational educators who have successfully adjusted self-paced instruction to include organized group problem solving experiences.

In response to the fourth recommendation, vocational instructors need to evaluate their instructional strategies and their curriculum to determine if problem solving experiences in their programs contain essential problem solving elements. Problem solving instruction needs to include formal organized group problem solving opportunities, experiences which allow students to articulate their reasoning to other students, and problem solving activities which require a variety of approaches.

Planned organized group problem solving activities provide an avenue in which students can develop team problem solving skills essential for today's worker. Opportunities where students can orally

explain their problem solving thought processes to peers and the instructor allow for insight into the problem solving approaches and strategies of others. It is important for students to be able to engage in metacognition or think about thinking and express their reasoning to others. Students should be exposed to problem solving situations which require a variety of problem solving approaches. Problem solving experiences provided by the instructor should include trial and error problem solving, problem solving steps or models, troubleshooting, and experiences in an actual work setting.

BIBLIOGRAPHY

- Airing, M. K. (1993). What the "v" word is costing America's economy. Phi Delta Kappan, 74(5), 396-404.
- Almy, M. (1966). Young children's thinking. New York: Teachers College Press.
- Bailey, T. (1988). Education and the transformation of markets and technology in the textile industry. (Tech., Paper No. 2). National Center on Education and Employment. New York: Columbia University
- Berryman, S. (1988, July). Education and the economy: A diagnostic review and implications for the federal role. Paper presented at the Aspen Institute's Seminar on the Federal Role in Education, Aspen, CO.
- Berryman, S. E., & Bailey, T. R. (1992). The double helix of education and the economy. New York: The Institute of Education and the Economy.
- Best, J. W. (1981). Research in education (4th ed.). Englewood Cliffs, NJ: Prentice-Hall.
- Brock, W. E. (1991, Feb./Mar.). Training for the high skilled workforce. American Association of Continuing Junior Colleges, 21-25.
- Brookfield, S. D. (1987). Developing critical thinkers. San Francisco: Jossey-Bass.
- Carnevale, A. P., Gainer, L. J., & Meltzer, A. S. (1988). Workplace basics: The skills employers want. The American Society for Training & Development, and the United States Department of Labor Employment & Training Administration. Washington, DC: U. S. Government Printing Office.
- Carnevale, A. P., Gainer, L. J., & Meltzer, A. S. (1990). Workplace basics: The essential skills employers want. San Francisco: Jossey-Bass.
- Cattell, R. B. (1963). Theory of fluid and crystallized intelligence: A critical approach. Journal of Educational Psychology, 54(1), 1-22.

- Chute, A., Hancock, B., & Balthazar, L. (1991). Distance education futures: Information needs and technology options. Performance & Instruction, 30(10), 1-5.
- Collins, A., Brown, J., & Newman, S. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L. B. Resnick (Ed.), Knowing, learning, and instruction (pp. 453-494). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Cross, K. P. (1981). Adults as learners: Increasing participation and facilitating learning. San Francisco: Jossey-Bass.
- Dewey, J. (1933). How we think. Boston: Raytheon Education Co.
- Dixon, R. A., & Baltes, P. B. (1986). Toward life span research on the functions and pragmatics of intelligence. In R. J. Sternberg & R. K. Wagner (Eds.), Practical intelligence: Origins of competence in the everyday world. New York: Cambridge University Press.
- Drucker, P. (1989, May). How schools must change. Psychology Today, 18+.
- Ernst, G. W., & Newell, A. (1969). GPS: A case study in generality and problem solving. New York: Macmillan.
- Feuer, D. (1987). The skill gap: America's crisis of competence, Training, 24(12), 27-35.
- Flavell, J. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), The nature of intelligence (231-235). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Greenfield, L. B. (1987). Teaching thinking through problem solving. In J. Stice (Ed.), Developing critical thinking and problem solving abilities. New Directions for Teaching and Learning, 30, 5-22. San Francisco: Jossey-Bass.
- Guba, E. G., & Lincoln, Y. S. (1981). Effective evaluation. San Francisco: Jossey-Bass.
- Horn, J. L. (1982). The aging of human abilities. In B. B. Wolman (Ed.), Handbook of development psychology. Englewood Cliffs, NJ: Prentice-Hall.
- Howell, W. C., & Cooke, N. J. (1989). Training the human information processor: A look at cognitive models. In I. L. Goldstein (Ed.), Training and development in work organizations: Frontiers of industrial and organizational psychology. (pp. 121-182). San Francisco: Jossey-Bass.
- Inhelder, B., & Piaget, J. (1964). The early growth of logic in the child. New York: Harper and Row.

- James, W. K. (1990). Development of creative problem solving skills. The Technology Teacher, 49(5), 29-30.
- Johnson, S. (1989, Sept.). Using cognitive task analysis. Instructional Microcomputing Newsletter, pp. 8-10.
- Johnson, S., & Thomas, R. (1992). Technology education and the cognitive revolution. The Technology Teacher, 51(4), 7-12.
- Jorgenson, D. L. (1989). Participant observation. Newbury Park, CA: Sage.
- Kerlinger, F. (1986). Foundations of behavioral research (3rd ed.). Orlando, FL: Harcourt Brace Jovanovich.
- Killeffer, D. H. (1969). How did you think of that? Garden City, NY: Doubleday.
- Krulik, S., & Rudnick, J. (1980). Problem solving: A handbook for teachers. Boston: Allyn and Bacon.
- Langley, P. (1989). The central role of learning in cognition. In H. A. Simon (Ed.), Models of thought (vol. 2, pp. 102-115). New Haven, CT: Yale University Press.
- Larkin, J. H. (1989). What kind of knowledge transfers? In L. B. Resnick (Ed.), Knowing, learning, and instruction (pp. 283-305). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Lockhead, J., & Whimley, A. (1987). Teaching analytical reasoning through thinking aloud pair problem solving. In J. Stice (ed.), Developing critical thinking and problem solving abilities. New Directions for Teaching and Learning, 30, 73-92. San Francisco: Jossey-Bass.
- Marzano, R. J., & Ewy, R. (1989). Thinking for tomorrow. Vocational Education Journal, 64(5), 28-31.
- Merriam, S. (1988). Case study research in education. San Francisco: Jossey-Bass.
- Merriam, S., & Caffarella, R. (1991). Learning in adulthood. San Francisco: Jossey-Bass.
- Pellegrino, J., & Schadler, M. (1974). Maximizing performance in a problem solving task. Unpublished manuscript, University of Pittsburgh, Learning Research and Development Center.
- Polya, G. (1945). How to solve it. Princeton, NJ: Princeton University Press.
- Porter, M. (1990). The competitive advantage of nations. New York: Free Press.

- Reich, R. B. (1991). The work of nations: Preparing ourselves for 21st century capitalism. New York: Knopf.
- Resnick, L. (1987). Education and learning to think. Washington, DC: National Academy Press.
- Resnick, L., & Ford, W. (1981). The psychology of mathematics for instruction. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Resnick, L., & Glaser, R. (1976). Problem solving and intelligence. In L. B. Resnick (Ed.), The nature of intelligence (pp. 205-230). Hillsdale, NJ: Lawrence, Erlbaum Associates.
- Rubinstein, M., & Firstenberg, I. (1987). Tools for thinking. In J. Stice (ed.), Developing critical thinking and problem solving abilities. New Directions for Thinking and Learning, 30, 23-26. San Francisco: Jossey-Bass.
- Rybash, J., Roodin, P., & Santrock, J. (1991). Adult development and aging (2nd ed.). Dubuque, IA: William C. Brown.
- Schulz, R., & Ewen, R. (1988). Adult development and aging. New York: Macmillan.
- Scribner, S., & Cole, M. (1981). The psychology of literacy. Cambridge, MA: Harvard University Press.
- Sellwood, P. (1989). The role of problem solving in developing thinking skills. The Technology Teacher, 49(3), 3-10.
- Senge, P. M. (1990). The fifth discipline. New York: Doubleday.
- Simon, H. A. (1989). Problem solving and education. In H. A. Simon (Ed.), Models of thought (vol. 2., pp. 278-288). New Haven, CT: Yale University Press.
- Spradly, J. P. (1980). Participant observation. New York: Holt, Rinehart, & Winston.
- Stake, R. E. (1981). Case study methodology: An epistemological advocacy. In W. W. Welsh (Ed.), Case study methodology in educational evaluation. Proceedings of the 1981 Minnesota Evaluation Conference. Minneapolis: Minnesota Research and Evaluation Center.
- Sternberg, R. (1985). Beyond IQ: A triarchic theory of human intelligence. New York: Cambridge University Press.
- Sternberg, R. (1986). Intelligence applied: Understanding and increasing your intellectual skills. Orlando, FL: Harcourt Brace Jovanovich, Inc.
- United States Department of Labor. (1991). What work requires of schools: A SCANS report for America 2000. Washington, DC: U. S. Government Printing Office.

- Vobejda, B. (1987, April 14). The new cutting edge in factories. The Washington Post, p. A14.
- Wilson, B., & Cole, P. (1991). A review of cognitive teaching models. Educational Technology, Research, and Development, 39(4), 47-63.
- Winn, W., Li, T., & Schill, D. (1991). Diagrams as aids to problem solving: Their role in facilitating search and computation. Educational Technology, Research, and Development, 39(1), 17-29.
- Wirth, A. G. (1992). Education and work for the year 2000. San Francisco: Jossey-Bass.
- Wirth, A. G. (1993). Education and work: The choices we face. Phi Delta Kappan, 74(5), 361-366.
- Woods, D. R. (1987). How might I teach problem solving? In J. Stice (ed.), Developing critical thinking and problem solving abilities. New Directions for Teaching and Learning, 30, 55-72. San Francisco: Jossey-Bass.
- Yin, R. K. (1994). Case study research (2nd ed.). Thousand Oaks, CA: Sage.
- Zuboff, S. (1988). In the age of the smart machine: The future of work and power. New York: Basic Books.

APPENDIXES

APPENDIX A

RESEARCH PROJECT INFORMATION SHEET

RESEARCH PROJECT INFORMATION SHEET

Title of Project: A Case Study of Problem Solving Instruction
in Selected Vocational Education Programs.

Purpose of Research Project:

A review of the literature indicates that problem solving is a skill that workers need in order to succeed in the workplace. The purpose of the research study is to investigate through a case study approach the level and types of problem solving instruction occurring in selected vocational programs within an area vocational technical school in Oklahoma.

Classroom Observations:

I will need to observe three of your classes. Since classes are in three hour blocks, this will amount to approximately nine hours of classroom observation. I will schedule the observations with you ahead of time. I will observe no more than one class per week. The observations will take place over a period of eight weeks. Please continue to conduct your classes as usual. If you have no objection, I will use a small audio tape recorder to record the classroom activities. The use of the tape recorder will help me to take accurate notes.

Interview:

At the end of the observations, I will need to conduct an interview with you. The interview will take approximately 20 minutes. I will use a small audio tape recorder during the interview and take brief notes.

Curriculum Review:

I will need to look at a copy of the curriculum that you are currently using in your class. I will be reviewing the curriculum to see if problem solving has been included as a part of the curriculum objectives, content, and activities.

Thank you for agreeing to participate in the study. To ensure confidentiality of the data collected, your name will not appear on any documents used in the study nor the name of the vocational technical school.


Stephanie Curtis

APPENDIX B

RESEARCH INSTRUMENTS

Problem Solving Incident		Comments
6. Using computers/ machinery to solve problems.		
7. Trouble shooting		
8. Repairing items		
9. Creating things		
10. Building/ constructing projects		
11. Decision making		
Instructor facilitates problem solving by:		
12. Instilling adequate knowledge base.		
A. Domain		
B. Heuristic		
C. Control Strategies		
D. Learning Strategies		
13. Building classification skills.		
14. Questioning		
15. Using a variety of methodologies.		
A. Modeling		
B. Coaching/ prompting		
C. Scaffolding/ fading		
D. Articulation		
E. Reflection		
F. Exploration		
16. Sequencing learning activities.		
A. Increasing the complexity of tasks		
B. Increasing the diversity of tasks		
C. Teaching global before local skills		

INTERVIEW DATA

Program: _____
Class: _____
Date: _____

1. How did you come to be an instructor
at _____ VoTech?

Comments:

2. What skills do entry level workers currently need to have
in this occupation?

Comments:

3. What do you think the role of problem solving is to future
workers?

Comments:

4. How important to entry level workers in this occupation is
the ability to solve problems?

Why or why not is problem solving important in this
occupation?

Comments:

5. Do you think that problem solving skills can be taught?

Comments:

6. Do you teach problem solving skills in your class?
If yes,

a. Would you describe the techniques/ methodologies you use to teach problem solving?

b. Describe any activities which you use to develop the student's ability to problem solve.

c. Describe examples students work on in class.

d. How do you measure success in teaching problem solving?

Comments:

7. What do you think makes some students better than others at problem solving?

Comments:

8. Do you have external evidence (i.e. from employers) that makes you believe students learn problem solving in this class?

Comments:

9. Do workers in this occupational area ever have to work in teams? If yes,
- a. Do they have to solve problems as a function of these teams?
 - b. Give examples.

Comments:

10. Do students in this class ever work in teams? If yes,
- a. Do students engage in group problem solving?
 - b. Give examples.

Comments:

CURRICULUM DATA

Program: _____

Class: _____

Date: _____

Course Content Likely to Include Problem Solving Instruction:

Course Objectives Related to Problem Solving:

Problem Solving Activities to be Undertaken by the Students:

Instructional Strategies to be Used by the Teacher:

APPENDIX C

INSTITUTIONAL REVIEW BOARD APPROVAL FORM

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 10-03-94

IRB#: ED-95-017

Proposal Title: A CASE STUDY OF PROBLEM SOLVING INSTRUCTION IN SELECTED
VOCATIONAL EDUCATION PROGRAMS

Principal Investigator(s): Melvin D. Miller, Stephanie A. Curtis

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

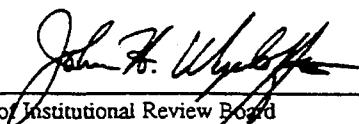
APPROVAL STATUS SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT
MEETING.

APPROVAL STATUS PERIOD VALID FOR ONE CALENDAR YEAR AFTER WHICH A CONTINUATION
OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.

ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Reasons for Deferral or Disapproval are as
follows:

Signature:


Chair of Institutional Review Board

Date: October 14, 1994

2
VITA

Stephanie A. Curtis

Candidate for the Degree of
Doctor of Education

Thesis: A CASE STUDY OF PROBLEM SOLVING INSTRUCTION IN SELECTED
VOCATIONAL PROGRAMS WITHIN A VOCATIONAL TECHNICAL SCHOOL

Major Field: Occupational and Adult Education

Biographical:

Personal Data: Born in Riverside, California, January 27, 1961,
the daughter of Doris and V.K. Curtis.

Education: Graduated from Alva High School, Alva, Oklahoma in
1979; received Bachelor of Science degree in Home
Economics from Oklahoma State University in December, 1982;
received Vocational Home Economics Teacher Certification
from Northwestern Oklahoma State University in December,
1983; received Master of Science degree from Oklahoma
State University in December, 1988; completed requirements
for the Doctor of Education degree at Oklahoma State
University in May, 1995.

Professional Experience: Vocational Home Economics Teacher,
Buffalo High School, Buffalo, Oklahoma, 1984-86; Child
Nutrition Programs Coordinator for the Oklahoma State
Department of Education, 1986 to present.

Professional Organizations: Member of American Vocational
Association, Oklahoma Vocational Association, American
Association of Adult and Continuing Education, Association
for Supervision and Curriculum Development, American
School Food Service Association.