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Learning Expectations and Learning from Problem Situations in Occupational Education

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LEARNING EXPECTATIONS AND LEARNING FROM PROBLEM SITUATIONS IN OCCUPATIONAL EDUCATION

by

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Employers have shown a growing interest in problem-solving skill in addition to specific occupational skills (Carnevale, Gainer, and Meltzer, 1990). Learning expectations are defined as attitudes involving the self-conception of one's ability to respond to difficult situations, and learning from problem situations is defined as the ability to organize specialized knowledge so that it can be applied to a new situation. The purpose of the study was to examine relationships among these two variables and performance in a situation requiring the application of occupational knowledge under a novel set of conditions. The study was carried out at the Industrial Machine Tool program of the Regional Manufacturing Technology Center in Battle Creek, Michigan.

A problem scenario was constructed involving a request to set up a machine to cut a part which the trainees had previously learned to produce; however, the scenario required use of an unfamiliar method and provided information in an unfamiliar manner. Eighteen subjects responded to the scenario and completed instruments measuring learning

expectations and learning from problem situations. The Intellectual Achievement Responsibility scale (IAR) (Crandall, Katkoksy, and Crandall, 1965) was used to operationalize learning expectations. The IAR requires a choice between internal and external assessments of responsibility for positive and negative intellectual outcomes. A three-question interview following the problem scenario was used to operationalize learning from problem situations. The interview questions concerned the concepts necessary to apply previously acquired knowledge to the scenario.

There was a significant positive correlation between performance on the problem scenario and the results of the follow-up interview. There was no correlation between total IAR scores and both performance on the problem scenario and learning from problem situations. However, there was a significant positive correlation between the IAR scale for positive outcomes and performance on the scenario and a significant negative correlation between the IAR scale for negative outcomes and the results of the follow-up interview. These results indicate that the organization of occupational knowledge is related to the ability to apply it to new situations. However, the results do not support the hypothesized relationship between learning expectations and learning from problem situations.

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CHAPTER I

THE PROBLEM

Introduction

Under the "scientific management" movement of the early twentieth century, front-line industrial workers were only expected to do what they were told to do, leaving problem-solving and decision-making to efficiency experts (Nelson, 1975). Today, however, employers expect workers to do more than follow directions; quality circles and self-managed teams require both individual and group problem-solving and decision-making. Bailey, (1990) lists technological change, shorter production runs, and increased emphasis on quality as factors which have increased responsibilities for the front-line manufacturing workforce. Cohen and Zysman (1987) attribute the success of Japanese industry to the fact that front-line workers are given broad areas of responsibility rather than assigned specific tasks. In contrast, Berger and others (1989) note the lack of training in problem-solving in the American manufacturing work force.

Surveys of employers (Carnevale, Gainer, and Meltzer, 1990; Hulsart and Bauman, 1983; Junge, Daniels, and Karmos,

1984; and Mehrens, 1989) show that front-line workers are expected to be able to recognize problems, respond to new situations, and learn new skills. These findings are symptomatic of a new view of occupational skills; Berryman (1993) notes that the traditional conception of a job as a "fixed bundle of tasks and skill requirements" is being replaced by the expectation that an individual will be flexible enough to meet the varied demands of a particular work environment (p. 346). Because employers need front-line workers who can analyze a situation and determine an appropriate response, occupational education programs are increasingly expected to include problem-solving skills along with job-specific skills.

Statement of the Problem

General Problem-solving Skill

There is no doubt that entry-level employees must have at least a basic level of problem-solving skill; however, there is a lack of agreement as to how these skills should be taught in occupational education programs. One possible solution would be to teach procedures that have been associated with a high level of success in problem situations. Bransford, Sherwood, Vye, and Rieser (1986) state that a common element in the behavior of successful problem-solvers regardless of the content domain is the use of an

organized problem-solving process consisting of recognition, definition, exploration, action, and revision. The use of a structured process is particularly important if the problem situation requires an extensive search for applicable knowledge (Salomon and Perkins, 1989) or if the problem situation is in an area in which the problem-solver lacks previous experience (Simon, 1980).

However, the idea that the acquisition of problem-solving skill based on practice in one content domain results in a similar level of problem-solving proficiency regardless of the content domain was discredited almost a hundred years ago by Thorndike and Woodworth (1901/1965; also summarized in Clifford, 1968, pp. 270-273). By challenging then current beliefs about "mental disciplines," Thorndike initiated the study of transfer, the ability to use what has been learned in one context in another context. Thorndike put forward a more limited theory of transfer based on "identical elements," common characteristics of different situations; however, Royer (1979) states that this explanation of transfer is limited to the characteristics of the transfer situation rather than those of the problem-solver. Bransford, Sherwood, Vye, and Rieser (1986) note that although problem-solving proficiency is characterized by the use of general problem-solving strate-

gies, it also requires the presence of organized knowledge in a specific content domain.

One factor in problem-solving competence is how people feel about their ability to solve problems. Despite denying the independent existence of mental functions related to general problem-solving skill, Thorndike (1902) did include attitudes arising from specific types of situations as examples of the influence of "generally applicable ideas which special training may inculcate" (p. 176). Nickerson (1988-89) takes a similar approach by defining problem-solving ability as including both the ability to employ a set of general techniques and proficiency in a particular content domain. He attempts to minimize the question regarding the existence of a general problem-solving skill that can be transferred into competence in a wide variety of specific content domains: "The controversy . . . regarding the relative importance of general thinking skills and domain-specific knowledge . . . seems to involve primarily a question of emphasis" (p. 13). Among the common elements of problem-solving proficiency, Nickerson includes attitudes relating to the control of cognitive processes and self-responsibility for outcomes of difficult situations. Derry and Murphy (1986) also include attitudes toward problem situations as elements of problem-solving skill by noting that general problem-solving skills

may not be applied to specific situations unless certain requirements for their use are met, including "feelings of efficacy regarding . . . their potential" (p. 8). "Feelings of efficacy" depend on possession of knowledge related to a specific content domain, but regardless of the content domain, an individual's attitudes toward difficult situations constitute a common element of the problem-solving process.

Attitudes Toward Difficult Situations

The level of effort that an individual will expend when faced with an uncertain outcome depends on his or her judgment regarding the likelihood of a positive outcome in new or difficult situations. Both personal and task characteristics affect the initial evaluation of a new situation (Palmer and Goetz, 1988). One aspect of the attitudes relating to personal characteristics involves beliefs about the degree of self-responsibility for the outcomes of difficult situations (McCombs, 1988). In other words, individuals who are confident about their problem-solving ability are more likely to use strategies requiring a high level of effort. Resnick describes the willingness to use learning strategies as involving a "definition of oneself as someone who's able to do these complex things" (quoted in Brandt, 1988, p. 15). The possession of related knowl-

edge affects the willingness to use a particular problem-solving strategy, but expectations of success can differ among individuals with similar knowledge levels.

Support for a relationship between attitudes toward difficult situations and the use of problem-solving strategies is provided by studies of the use of learning strategies. The association between awareness of the value of particular reading skills and self-regulation of reading behavior (Palincsar and Brown, 1989) means that individuals who are aware of the purpose of different reading strategies are more likely to use a variety of reading strategies than those who are not. Similarly, the use of study strategies has been shown to depend on knowledge of the purposes of particular techniques in addition to knowledge of the strategies themselves (Hounsell, 1979). Resnick and Klopfer (1989) see a stronger association between problem-solving ability and willingness to use problem-solving techniques than between problem-solving ability and knowledge of problem-solving techniques. This leads to the proposition that success in difficult situations, i.e situations in which a high level of effort is required, is associated with attitudes such as confidence in one's abilities, persistence in the face of difficulty, openness to new ideas, and willingness to revise a working hypothesis when faced with new information.

This study is an attempt to provide support for the existence of a relationship between attitudes toward difficult situations and the organization of specialized knowledge as an element of problem-solving proficiency. Attitudes toward difficult situations involve an individual's approach to learning over a wide variety of content areas. On the other hand, the organization of specialized knowledge is based on the identification of characteristics that are used to define the common elements of a particular type of problem situation. Because possession of the knowledge needed to identify the key elements of a problem situation may not always lead to a successful response to a problem situation, a third variable was added to this study, namely performance in a problem situation requiring the application of occupational knowledge. In other words, this study examined relationships between general and domain-specific components of problem-solving skill as well as between those variables and problem-solving proficiency.

In order to address the research problem, it was necessary to identify a body of occupational knowledge in which performance in new situations is a common occurrence. Machine tool technology was used for this study because problem-solving is a key element of the wide variety of tasks performed under both conventional and computerized technologies (Martin and Scribner, 1991). The common

characteristics of machine tool-related occupations include a high level of precision, responsiveness to a wide variety of task demands, and the necessity of transforming information from verbal, written, or graphic instructions.

Definitions of Variables

Three variables were involved in this study: learning expectations, performance in a problem situation, and learning from problem situations. Learning expectations are attitudes relating to an individual's ability to respond to problem situations, performance in a problem situation is the ability to respond successfully to a new situation, and learning from problem situations is the ability to apply general principles from a body of knowledge to new situations.

Learning Expectations

Learning expectations are beliefs regarding one's ability to use learning strategies to develop a successful response to a difficult situation. Learning strategies are procedures that have been used in previously encountered situations and are expected to facilitate the response to a new situation. Learning expectations have been shown to affect persistence in the use of strategies (Palmer and Goetz, 1988) and the willingness to refer to what is al-

ready known (McCombs, 1988). Learning expectations reflect the outcome of previous situations that are perceived to be similar as well as general attitudes toward problem situations. Particularly in situations when levels of knowledge and experience are equivalent, differences in learning expectations can be used to explain differences in attitudes toward difficult or challenging situations as well as differences in the willingness to use learning strategies.

Differences in learning expectations have been found in situations when different approaches to learning tasks are possible. Schmeck (1983; 1988) studied how college students approach learning tasks. He found that differences in learning expectations are associated with differences in the use of learning strategies when studying. An approach to learning based on a goal of transforming what is learned is associated with the use of a wide variety of learning strategies. On the other hand, an approach to learning tasks based on a goal of memorizing what is learned is associated with the use of a limited repertoire of learning strategies. Säljö (1979a) identified differences in learning expectations in a population of out-of-school adults. He found that his subjects understood learning as either a qualitative or quantitative process. The qualitative conception of learning emphasizes learning as a process of assimilation and creation of meaning; the

quantitative conception of learning emphasizes the ability to reproduce the content of what is learned. Säljö (1979b) showed that these differences are related to differences in the understanding of complicated texts.

Operational Definition of Learning Expectations

Measurement of learning expectations requires some means of illustrating differences in self-conception of learning. The Intellectual Achievement Responsibility scale (IAR) (Crandall, Katkovsky, and Crandall, 1965) is a thirty-four question inventory requiring a forced-choice between internal and external attributions of responsibility for both positive and negative intellectual achievements. Dweck and Bempechat (1983) used the IAR in a study of persistence in challenging situations to classify attitudes toward intelligence as entity or incremental. Under the entity conception, intelligence is seen as a fixed quantity, and problem situations are seen as tests of existing knowledge. Under the incremental conception of intelligence, problem situations are seen as opportunities for learning in which related knowledge can be used to develop an appropriate response. The rationale for using the IAR is that under the incremental perspective, learning is viewed as an internal process characterized by an attribution of self-responsibility for learning outcomes and

that under the entity perspective, learning is viewed as an external process characterized by an attribution of responsibility for learning outcomes to outside agencies.

Performance in a Problem Situation

Performance in a problem situation, the second variable in this study, is the ability to respond to a situation for which a response is not immediately available because it is different from those that have been previously encountered. Problem difficulty depends on the degree of difference between a problem situation and a target situation, a potentially relevant situation in a problem-solver's previous experience. The least difficult problem situations, such as performance of a mathematical computation by an elementary school student or performance by a mechanic of a familiar repair operation on a slightly different type of automobile, involve an easily identifiable correspondence between the elements of a problem situation and those of a recently experienced target situation. The most difficult problem situations, such as reducing the dropout rate in an inner city high school or designing an energy-efficient automobile are characterized by the absence of an identifiable target situation, thus requiring the creation of a hypothetical target situation out of fragments of previously experienced situations.

The level of problem-solving skill under investigation in this study falls between the two extremes of difficulty. The availability of a target situation and a generally accepted solution procedure are characteristics of a problem situation below the highest level of difficulty. On the other hand, the selection of a target situation from among several possible variations and the subjects' lack of experience with the process of selection are indications of a problem situation above the lowest level of difficulty.

Operational Definition of Performance in a Problem Situation

Machine tool technology can be viewed as a body of occupational knowledge and skills which are frequently applied to new situations. This study used a problem scenario developed by the researcher based on principles of machine tool technology to measure performance in a problem situation. The scenario involved a request to set up a lathe to cut a type of part which the subjects had previously produced during their training. However, both the information that was given and the conditions under which the part had to be produced required operations not previously performed by the subjects. During their response to the scenario, the subjects were provided with reference material containing a comprehensive treatment of the various procedures for cutting this type of part. Performance

on the scenario was evaluated according to the following criteria: the selection of an appropriate method, the performance of necessary calculations, and the explanation of how the machine would be set up to produce the requested part.

Learning From Problem Situations

Learning from problem situations, the third variable in this study, is the transformation of what has been learned in one set of conditions into the knowledge that is needed to respond to a different but related set of conditions. Learning from problem situations is required when the conditions under which a skill has been acquired are unlikely to recur without changes. Hatano and Inagaki (1984) described learning from problem situations when they drew a distinction between procedural knowledge as the production of defined behaviors under specified conditions and conceptual knowledge as the ability to modify principles based on the requirements of a particular situation. In a comparison of different approaches to providing instruction in the operation of a fictitious device, Greeno and Berger (1987; 1990) differentiated between instruction based on general principles and instruction based on procedures. They found that principles could be used to infer procedures, but not the reverse. Schneider (1985) applied

the distinction between performance based on principles and performance based on procedures to air-traffic-control skills; procedural components of tasks could be performed automatically after adequate practice even though task components based on application of principles always required a high level of attention for proficient performance.

Recent problem-solving research has viewed the application of knowledge to new situations as the ability to develop strategies applicable to specific categories of problems. What Glaser (1984) calls "accessible and usable knowledge" (p. 97) is knowledge that can be applied to a specific category of related situations. General problem-solving skill is the result of a process of abstraction of problem-solving strategies across a broad range of content domains (Glaser, 1985; Larkin, 1989; Rabinowitz and Glaser, 1986). In other words, examining learning from problem situations as the organization of knowledge in a particular content domain will also provide an indication of common characteristics of response to problem situations in a variety of content domains.

Operational Definition of Learning From Problem Situations

Learning from problem situations was measured through observation of the recognition and representation stages of

the response to a problem situation. Problem recognition consists of the initial response to a difficult situation. It involves the problem-solver's tentative identification of a type of situation which will be used as the target situation, a situation comparable to the problem situation for which a solution procedure is available. Laurillard (1984) used subjects' reports of their initial intentions in problem situations to describe differences in problem recognition, contrasting an active approach involving a search for meaning with an intention to memorize or reproduce. Problem recognition is followed by problem representation, the classification of the characteristics of the problem situation according to comparable characteristics of the target situation; the result of representation is a series of steps to be followed in response to the problem situation. Chi and Bassok (1989) and Chi, Bassok, Lewis, Reimann and Glaser (1987) asked subjects to report their use of worked-out sample problems in order to describe different approaches to the classification of problem situations.

Problem recognition and representation were determined through a brief interview following exposure to the scenario. Problem recognition was operationalized by asking subjects to compare the situation in the scenario to previously encountered situations. The level of learning from

problem-solving found in the recognition stage is reflected in the search for a common category that can be used to classify a new situation and previously encountered situations. A low level of learning from problem situations leads to the development of categories limited to an unselective combination of characteristics contained in a problem situation. A low level of learning from problem situations was attributed to subjects who viewed a problem situation as unrelated to previously encountered situations. On the other hand, a high level of learning from problem situations leads to the development of a broadly defined category based on the selection of key characteristics from a problem situation. A high level of learning from problem situations was attributed to subjects who attempted to compare a problem to previously encountered situations.

Problem representation was operationalized by the subjects' response to two questions: one asking them to discuss the general principles used in responding to the scenario and the other one asking them to discuss the logical or mathematical connections required for implementation of a solution procedure. During the representation stage, the elements of a problem are classified according to their relevance to a likely method of solution. A low level of willingness to learn from problem situations leads

to the classification of problem elements on the basis of features which are not related to possible solution procedures. A low level of learning from problem situations was attributed to subjects who described a solution path by referring only to a specific set of conditions and who responded to a specific set of conditions without referring to other sets of conditions. On the other hand, a high level of willingness to learn from problem situations leads to the classification of problem elements according to features which are relevant to potential solution procedures. A high level of learning from problem situations was attributed to subjects who described a solution path based on general guidelines for the selection of methods and who constructed connections between responses to different sets of conditions.

Research Objectives

The main focus of this study is the application of the findings of learning and problem-solving research to a population and content area that have not been the subjects of previous studies. Therefore, the research objectives for this study include the measurement of the individual variables as well as the hypothesized relationships between them. Measuring attitudes toward learning requires an instrument containing learning situations that are relevant

to adults who are not primarily participants in organized learning experiences, measuring performance in a problem situation requires a problem situation that is not only challenging but also related to previously acquired knowledge, and measuring learning from problem solving requires identification of concepts that are required for a satisfactory response to the problem situation. With respect to the relationships among the three variables, the purpose of this study is to examine the relationships between an attitude regarding the likely outcome of a high level of effort in a difficult situation and the development of a body of knowledge that can be applied to a problem situation, as well as between both of the above and the response to a problem situation.

Conceptual Framework

Examining the possibility of a relationship between attitudes toward learning and problem-solving behavior is a preliminary step toward the goal of increasing the attention given to learning and problem-solving skills in occupational education curricula. Particularly with regard to occupational education programs targeted to out-of-school adults, there is considerable pressure to limit the focus of programs to the knowledge and skills needed for actual performance situations. Establishing that the application

of occupational knowledge to new situations is related to attitudes toward learning would provide support for the incorporation of problem-solving experiences as an integral part of occupational education programs. Computer simulations of occupational problem situations can be used to overcome a variety of practical barriers to increased exposure to problem situations (Gott, 1988-89; Lesgold, Lajoie, Bunzo, and Eggan, 1988), but given the high initial investment, problem-based occupational training has been limited to only a few occupational areas, primarily those involved in the operation of highly complex systems.

By studying the relationship between attitudes toward learning and problem solving, this study is investigating the importance of these attitudes; it does not attempt to demonstrate that the attitudes which constitute learning expectations are fixed personality characteristics. Instead, it is assumed that attitudes toward learning in adults are formed through the influence of a variety of previous learning situations and that the attitudes which are brought into a new learning situation are based on the outcomes of previous learning situations. Furthermore, it is likely that these attitudes are also subject to continual modification based on the perceptions of the causes of successful and unsuccessful learning experiences. If the importance of problem-solving skill to the acquisition of

occupational skills receives greater recognition, it would be a logical next step to search for those variables which can be manipulated and which have a demonstrable influence on the acquisition of problem-solving skill. This study seeks to identify and measure the variable learning expectations as one such potential influence on the development of problem-solving ability.

Assumptions

The conceptual base of this study contains assumptions regarding both attitudes toward learning and the application of specialized knowledge to new situations. With regard to attitudes toward learning, the assumption is that differences in learning intentions are reflected in the setting of learning goals and in the use of learning strategies. With regard to the application of specialized knowledge, the assumption is that differences in outcomes reflect approaches to problem situations. In both cases, the assumption is one of consistency between thought and action.

Schmeck (1983) found that use of learning and study techniques among secondary and college students is related to general tendencies involving how students approach learning. Secondary and college students may have stronger perceptions of themselves as primarily engaged in learning

than students in occupational education programs because the former are engaging in familiar types of learning activities such as reading, note-taking, and test-taking. However, it is assumed that students in occupational education programs are also conscious of participating in a learning experience. The assumption of conscious participation in a learning experience need not imply that learning proficiency be perceived as requiring skills similar to those found in non-occupational subject areas, only that there is a consistent approach to difficult situations within a particular content domain.

Using the IAR to operationalize learning expectations involves assuming that learning expectations can be identified with a perception of internal or external control of the outcome of a learning situation. However, Andrews and Debus (1978) criticized the IAR for requiring a choice between self and external control instead of providing choices between types of internal control. They contend that perceptions of self-control involve the competing claims of four factors: effort, ability, task difficulty, and luck. Furthermore, they claim that the distinction between the level of effort, which is subject to self-conscious control, and the other three factors, ability, task difficulty, and luck, which are not subject to self-conscious control, is more important than the distinction

between internal and external control. For the purposes of this study, it will be assumed that ability attributions for difficult situations in familiar content domains are relatively stable and that the distinction between attributions of internal and external control of the outcomes of difficult situations corresponds to the level of belief in the use of learning strategies.

With regard to the operationalization of learning from problem situations, the use of a follow-up interview to ask subjects to explain their understanding of concepts required for response to the scenario is based on two assumptions. The first assumption is that production of a solution in a single problem situation does not always indicate the level of understanding of the principles involved. In other words, additional information may be required to explain the occurrence of a particular response to a problem situation. The second assumption is that the ability to articulate principles or concepts is identical to the ability to use them in a variety of situations; it is possible, but not likely, that concepts which are applied to a particular situation will not be applied to other potentially relevant situations.

The use of a content-related problem requires assumptions regarding the adequacy and equivalency of subjects' knowledge in the relevant content area. Some problem-

solving studies provided subjects with a factual background in a specific content domain as part of the study, using either a content domain in which the subjects did not have prior knowledge or a fictitious content domain. Asking subjects who are participants in an occupational education program to respond to a scenario requires the assumption that the subjects have the knowledge necessary to respond to the situation but that there are not significant experiential differences among them with respect to applying that knowledge base. The common use of a project method in occupational education programs means that students must use certain basic techniques, but that they are often exposed to elaborations and variations on those techniques only through indirect means such as lecture or reading. In other words, it is possible to assume that subjects who have completed a segment of training are familiar with techniques which they have used but that they do not possess a high level of experience applying these techniques in different situations.

Limitations

As an aspect of learning intentions, learning expectations play a role in the initial stage of an encounter with a difficult situation. Learning from problem situations, the development of concepts applicable to a specific type

of problem situation, occurs following exposure to relevant problem situations. However, a correlational study such as this does not allow implications to be drawn regarding causation from a temporal sequence of variables. Furthermore, the possibility that another variable could be related to both of the variables in this study raises the possibility that both learning expectations and learning from problem situations are effects of a third variable.

This study will not address the question of whether an individual's overall level of learning expectations should be viewed as a fixed characteristic, i.e. as an attribute variable. In laboratory studies of problem-solving, subjects' self-conception of intelligence has been subjected to deliberate experimental manipulation. Andrews and Debus (1978) found that learning expectations based on the difficulty of a learning situation or on the ability of a learner are less likely to change than expectations based on effort or luck. Wood and Bandura (1989) were able to manipulate learning expectations by varying the information provided to subjects regarding the ease with which a particular skill could be acquired. Dweck (1975) used attribution retraining as a treatment variable by having an experimenter repeatedly attribute a subject's lack of success to lack of effort. A single measurement of learn-

ing expectations does not eliminate the possibility of changes in other types of learning situations.

The role of external influences on the development of learning expectations is also beyond the scope of this study. Argyris and Schoen (1978) develop the concept of organizational learning as a common set of learning expectations through which members of an organization analyze experiences that determine the type of learning that will take place. Cheren (1987) describes learning expectations as subject to a developmental process through the management of both incentives for learning and learning tasks within an organization that is committed to the development of learning skill. Like Argyris and Schoen, Cheren sees the relationship between self-conception of learning and problem-solving as dependent on a set of environmental variables. In order to study the effect of variables such as organizational climate and supervisory behavior on attitudes toward learning and problem solving behavior, it would be necessary to conduct a comparative study of learning expectations in a variety of settings.

The results of a study of learning from problem-solving based on a problem situation encountered by a single subject in a single problem-solving episode may not apply to group problem-solving situations or problems which require more than a single problem-solving episode. The

necessity of assigning scores to individual subjects may not correspond to the most effective means by which subjects could respond to a problem situation. Effective problem-solving has been shown to require the ability to use a variety of sources of information (Glaser, 1991). In other words, several subjects working individually may fail to respond in a satisfactory manner to a situation, but if they were allowed or encouraged to work together over a longer period of time, the outcome might be different.

An important issue with respect to limitations of this study is the question of the population to which its findings may be applied. Although there are some indications that occupational knowledge is typically organized around categories of problem situations (Scribner and Sachs,1990), the relative importance of routine versus new situations for many occupations requires further investigation. Furthermore, even within a particular occupation, factors such as organizational structure and supervisory practices make it difficult to generalize about the need for problem-solving skills. It is likely that the gradual accumulation of experience increases the routine elements of performance for many occupations, but it is also likely that organizational and technological innovations increase the frequency and type of new situations which are encountered. Estimating the impact of organizational innovations and new tech-

nology on the overall skill requirements of the workforce is a process subject to considerable controversy, but the results of this study should be applicable to workers in situations characterized by a high degree of change.

CHAPTER II

REVIEW OF LITERATURE

Introduction

The first section of this chapter, "Problem-solving and the Acquisition of Occupational Skills," examines attempts to identify transferable outcomes associated with the acquisition of occupational skills and to identify problem-solving strategies required for the performance of actual or simulated occupational tasks. The following section, "Learning Expectations," examines how studies of self-conception of intelligence, approach to studying, and understanding of the purpose of learning provide examples of differences in attitudes toward learning. The feasibility of various methods of measuring attitudes toward learning within an occupational education framework is also considered. The third section, "Learning from Problem Situations," first examines the controversial issue of whether direct instruction in problem-solving skill can be provided independently of any particular content domain. Then transfer theory is used to introduce the idea of the organization of knowledge as a factor in how knowledge is applied to new situations. The variable, learning from

problem situations, is derived from studies of individual differences in the application of specialized knowledge that emerge despite equivalent knowledge and experiential backgrounds. These studies, based on the thesis that effective problem-solving behavior involves a combination of general skills and the organization of specific knowledge, provide guidelines for the operationalization of learning from problem situations as the organization of knowledge required for use in specific problem situations.

The purpose of this chapter is to demonstrate that many researchers view the ability to apply skills to new situations as an important aspect of occupational education and to demonstrate the relevance of research on attitudes toward learning and problem-solving proficiency for a study of the application of occupational knowledge to new situations. The use of an occupational education program as the setting in which the hypotheses were tested reflects the former purpose, and the content of the hypotheses that were tested reflects the latter purpose.

Problem-solving and the Acquisition of Occupational Skills

Transfer of Occupational Skills

Because the ability to apply knowledge to a broad variety of situations is an increasingly desirable outcome

of occupational education programs, there is a growing interest in identifying general skills and attitudes that promote the transfer of occupational skills to new situations. Furthermore, especially at the secondary level, completion of an occupational education program often does not lead to seeking directly related employment. This is why Pratzner (1985) called for occupational education programs at the secondary level that emphasize "higher-order transferable skills, judgments, and initiative, e.g. problem-solving, decision-making, [and] planning" (p. 9). On the other hand, Moss (1987) expressed concern that broadening the scope of occupational education programs would lead to the acquisition of general occupational knowledge at the expense of specific occupational skills. One solution to this dilemma would be to combine specific occupational skills with the general skills and attitudes needed to transfer occupational skills to new situations.

Elements of problem-solving skill have been identified which can be used to transfer specific occupational skills to situations that are not identical to those in which they were acquired. Furthermore, attitudes are also important for the use of problem-solving skills. Fitzgerald (1986) lists such transferable outcomes of occupational training as "suspension of closure," "sustained analysis," and "rule application" (p. 274), which can be acquired along with

specific occupational skills. Transferable skills are useful in a variety of situations provided that the learner also possesses transfer skill, the awareness that such wide-ranging transfer is possible. Miguel (1977) differentiates between specific occupational skills that are transferable and skills that facilitate transfer, such as "knowing how to access information," "identifying information needed for a particular task," and "using information" (p. 14).

The need to combine occupational skills and proficiency in their application has led to a renewed interest in apprenticeship. Raizen (1989) summarizes how apprenticeship allows a trainee to participate in the collaborative performance of complex tasks. Problem-based training based on "ill-defined problems" and "multiple solutions" leads to the gradual acquisition of "competencies that integrate specific job knowledge and skills and more general habits and ways of approaching problem situations" (p. 12). Since apprenticeship typically involves learning while assisting in the performance of actual tasks by an expert, it is necessary to examine how instruction in problem-solving skill can be integrated with the acquisition of occupational skills in an instructional format. Stasz, McArthur, Lewis and Ramsey (1990) offer examples of problem-based training in a more structured setting. They observed

occupational education programs in which problem-solving skills were viewed as valued outcomes along with domain-specific skills. They concluded that attitudes related to decision-making affected the use of problem-solving skills. In other words, creating an instructional setting that rewarded examination of alternatives, decision-making, and practical applications of knowledge facilitated the use of problem-solving skills as well as the application of specific occupational skills to new situations.

Training for Complex Tasks

Just as apprenticeship allows participation in problem-solving and decision-making situations, some occupational education programs have attempted to expose trainees to simulations in order to promote application of knowledge to new situations. Simulations have been particularly useful with respect to instruction aimed at the performance of tasks which consist of a large number of individual elements and which are performed under a variety of conditions. Schneider (1985) describes air-traffic- controller training in terms of consistent and variable task components. Trainees can practice the consistent components of tasks until they are able to perform them automatically, while they are encouraged to practice the decision-making skills required for the variable components of tasks using

a high level of attention and analysis. Lajoie and Lesgold (1989) describe a computerized simulation for instructing air force mechanics in the diagnosis of problems in electronic troubleshooting equipment. Among the advantages of the program is its ability to track each trainee's use of problem-solving techniques and to provide a series of hints that are appropriate to a trainee's level of problem-solving sophistication.

The conceptual understanding that is required for the performance of occupational tasks involves problem-solving skill. Gott (1988-89) distinguishes between procedural knowledge based on the predictable application of rules to clearly defined situations and declarative knowledge based on the understanding of general principles governing an entire system or device. Procedural knowledge based on "if-then" statements is useful as long as the number of possibilities can be kept within reasonable limits. However, when systems become more complex, access to this type of knowledge becomes inefficient unless general strategies are available to limit the search for applicable conditions. Noting that proficiency involves a strategic component as well as the ability to perform specific operations, Morris and Rouse (1985) divide trouble-shooting skill into general knowledge and specific procedural components.

Experienced performers organize specialized knowledge in order to facilitate a systematic consideration of possible causes of a particular situation. Scribner and Sachs (1990) note that experienced stockroom workers describe their duties in terms of responses to particular types of problems rather than as an arbitrary set of tasks. Martin and Scribner (1991) explain the change from conventional to computer-controlled machine tools in terms of a transition from problem situations characterized by sensory clues to problem situations characterized by computer-based clues. It is likely that many more occupational areas contain tasks that are characterized by the need for the use of problem-solving strategies in order to apply specific aspects of occupational knowledge and skill to a variety of situations.

Learning Expectations

Learning expectations are one aspect of an individual's feeling of self-efficacy, that is, a self-evaluation of one's capacity to act in a particular type of situation. Learning expectations in a problem situation are based on a comparison between the outcomes of past situations and an evaluation of the difficulty of the present situation. The influence exerted by the outcomes of previous situations depends on attributions, explanations given for the results

of those situations. An individual's level of self-efficacy reflects the degree to which he or she attributes outcomes to factors subject to that individual's control (Bandura, 1986). Bandura (1990) uses the phrase "perceived competence" (p. 329) to describe beliefs about the self and the demands of a situation: a positive self-evaluation of competence leads to a high level of self-efficacy for difficult situations, while a negative self-evaluation of competence has the reverse effect.

McCombs (1988) explains learners' sense of self-efficacy as a self-assessment of their ability to regulate their learning and thus affect its outcome. The higher the level of self-efficacy, the more likely a learner is to apply what has previously been learned to new situations. Similarly, Palmer and Goetz (1988) assert that learning is influenced by the interaction between learner and task characteristics and that learning in difficult situations requires a high level of effort and persistence. The willingness to use a particular strategy is determined by expectations for the success of its use. Furthermore, the greater the attribution of success or failure to factors which are seen as stable and unchanging, the greater influence outcomes of previous situations will have on learning expectations.

As an aspect of self-efficacy, learning expectations reflect attitudes regarding the uses of learning in difficult situations. Three ways of defining and measuring learning expectations have been found: self-concept of intelligence, approach to studying, and understanding of the purpose of learning. Each of these factors has been shown to be related to responses to various types of new or difficult situations. Self-concept of intelligence is a belief about the flexibility or rigidity of the nature of intelligence. Approach to studying involves the purpose or goal that is associated with the use of study strategies. Understanding of the purpose of learning involves the purpose or goal that is associated with learning in general.

Self-conception of Intelligence

Self-conception of intelligence is an individual's explanation of what intelligence is and how it can be acquired. Dweck and Bempechat (1983) identify two self-conceptions of intelligence: the "entity" theory, in which intelligence is seen as a "trait that is judged," and the "instrumental-incremental" theory, in which intelligence is seen as "a dynamic repertoire of skills that is increased through one's efforts" (p. 239). Holders of the "entity" theory view intelligence as a fixed quantity and pursue

"performance goals" in order to "seek to establish the adequacy of their ability and to avoid giving evidence of its inadequacy." On the other hand, holders of the "instrumental-incremental" theory view intelligence as a flexible quantity and pursue "learning goals" in order to use "achievement situations as opportunities to increase their competence and . . . extend their mastery" (Dweck and Leggett, 1988, p. 259).

Performance and mastery goals reflect differences in learning expectations in difficult situations. Performance goals involve the classification of difficult tasks as outside the capability of a learner; difficult situations evoke what Dweck and Goetz (1978) term a "helpless" orientation in which failure is attributed to external factors. On the other hand, mastery goals reflect the classification of difficult tasks as opportunities for learning. With a "mastery" orientation, failure is defined as a temporary, reversible state. These differences in self-concept of intelligence have been used experimentally to explain levels of performance in difficult situations (Dweck, 1986; Dweck and Goetz 1978).

Approach to Studying

Schmeck (1988) describes studying as the result of an interaction between elements of a learner's personality and

the demands of a learning task. Preferences for learning strategies and use of particular learning tactics are based on a learner's general approach to learning situations and the needs of a specific situation. Learning style is the most personal and stable expression of what Schmeck sees as the individual and situational factors that determine response to a learning situation: "Learning style is the expression of personality within the situational context" (1988, p. 175). Learning style can be understood as a complex of learning-related attitudes covering the intention, process, and outcome of learning situations (Entwistle, Hanley, and Hounsell, 1979).

Motivation for learning may either be external, that is aimed at satisfying the demands of others, or internal, that is aimed at satisfying an individual's own demands. It is also possible to have combinations of motives; Schmeck (1988) finds this characteristic of learners who desire to make learning both meaningful and useful. Approach to learning may either be serialist, that is focused on procedures, or holist, that is focused on understanding. It is also possible to have combinations of approaches. Entwistle (1988) considers deep understanding as the combination of holist and serialist orientations to learning and shallow understanding as the result of the exclusive use of a single orientation. Schmeck and Meier (1984) describe

learning outcomes in terms of three types of understanding: deep understanding resulting from an exploration of the implications of what has been learned, elaborative understanding resulting from the association between what has been learned and the personal needs of the learner, and shallow understanding resulting from memorization of what has been learned.

Schmeck (1988) has analyzed depth of processing in the learning tasks of college students through their reports of the use of various study strategies. He found that learners who approach learning tasks with the intention to memorize show performance and evaluation anxiety, fear of failure, and an external locus of control. McCarthy and Schmeck (1988) also note that approaching learning with the intent to memorize leads to limited expectations but does not threaten self-concept in the event of failure. In other words, minimizing the importance of doing something minimizes the consequences of failure. The similarity is clear between the approach to learning associated with low-level information processing and the self-conception of intelligence associated with performance goals.

The importance of what is to be learned can be based either on the need for understanding or for achievement. Entwistle (1988) distinguishes between a meaningful orientation to learning tasks characterized by both logical

analysis and personal relevance and an achieving orientation characterized by the adaptation of learning techniques to meet external demands. Similarly, Schmeck (1988) separates a conceptualizing orientation from a personalizing one: In a conceptualizing approach the learner "categorizes, compares, and contrasts at the highest possible levels of abstraction," while in a personalizing approach the learner "operationally defines and relates all material to personal experience" (1983, p. 261). The relative advantages of a conceptualizing or personalizing approach may depend on the importance of logical/mathematical operations or a broad base of previously experienced situations in a given problem situation.

Self-definition of Learning

The nature of learning as an object of reflection is related to differences in the use of learning techniques (Gibbs, Morgan, and Taylor, 1982). Säljö (1979a) in the context of a broader interview asked subjects to explain what they meant by learning. He classifies definitions of learning as a process of increasing knowledge or as memorization as quantitative conceptions of learning, that is a concern for how much is learned. He classifies definitions of learning as abstraction of meaning or as an interpretive process aimed at understanding reality as qualitative

conceptions of learning, that is a concern for how well something is learned (Säljö, 1979b). A qualitative conception of learning represents a high level of learning expectations because learning is seen as the result of a process requiring a high level of effort: "Learning in itself has become an object of reflection" (Säljö, 1979c, p. 446). On the other hand, a quantitative conception of learning represents a low level of learning expectations because learning is seen as the result of a process requiring a low level of effort: "Learning is ... an essentially reproductive activity" (Säljö, 1979c, p. 446).

Marton and Säljö (1976a) have found that learning intentions affect the ability to interpret complex texts. Subjects who have a quantitative conception of learning are not able to relate details to the main idea while subjects who have a qualitative conception of learning are able to explain the relation between a main idea and supporting details. Marton and Säljö (1976b) also found differences in how these two groups respond to attempts to manipulate the type of processing they engage in. When subjects were asked questions about a text requiring recognition of the main idea, learners with a quantitative approach continue to use techniques based on memorization. On the other hand, both groups of learners were able to respond appropriately when questions were asked that required attention

to specific details. Gibbs (1983) makes the point that it is learners' description of their own intentions rather than the use of any particular technique that distinguishes the intention to understand from the intention to memorize.

Studies of learning purpose have not been consistent in their explanation of the flexibility to respond to different learning demands. Säljö (1979b) describes the flexibility to respond to different learning demands as an outcome of the learner's becoming more reflective regarding awareness of learning, purposes for learning, and objects of learning. He also regards flexibility as important for determining the best sequence for switching between procedural and conceptual learning (1981). On the other hand, Marton and Säljö (1984) conclude that a qualitative conception of learning is not compatible with responsiveness to external learning demands. Both Entwistle (1988) and Biggs (1979) identify a separate learning purpose based on the achievement of learning goals defined by others. Entwistle (1979) notes that the level of understanding attained in a learning situation depends on the capability of the learner, his or her interest in the content which is being learned, and the degree of stress in the learning situation. In other words, it is possible that learners do not always approach learning situations with the same set of expectations; however, only learners with a qualitative

conception of learning will be able to vary their expectations to suit the demands of a particular situation.

Measuring Learning Expectations

The written instruments used in the above-mentioned studies to measure learning expectations are the Intellectual Achievement Responsibility questionnaire (IAR; Crandall, Katkovsky, and Crandall, 1965), Inventory of Learning Processes (ILP; Schmeck, Ribich and Ramanaiah, 1977), and the Study Process Questionnaire (SPQ; described in Biggs, 1979). Also, the definitions of learning were derived from an analysis of open-ended interviews (Säljö 1979a; Biggs, 1979). The ILP and the SPQ are both based on activities related to the independent learning of written material. The IAR was chosen for use in this study because it has been used to operationalize self-conception of intelligence (Dweck and Bempechat, 1983). The IAR assumes recent participation in a formal learning setting but is not based on methods of conducting out-of-class study sessions, as are the ILP and SPQ. In other words, the IAR focuses on learning situations rather than on study situations.

The stems of IAR items describe either a positive intellectual outcome (e.g. doing well on a test) or a negative one (e.g. having trouble with math problems), and

the two choices consist of possible causes: one based on self-responsibility (e.g. studying hard) and one based on external responsibility (e.g. an instructor's dislike). The IAR contains thirty-four items, equally divided into positive and negative outcomes. Scoring consists of the number of items for which the self-responsibility choice is selected. Total IAR scores as well as scales for positive and negative outcomes were reported by the authors of the IAR (Crandall, Katkovsky, and Crandall, 1965). Dweck and Reppucci (1973) noticed that the attributions of self-responsibility could be used to divide the IAR according to whether the attribution was based on ability (e.g. doing well in a course) or effort (e.g. studying for a test). The result of this classification of IAR items is a fifteen-item ability scale and a nineteen-item effort scale. Crossing the positive-negative and ability-effort scales results in four subscales: positive ability, positive effort, negative ability, and negative effort, with from seven to ten items each.

Dweck and Goetz (1978) note that persistence in difficult situations is more likely when failures are attributed to a lack of effort than to lack of ability. Similarly Diener and Dweck (1978) use the negative effort subscale to operationalize learned helplessness in a study of responses to frustrating circumstances. These studies support the

use of the negative and effort scales in preference to the positive and ability scales as a means of operationalizing learning expectations if differences in scores on the various IAR scales are noted. In other words, a willingness to assume responsibility for negative outcomes based on a lack of effort would seem to be closest to the definition of learning expectations as a belief in one's ability to respond successfully to difficult situations. Furthermore, Andrews and Debus (1978) note that the IAR does not measure the relative importance of attributions relating to effort or ability for the same situation. They classify an attribution based on ability as similar to attributions based on luck or the difficulty of a situation, i.e. as not subject to individual self-control.

The IAR was tested on students in grades three to twelve. Overall test-retest reliabilities at two-month intervals were moderately high and were higher for failures than for successes. Correlations between scores for positive and negative outcomes were not significant for many of the age levels in the sample, indicating that the two scales may not measure the same variable (Crandall, Katkovsky, and Crandall, 1965, p. 101). IAR scores were only moderately correlated with intelligence test scores and not at all with achievement test scores. Although the IAR has not been used with learners older than the second-

ary level, its format and content are suitable with only minor modifications for use with adults who are enrolled in formal educational programs. The modifications made by the researcher to the IAR involved eliminating gender-specific pronouns and substituting age-appropriate educational activities, such as passing a course instead of passing a grade or reading magazine articles instead of reading stories. (See Appendix A for the complete text of the revised IAR.)

Learning From Problem Situations

General Problem-solving Skill

Learning from problem situations requires the ability to relate problem situations to previously experienced situations. Bransford, Sherwood, Vye, and Rieser (1986) describe procedural deficiencies that are characteristic of less successful problem solvers; for instance, they are less likely to follow an organized plan of action and are less likely to monitor their progress and revise their plan of action. Direct instruction in these problem-solving skills would seem to offer the quickest possibility of improving the ability to apply occupational knowledge. Courses or training programs in thinking skills, critical thinking, creative thinking, or problem-solving could create the conditions necessary for the application of

knowledge to new situations regardless of the content domain and regardless of whether knowledge in a particular domain has been acquired prior to or subsequent to the instruction.

Training programs that claim to teach specific problem-solving procedures have both supporters and skeptics. De Bono (1987) asserts that a key element of successful problem-solving is a willingness to look for alternatives and that this skill can be learned much as any other skill. Furthermore, because a skill is more easily acquired in isolation, simultaneously attempting to learn content can only interfere with the acquisition of problem-solving skill: "You cannot build meta-patterns on one level and experience patterns on another level at the same time" (de Bono, 1987, p. 223). Other programs use a particular method to teach a variety of problem-solving skills. Whimbey and Lochhead (1986) have developed a problem-solving training method using a listener who demands constant explanations during each step in the problem-solving process (pp. 28-29). However, the tests which they provide to evaluate progress contain problems of the types for which instruction has been provided.

Owen and Sweller (1989) conclude that the ability to apply knowledge requires both insight into the principles behind a particular type of problem structure and practice

with that type of problem. On the other hand, Lawson (1990) believes that it is possible to go beyond teaching how to respond to types of problems, stating "there is encouraging evidence that training in the use of different types of general problem-solving strategies has positive impact" (p. 406). In reply Sweller (1990) reports having abandoned the idea that problem-solving expertise consists of mastery of teachable techniques. Similarly Mayer (1992) notes that most creative thinking and problem-solving programs have not been subject to rigorous evaluation and that claims for improved performance in a wide variety of problem situations have not been substantiated: "Research evidence... demonstrates a preponderance of specific transfer, that is skills learned in one domain can be successfully used mainly in that domain" (Mayer, 1992, p. 365). Bransford, Sherwood, Vye, and Rieser (1986) advocate the improvement of problem-solving ability in a limited area through "the systematic development of well-organized knowledge in addition to executive processes" (p. 1084). Although it may be possible to describe problem-solving skills common to a wide variety of problem situations, instruction in problem-solving proficiency is most clearly linked to specific categories of problems.

Transfer

Learning from problem situations should be seen as an aspect of specific transfer, rather than as a universally applicable problem-solving skill. Specific transfer is the degree to which the ability to solve one problem improves the ability to solve other problems with similar elements. In other words, learning from problem situations is limited to problems that are perceived as possessing common elements or belonging to the same category, and transfer of problem-solving ability from one domain to another depends on the recognition of common elements in the problem-solving process.

In differentiating between routine and non-routine problem situations, Gagné (1980) limits transfer (and by implication learning from problem situations) to routine problem situations. Selection of strategies for non-routine problem situations is governed by an executive control ability, "a strategy to select strategies" (1980, p. 90), and this ability is the product of experience rather than instruction. Larkin (1989) also minimizes the role of transfer in problem-solving ability: "The only way to teach problem solving is to teach it in each individual domain" (p. 288). On the other hand, Simon (1980) states that response to problem situations depends on a variable mixture of specialized knowledge and transfer. That is to

say, general problem-solving skills play a more important role for non-experts, who have less available specialized knowledge than do experts.

A transfer theory should explain what is known about the individual variability of applying knowledge to new situations (Bransford, Sherwood, Vye, and Rieser 1986; Mayer 1992). Royer (1979) argues that Thorndike's explanation of transfer, the theory of identical elements, explains transfer as resulting from the degree of similarity between source and target situations without considering learner characteristics such as the willingness to use problem-solving strategies. Salomon and Perkins (1989) describe one type of transfer based on what they call "mindful abstraction," which they define as "the problem-solver's use of general concepts for the purpose of comparing the problem situation to previous experiences" (p. 125-126). Similarly, Travers (1982) defines non-specific transfer, the transfer of a problem-solving strategy between situations that do not have the same structure, as the intentional application of what has been learned to a new situation. According to Royer (1979), the main thrust of recent cognitive theories of transfer has been to explain transfer based on the presence of organizing principles or schema. Learning from problem situations can be

seen as an expression of this limited conception of transfer.

Application of Knowledge in Problem Situations

Learning from problem situations has been defined as the application of related knowledge at various stages of the problem-solving process. One reason for this is that the focus of research on problem-solving has shifted from concern with general ability to concern with content-area expertise. Glaser (1984) notes that training programs aimed at improving problem-solving ability attempt to teach information-processing techniques, general knowledge of problem situations, and heuristics (problem-solving strategies). However, his own definition of problem-solving proficiency involves the ability to apply a specific body of knowledge to new situations: "A major component of thinking is seen to be the possession of accessible and usable knowledge" (Glaser, 1984, p. 97). Expert problem-solvers have the capacity to respond to variations of previously encountered situations.

Glaser (1985) defines expertise as knowledge which can be reorganized to meet the demands of a particular situation. Expertise can either be static, that is, limited to a fixed repertoire of situations, or dynamic, that is, able to meet the demands of new situations. Hatano and Inagaki

(1984) describe these two types of expertise as routine and adaptive. Routine expertise is adequate for behaving in static, predictable environments, while adaptive expertise is necessary to gain mastery over a less predictable environment. Greeno (1989) also views thinking as the reorganization of knowledge to cover new situations through the use of concepts derived from a specific knowledge domain. In contrast to Gagné's insistence on the distinction between problem-solving ability and conceptual knowledge, Glaser (1990) views the organization of usable knowledge as the "proceduralization" of declarative knowledge and its combination into meaningful units. Glaser (1991) describes this process as consisting of the representation of knowledge, the use of self-regulatory skills, and the dependence on other learners for assistance in the process of creating meaningful knowledge.

In a series of studies, Chi and associates have analyzed the differences between expert and novice problem-solving ability in terms of experts' ability to organize and apply large blocks of knowledge. In comparing differences between experts and novices in solving physics problems, Chi, Glaser, and Rees (1982) have noted that experts classify problems according to general laws or principles, while novices classify problems according to surface features. Chi and Glaser (1985) have also noted that experts

spend less time than novices on unprofitable alternatives. Experts do not display a greater level of proficiency in what are commonly considered signs of general problem-solving ability such as the examination of alternatives or the use of general problem-solving strategies (heuristics). Differences between experts and novices are clear, however, with respect to problem representation, "the solver's interpretation or understanding of the problem" (Chi and Glaser, 1985, p. 232).

Chi and Glaser (1985) use schema theory as a means of explaining differences in problem representation. A schema is defined as a "modifiable information structure that represents generic concepts stored in memory" (p. 241). Experts use schemata to organize knowledge, and this organization determines their response to a problem situation. Because a schema consists of patterns of expected information about a given category of situations, elements of a situation which a novice considers arbitrary or unrelated can be used by an expert to respond to a situation. When a task has been performed only once, knowledge may be contained in a conceptually limited schema, and a novice performer may be unable to separate accidental characteristics from those relating to a broader category. On the other hand, an expert can draw upon schemata focused on

characteristics essential to classifying a situation for a proper response.

Examining the ability of beginning physics students to utilize worked-out examples, Chi, Bassok, Lewis, Reimann, and Glaser (1987) found that successful problem-solvers made greater use of elaboration techniques such as generating explanations of the principles involved and responding to comprehension failures. Chi and Bassok (1989) explain the use of elaboration techniques as "an overt manifestation of active processing during learning" (p. 270). On the other hand, less successful students used examples as a means of "searching for a solution or a template from which they could map the to-be-solved problem so that they could generate a solution" (p. 276). Laurillard (1984) has found a similar pattern in the use by science students of theoretical explanations when solving problems. Some students attempted to understand what they were doing, while others preferred to ignore the structure of a problem and to manipulate elements in searching for a solution.

In order to obtain subjects with equivalent knowledge levels in the above-mentioned study of physics students, college students who were not physics majors were asked to read and study a chapter in a physics textbook and were given problems based on the knowledge contained in that

chapter. In order to tie problem-solving behaviors to problem-solving proficiency, researchers must design problems that some but not all of the subjects could respond to successfully. The following elements are required in order to measure learning from problem situations: subjects possessing an equivalent body of knowledge, a task requiring application of knowledge, and some means of observing the organization of knowledge that subjects apply to a problem situation.

Research Question

A review of research on occupational training shows an increasing interest in the ability to apply occupational knowledge to new situations. Consequently, there is considerable support for the proposition that occupational education should include the development of skills which are required for successful problem-solving. In order to accomplish this goal, instructional practices ranging from traditional apprenticeships to computer simulations are recommended in order to provide an environment in which occupational skills can be used in as wide a variety of situations as possible.

Learning ability has traditionally been identified with the skills required for successful learning in formal learning situations, i.e. classroom learning. However, the

ability to use learning skills appropriately has been found to depend on an understanding of the purpose of those skills. For this reason, an individual's self-concept of his or her learning ability is an important aspect of learning proficiency. Learning expectations are attitudes that influence the adoption of a learning strategy through prediction of the learner's capacity to respond to the demands of a new situation. Differences in learning expectations can be seen through differences in self-conception of intelligence, approach to studying, and understanding of the purpose of learning.

Despite the existence of instructional programs for general problem-solving skills, evidence is lacking that the application of knowledge to new situations is a skill that can be acquired independently of the content knowledge that is to be applied. On the other hand, both transfer theory and studies of successful problem-solving behavior show that the ability to organize and manipulate specialized knowledge is related to the ability to apply it to new situations. Based on this research, learning from problem situations has been defined as the organization of knowledge in a form that can be applied to new situations.

The theory of problem-solving in content areas emphasizes the manipulation of information contained in a problem situation and information derived from previously

encountered situations. The degree of learning from problem situations that has taken place is reflected during problem recognition and representation, the initial phases of the response to a new situation. In the recognition stage a decision is made whether a solution can be developed or whether it must be sought from an external source. In the representation stage, a decision is made whether a situation can be classified with previously encountered situations or whether it will be regarded as unique.

The purpose of studying learning expectations and learning from problem situations in occupational education students is to gain an understanding of their ability to apply occupational knowledge to new situations. For this reason, it is necessary to determine whether a particular body of occupational knowledge presents sufficient opportunities for the exercise of problem-solving skills. Since learning expectations involve general approaches to problem situations based on attitudinal rather than knowledge factors, it is also necessary to determine if occupational education students approach new situations with attitudinal differences similar to those which have been observed in other students. Finally, since learning from problem situations involves the organization and manipulation of specialized knowledge, it is necessary to determine if occupational education students display different levels of

organization and manipulation of knowledge in new situations. The above determinations represent a necessary preliminary for an investigation of a possible relationship between learning expectations and learning from problem situations. This study will attempt to answer the following question: Are differences in the learning expectations of occupational education students associated with differences in their willingness to learn from problem situations, and can either or both of these variables be associated with differences in problem-solving proficiency?

Hypotheses

1. There is a relationship between the understanding of a problem situation in terms of categories derived from previously encountered situations accompanied by the application of those concepts to a new situation (learning from problem situations) and the ability to apply what has been learned to situations that are different from those which have been previously encountered (performance in problem situations).

2. There is a relationship between attitudes about the use of learning strategies in problem situations (learning expectations) and the ability to apply what has been learned to situations that are different from those

which have been previously encountered (performance in problem situations).

3. There is a relationship between attitudes about the use of learning strategies in problem situations (learning expectations) and the understanding of a problem situation in terms of categories derived from previously encountered situations accompanied by the application of those concepts to a new situation (learning from problem situations).

CHAPTER III

PROCEDURES

Overview of the Research Design

This chapter describes the procedures that were used to test the three hypothesized relationships for participants in occupational education programs: (1) between learning from problem situations and performance in a problem situation, (2) between learning expectations and performance in a problem situation, and (3) between learning expectations and learning from problem situations. A combination of existing and original instruments was used. Performance in a problem situation was operationalized through a problem scenario developed by the researcher. Learning from problem situations was operationalized through a follow-up interview conducted by the researcher after the subjects had been exposed to the problem scenario. Learning expectations were operationalized through the Intellectual Achievement Responsibility scale (IAR) (Crandall, Katkovsky, and Crandall, 1965), an existing locus-of-control instrument. The subjects of the study were students from a community college machine tool technology training program in Southern Michigan. All instru-

ments were administered to subjects on an individual basis by the researcher in a machine-shop setting between December 1993 and March 1994 in the following order: problem scenario, the follow-up interview, and the IAR.

The initial stage of data analysis consisted of obtaining scores for the problem scenario, follow-up interview, and IAR. The researcher was responsible for scoring all instruments. Performance on the problem scenario was classified as successful, unsuccessful, or partially successful. The tape-recorded follow-up interview consisted of three questions regarding the organization of knowledge related to the scenario. Subjects were first asked to compare the scenario to previously encountered situations, then to provide reasons for the use of different methods for cutting the type of part called for in the scenario, and finally to provide an example of an alternative way of expressing the dimensions of this type of part. Based on divisions of the IAR items, four scale and four subscale scores were obtained in addition to the total IAR scores. The second stage of data analysis involved testing the operational hypotheses through correlations between each pair of variables.

Selection of Subjects

Subjects were students in the Industrial Machine Tool Program of the Regional Manufacturing Technology Center (RMTC) in Battle Creek, Michigan. The RMTC is a manufacturing technology training center located in the Fort Custer Industrial Park and is administered by Kellogg Community College which is also located in Battle Creek. The RMTC offers programs in machine tool and other aspects of manufacturing technology (electricity, electronics, welding, pipe fitting, sheet metal, and millwright training) on a self-contained and self-paced basis. Students complete academic activities and laboratory projects under the direction of an instructor. Unless required by a funding agency or employer, students are free to work at their own pace and at their own convenience. Programs are divided into modules which correspond to general task areas and are further subdivided into units which are based on specific skills. College credit (but not letter grades) is given for completion of each unit. In most cases, unsatisfactory work may be corrected or done over. Activities in supporting disciplines such as mathematics and blueprint reading are incorporated into the training programs. Coursework outside the area of concentration is not required for a certificate of completion; however, coursework

in a variety of disciplines is required to complete an associates degree.

The students in the Industrial Machine Tool Program at the RMTC fall into three main groups with respect to work experience in the machine trades: students without related job experience who are seeking to enter the machine trades, students with past or current employment in semi-skilled positions who are able to perform a limited number of machining operations on a repetitive basis, and students who are enrolled in formal or informal apprenticeship programs in which they perform a variety of machining tasks under the supervision of skilled machinists.

The subjects for the study were all volunteers. The researcher approached students on an individual basis and asked those who had completed the lathe unit if they were willing to participate in the study. The willingness of potential subjects to participate was reasonably high, probably due to the lack of time pressure in a self-paced program.

Subjects were asked to supply information regarding age, employment in the machine trades, level of formal education, and high school or college mathematics courses (Appendix I); however, the number of subjects available for this study was not sufficient to allow examination of possible differences in the variables according to differ-

ences in work experience or educational background. Women and minorities constitute only a small percentage of the machine tool technology students from which the subjects were drawn, so differences in variables according to gender and race could not be examined.

Problem Scenario

The simulation developed for this study was designed to require the application of skills acquired during a machine tool technology training program by presenting students with a set of conditions that they were unlikely to have previously encountered. The skill selected for use in the scenario was cutting a taper on a lathe. Cutting cylindrical parts on a lathe is typically one of the first complex skills acquired in machine tool technology training following acquisition of basic measurement and layout skills. Taper cutting on a lathe met the requirements of a scenario for selection of procedures under novel conditions because of the variety of methods that can be used to cut tapers and the complex geometry of a taper. (A taper is a cone with the point cut off). Determining an appropriate method for cutting a taper requires taking into account the dimensions of a taper, the size of the lathe, and the availability of a taper-cutting attachment. The

three main methods of cutting tapers are described in Appendix B.

Development

In order to acquire the expertise needed to develop the problem scenario, the researcher spent several months observing a machine tool technology training program. This allowed him to use machine tool textbooks to identify a particular type of part which trainees had produced under one set of conditions but which could be produced under several different sets of conditions that machine tool technology students were unlikely to find familiar. The problem scenario consisted of a request to machine this type of part under unfamiliar conditions. Subjects were asked to go through the planning process they would normally go through prior to the start of actual machining operations. In order to develop the follow-up interview, the researcher identified concepts required to respond to the problem scenario based on differences between the subjects' previous experiences with this type of part and the conditions in the scenario. The instructors in the training programs provided confirmation of the technical accuracy of the content of the scenario and follow-up interview.

The method chosen for the scenario, tailstock offset (moving one end of the lathe off center), would seldom be

used in a well-equipped machine shop, and, for this reason, offset is seldom employed during training programs. However, the offset method is discussed in standard machining textbooks because of its relevance to the operating principles of the lathe. Furthermore, there are circumstances under which tailstock offset would be used to cut a taper: a poorly equipped machine shop, perhaps a machine-repair department in a small factory, could conceivably use the offset method to cut an occasional taper. A machinist in this situation would likely determine whether a request for a taper could be handled in-house before sending the job to an outside machine shop at greater expense and loss of production time.

Because machinists often find it necessary to make drawings based on oral or written presentation of information, the problem scenario presented information about the desired taper in sentence form without using a drawing or diagram. In most training activities, drawings of the desired parts are provided. It was expected that subjects would produce their own drawings when responding to the scenario in order to analyze the given information. Appendix C describes the most common approach to representing a taper (a three-dimensional object) and its dimensions in a two-dimensional drawing.

Because the purpose of the scenario was to examine the application of knowledge through the selection of procedures, subjects were allowed to refer to a chapter on taper cutting from a machining textbook while responding to the scenario. The chapter contained treatments of the main methods of cutting tapers, including the rationale for use, necessary calculations, and directions for setup. Once the offset method had been selected, it was necessary for subjects to match the dimensions given in the scenario with the appropriate equations for calculating the amount of offset. Appendix D contains the equations for the mathematical relations between taper dimensions and the various combinations of dimensions which can be used to define a taper.

The original draft of the scenario was used in a preliminary study. Only one major change was made for the final form of the scenario (Appendix E). The change involved a reduction in the length of the taper and a revision in the means by which the appropriate method was indicated. Originally, the scenario requested a taper that was longer than the taper attachment on a small lathe, requiring the use of the offset method. However, a subject in the preliminary study proposed a means of extending the range of the taper attachment, and an instructor mentioned the limited offset capability of the lathe being used for

the scenario, raising the possibility that use of the taper attachment might actually be a better choice than offsetting the tailstock. Consequently, the researcher decided to provide a clearer indication of the necessity of the offset method. This was accomplished by disabling the taper attachment and shortening the length of the requested taper.

Initially, the procedures that subjects were expected to use for calculating needed values and setting up the machine were based on those found in a standard machining text. During the preliminary study, several subjects suggested a method of arriving at the correct offset not mentioned in the text. This method, based on a trial-and-error approach rather than direct calculation of the offset, involved calculations and placement of measuring indicators that were more familiar to subjects than those suggested in the text. Consultation with instructors revealed that this alternative method was justifiable (although possibly more time-consuming), and the form used to record performance (Appendix F) was revised to allow for an alternative solution path.

Administration

The problem scenario was administered by the researcher in a machine-shop setting on a one-to-one basis. The

researcher mounted a cylindrical piece of stock with the length and diameter described in the simulation on a small lathe on which one part of the taper attachment had been removed. Subjects were given the problem scenario (Appendix E), which described the need for a long, slightly-angled taper. Subjects were asked to decide how the taper should be cut, determine what values would be needed to set up the cut, and describe how they would set up the lathe. They were provided with a calculator and a copy of a chapter on taper cutting from a machining textbook. The chapter contained discussions of the different methods of taper cutting, formulas for calculating the required dimensions, and directions for setting up the lathe. Subjects were asked to perform calculations on the paper containing the scenario, which was retained for later examination. Since administration of the scenario took place during regular lab sessions, the researcher remained nearby in order to guard against any interference by others. Questions were answered by the researcher without providing any additional information. When subjects indicated that they were finished with the scenario, they were asked to demonstrate how they would set up the lathe.

Performance on the simulation was observed by the researcher and recorded using the form "Analysis of Performance on the Taper Problem" (Appendix F). This form di-

vides response to the simulation into three areas: selection of method, preparation for setup, and demonstration of setup. These three areas corresponded to the three tasks given to the subjects: selecting a method, calculating necessary values, and explaining how to set up the machine for the cut.

The main criterion under observation during the initial phase of response to the scenario involved a determination of whether the offset method had been selected. Additionally, the researcher noted whether subjects attempted to diagram the given information. No questions were asked of subjects at this stage, but many volunteered information. Once a method had been selected, subjects typically attempted to determine what values they needed and how they could be obtained. Subjects were allowed to work undisturbed for as long as they wished; however, for subjects who were hopelessly off-track, the researcher suggested that they could stop if they had done all that they could do.

For the demonstration of the setup, subjects presented the results of their calculations to the researcher and explained how they would use the values they had obtained to position one or more spring-operated measuring indicators during adjustment of the lathe. For both of the correct methods of setting up the lathe, there was a corre-

sponding placement of the indicators. For the standard method, indicator placement was described in the reference material; for the alternative method, placement of the indicator had to be determined independently.

Scoring

The researcher checked off the stages of the problem-solving process as they took place and made brief notes regarding the main elements of the response. Furthermore, subjects were reminded to put all computations directly on the scenario (or on an accompanying blank sheet of paper) and were asked to surrender it when they were done. After the subject was no longer present, the researcher made sure that entries for the selection of method and demonstration of the response had been made on the performance sheet and that the purpose and result of the subject's calculation of values were evident from the sheet containing the scenario.

The final classification by level of success took place at a later date after the subjects' names had been removed from their worksheets and the values calculated by the subjects had been checked for accuracy. Appendix G contains the calculations required for successful performance on the scenario as well as calculations for all other dimensions of the taper in the scenario. Calculations beyond those necessary for determining the offset were

noted, but did not enter into the scoring; a machinist would be likely to calculate additional dimensions for measuring purposes during the cutting process.

Success was defined as involving three components: the selection of the offset method, calculation of needed values (according to one of the two alternative approaches), and demonstration of the use of values in setting up the machine (corresponding to the approach selected). Partial success was defined as a single identifiable error preventing a successful response. All other responses were classified as unsuccessful.

Follow-up Interview

The follow-up interview was conducted after the subjects had responded to the problem scenario. The purpose of the interview was to measure the understanding and organization of concepts required during the recognition and representation phases of response to the problem scenario. Responses to the interview questions were utilized to compare how subjects were able to apply their knowledge to the scenario with the knowledge that was applied by the researcher in the construction of the scenario. In other words, the interview attempted to measure the understanding of general concepts that were likely to be useful in responding to the scenario.

Development

Three questions were used (Appendix H). The first question, a request to compare the scenario to previously encountered situations, was intended to establish problem recognition, that is, to determine the existence of the category of situation used to classify the problem scenario. The second question, a request to discuss the uses of the different methods of cutting tapers, was designed to establish methodological representation, the classification of a problem situation in a category based on common solution procedures. The third question, a request to explain different ways of providing the information needed to describe a taper, was designed to establish mathematical representation, the classification of a problem situation based on a set of mathematical relationships.

The three questions went through various changes during the preliminary study, primarily in order to reduce the number of questions and to simplify and clarify their wording. In general, there was a shift away from asking subjects to describe their thinking and toward descriptions of the results of thought processes. For example the question, "Did anything you had done previously help you decide what to do?" was replaced with the question, "How would you compare this situation to tapers that you cut during the lathe unit?" Instead of asking subjects to

describe how their intentions had changed during the course of their response to the scenario, they were asked to tell when they would use the different methods of cutting tapers.

Administration

The follow-up interview was conducted by the researcher immediately after subjects had completed work on the problem scenario and after they had demonstrated how they would set up the lathe. The interview was introduced with a request to ask the subjects a few questions about taper cutting. Subjects were informed that the interview was being tape-recorded.

Scoring

The taped interviews were transcribed at the conclusion of the study. Subjects were identified by name on the tapes; names were removed from the transcripts after all data for a subject had been assembled. The transcripts were examined for the required knowledge. A positive answer to each of the three questions was counted as one point for a total learning score between zero and three.

A positive score on problem recognition required a comparison of the scenario to previous taper-cutting experiences. Recognizing taper cutting as a category of situa-

tions requires awareness of both similar characteristics for all taper-cutting situations and differences among particular taper-cutting situations.

A positive score for methodological representation required recognition of the variables required for determining an appropriate method for cutting a taper and an understanding of how different ranges of values for those variables were associated with a particular method of cutting tapers.

The researcher's initial expectation for the interview question regarding mathematical representation was that "define a taper" would be interpreted as constituting a request to provide sufficient information to produce an actual tapered part. In this case subjects would indicate their recognition of the existence of multiple combinations of dimensions capable of providing the minimum information necessary to define a taper. However, it is also possible to interpret the phrase "define a taper" as indicating a request to provide information only about the rate of taper rather than about the entire part. If a subject appeared to understand the question in this sense, a positive score for mathematical representation was given for a response indicating awareness of multiple means of describing the rate of taper.

Administration of the IAR

The Intellectual Achievement Responsibility scale (IAR), used to operationalize learning expectations, contains thirty-four items requiring a choice between internal and external attributions of causes for intellectual achievements or failures. The original target population of the IAR was elementary and high school students. The version used for this study was modified by the researcher to eliminate gender-based pronouns and to make the references to educational outcomes age-appropriate for adults. The order of items and the essential nature of the choices remained unchanged.

The IAR was administered to subjects after the follow-up interview. They were informed that the questionnaire did not have anything to do with machining and that they would be asked to choose the best possible explanation of why some things might happen. They were instructed to answer the questions as best they could and to answer all the questions, but several subjects indicated that there were some items for which they could not make a decision. They were then informed to leave an item blank if they could not choose between the alternatives.

Data Analysis Methods

IAR scores consist of the number of self-attributions (as opposed to external attributions). IAR scores were calculated for each subject (the maximum scores are in parentheses) for the following categories: total (34 items), positive and negative outcome scales (17 items each), outcomes due to ability scale (15 items), and outcomes due to effort scale (19 items). The positive-negative breakdown was crossed with the effort-ability breakdown, resulting in four subscales: positive outcomes due to ability (8 items), positive outcomes due to effort (9 items), negative outcomes due to ability (7 items), and negative outcomes due to effort (10 items). Based on the previous use of the IAR in studies of responses to difficult situations, it was predicted that the score on the negative effort subscale would be the most appropriate approximation of a subject's level of learning expectations.

Frequency distributions and means for each of the nine IAR scores were calculated. Mean scores were also converted to percentages of the total number of items in order to compare levels of positive responses among the nine IAR scores. In order to examine the consistency between the various scales and to aid consideration of whether a unified measure of learning expectations could be derived from

the IAR, a product-moment-correlation matrix for the means of all nine reported scores was calculated, and *t*-tests for dependent means were performed for the positive-negative and ability-effort breakdowns.

The results of the problem scenario provided data regarding performance in a problem situation. An overall performance rating was assigned based on performance on the components of the problem scenario: selection of method, preparation for setup, and demonstration of setup. The rating consisted of one of three possibilities: success (the subject was able to demonstrate a setup appropriate for cutting the requested taper), partial success (the subject was prevented from reaching successful performance by a single, identifiable mistake) and no success (all other responses). The overall distribution of subjects' performance on the problem scenario was used to determine whether the problem scenario provided an appropriate level of difficulty for the subjects, i. e. whether there were sufficient numbers of successful and unsuccessful responses.

In order to evaluate learning from problem situations, the researcher transcribed responses to each of the three questions contained in the tape-recorded follow-up interview and compared them to the conceptual knowledge required to respond to the problem scenario. Each question involved

a different stage of the application of knowledge to the problem scenario: problem recognition, methodological representation, and mathematical representation. Responses to each question were characterized as satisfactory or not satisfactory, resulting in a total learning score between zero and three. Partial credit for a response to a question was given only in cases for which an ambiguous element of the response could be identified. In order to compare the level of difficulty among the components of the learning score and to help determine whether a unified measure of learning from problem-solving could be derived from the interview questions, a product-moment-correlation matrix for the total learning score and individual learning scores was prepared, and t-tests for dependent means were performed between the pairs of individual learning scores.

The first hypothesis, regarding the relationship between performance on the problem situation and learning from problem situations, was tested through correlations between the level of success on the problem scenario and both the total learning as well as individual learning scores. Because the results of the problem scenario (levels of success) could be considered ordinal data (rankings) rather than interval data, both product moment (Pearson r) and rank (Spearman ρ) correlations were calculated.

The second hypothesis, regarding the relationship between learning expectations and performance in a problem situation, was tested through correlations between the total IAR score as well as the IAR scales and subscales on the one hand and the level of success on the problem scenario on the other hand. Both product moment and rank correlations were calculated for the same reason as they were for the first hypothesis, namely the question of the type of data represented by the level of success on the scenario.

The third hypothesis, regarding the relationship between learning expectations and learning from problem situations, was tested through correlations between the total IAR score and the various scales and subscales on the one hand and the total and individual learning scores on the other hand.

Demographic data for the subject group regarding potential external variables such as age, prior employment in the machine trades, the level of formal education, and high school or college mathematics courses were compiled based on the Participant Information Sheet (Appendix I). However, the question of whether either learning expectations or learning from problem situations could be related to any of these factors could not be addressed in this study because the number of subjects was not sufficient for

them to be classified into groups according to the above-mentioned demographic factors.

CHAPTER IV

RESULTS

Introduction

Two aspects of the acquisition of problem-solving skill during occupational training have been defined: learning expectations (attitudes toward difficult situations) and learning from problem situations (the ability to apply previously acquired knowledge to new situations). The purpose of this study was to examine relationships between learning expectations and learning from problem situations as well as between these two variables and performance in problem situations. Subjects were students in a community college machine tool technology program.

The Intellectual Achievement Responsibility scale (IAR) (Crandall, Katkovsky, and Crandall, 1965), an existing locus-of-control instrument, was used to measure learning expectations. This instrument required subjects to choose between attributing responsibility for intellectual outcomes to themselves or to outside causes. In addition to total scores, IAR scores were reported for scales based on two different breakdowns of the IAR items: positive or negative outcomes and attributions of self-control due to

ability or effort. Also, scores for four subscales obtained by crossing the positive-negative and ability-effort divisions were reported. A correlation matrix was prepared for all IAR scores.

A problem scenario created by the researcher was used to measure problem-solving proficiency. The scenario consisted of a request to set up a lathe to produce a particular part. Subjects were asked to select an appropriate method, perform necessary calculations, and demonstrate the setup. Performance on the problem scenario was classified as successful if a subject was able to select an appropriate method, calculate the needed values, and use the values in demonstrating the setup. Performance on the problem scenario was classified as partially successful if a subject was prevented from a successful performance by a single identifiable action. All other performances were classified as unsuccessful.

A follow-up interview was used to measure learning from problem-solving. The interview questions concerned concepts used in applying previously acquired knowledge to the scenario. Each of the three questions in the follow-up interview concerned one aspect of the problem-solving process. The first question, a request for a comparison of the scenario to previously encountered situations, involved recognition of a category of situations based on the pro-

duction of this particular part. The second question, a request for reasons why different methods of producing this type of part would be used, involved the comparison of different situations within an established category. The third question, a request for an example of the mathematical relations between dimensions of the part, involved the use of mathematical operations to compare different situations within this category. Based on a scoring system of one point for a satisfactory response to each question, a total learning score between zero and three points was derived.

Three hypotheses were tested. The hypothesis concerning a relationship between learning from problem situations and performance in a problem situation was tested by correlations between learning scores and performance on the problem scenario. The hypothesis concerning a relationship between learning expectations and performance in a problem situation was tested by correlations between IAR scores and performance on the problem scenario. The hypothesis concerning a relationship between learning expectations and learning from problem situations was tested by correlations between IAR scores and learning scores.

Educational and Occupational Background of Subjects

Of the eighteen subjects, there were seventeen males and one female. The age of the subjects ranged from twenty-one to fifty; the median age was between thirty-two and thirty-three.

With regard to formal education, all of the subjects were high school graduates, and all had some college credit; six of the subjects (33.3%) reported having completed at least two years of college.

With regard to formal course work in mathematics at the high school or college level, twelve (66.7%) reported taking courses in algebra, eight (44.4%) reported taking courses in geometry, eight (44.4%) reported taking courses in trigonometry, and twelve (66.7%) reported taking courses in technical or shop mathematics. On the other hand, three subjects (16.7%) reported not taking any of the above-mentioned courses.

With regard to work experience, ten of the subjects (55.5%) reported at least one year in a skilled position in the machine trades, and an additional five subjects (27.7%) reported at least one year in a semi-skilled position. The other three subjects reported no manufacturing work experience or only unskilled labor in a manufacturing setting.

Results of the IAR

The total IAR score is the number of responses (out of thirty-four) which favor self-responsibility as opposed to external responsibility for an intellectual outcome. One-half point was scored for items on which a subject was unable to make a decision. The total IAR score is based on attributions of self-responsibility regardless of whether the outcome is positive or negative and regardless of whether the outcome is due to ability or effort.

Table 1 shows the distribution of total IAR scores for the twenty-one subjects. The mean and median scores are quite close, and the mode is two points higher. The least frequent scores are located at both extremes, indicating a distribution of scores that is approximately normal. Only one subject answered all of the items positively, but the overall number of self-responsibility choices is high; expressed as a percent, the mean score is 82.9%.

A high number of positive responses has been characteristic of the IAR; in the original norming study (Crandall, Katkovsky, and Crandall, 1965) mean percentage scores for different grade levels and gender groups ranged from 68.1 to 80.3%. For twelfth-grade boys, the mean percentage score was 71.7 %. Thus, the high number of positive responses indicating a high level of assumption of

Table 1

Total IAR Scores for All Subjects
(34 items)

score	number of subjects	percent
34	1	5.6
32	1	5.6
31	1	5.6
30	5	27.8
29	1	5.6
28	3	16.7
27	1	5.6
26	2	11.1
24	1	5.6
23	1	5.6
21	1	5.6
total	18	100.0

mean	28.17	standard deviation	3.26
median	28.50	standard error	.77

self-responsibility for an adult sample is not particularly surprising.

The IAR items are equally divided between attribution of responsibility for positive outcomes, i.e. successful responses to intellectual challenges, and negative outcomes, i.e. unsuccessful responses. The importance of this classification is based on possible differences between accepting responsibility for successful outcomes and for unsuccessful outcomes. Positive outcomes characterize situations in which there is a correspondence between

learning expectations and outcome, while negative outcomes indicate a discontinuity between expectations and outcome. For example, accepting responsibility for unsuccessful outcomes may depend on a willingness to view failure as a temporary outcome that is subject to reversal.

Table 2 shows the distributions of IAR scores for positive and negative outcomes. The means show similar levels of positive responses, 84.0% and 82.0% respectively. The means are close to the medians for both distributions, and the distributions are approximately normal. Compared, to the distribution of total IAR scores there is an increased frequency of maximum and near-maximum scores.

Despite the prediction that subjects would be less willing to take responsibility for negative outcomes and that scores for this scale would be lower than for positive outcomes, the levels of learning expectations reflected by these two scales are similar. Despite similar means for overall responses to positive and negative outcomes, it is possible that there is a significant difference between mean difference scores for positive and negative outcomes; however, a $\underline{t}$-test for dependent means showed that the difference between the two means failed to reach even a .5 level of significance.

The classification of IAR items according to ability or effort depends upon whether the internal-control re-

Table 2

IAR Scales for Positive and Negative Outcomes

Positive Outcomes (17 items)			Negative Outcomes (17 items)		
score	number of subjects	percent	score	number of subjects	percent
17	3	16.7	17	2	11.1
16	3	16.7	16	2	11.1
15	1	5.6	15	3	16.7
14	4	22.2	14	5	27.8
13	3	16.7	13	3	16.7
12	4	22.2	12	1	5.6
			10	1	5.6
			9	1	5.6
total	18	100.0	total	18	100.0
mean		14.28	mean		13.86
median		14.00	median		14.00
standard deviation		1.84	standard deviation		2.08
standard error		.43	standard error		.45

sponse for each IAR item is based on ability (such as being smart) or effort (such as trying hard). This breakdown was not reported in the original IAR study but has been utilized by subsequent researchers. This division of the IAR contains a different number of items in each category. The potential importance of this division is that effort is more variable and outcomes due to levels of effort are more likely to be considered under an individual's control than outcomes due to ability.

Table 3 shows the distribution of IAR scores for outcomes due to ability and outcomes due to effort. Expressed as percentages, levels of positive responses for ability and effort items are similar, 84.5% and 81.9% respectively.

Table 3

IAR Scales for Outcomes Due to Ability and Effort

Ability Outcomes (15 items)			Effort Outcomes (19 items)		
score	number of subjects	percent	score	number of subjects	percent
15	1	5.6	19	1	5.6
14	5	27.8	18	1	5.6
13	5	27.8	17	4	22.2
12	3	16.7	16	5	27.8
11	2	11.1	15	3	16.7
10	2	11.1	14	2	11.1
			12	1	5.6
			10	1	5.6
total	18	100.0	total	18	100.0
mean		12.67	mean		15.56
median		13.00	median		16.00
standard deviation		1.46	standard deviation		2.12
standard error		.34	standard error		.50

Table 3 shows similar patterns for ability and effort items; the predicted differences between ability and effort scores do not occur. Just as for positive and negative

outcomes, the similar means for overall responses to outcomes due to ability and effort leave open the possibility of a significant difference between the mean difference scores for positive and negative outcomes; however, a *t*-test for dependent means showed that the difference between the two means did not even reach a .3 level of significance. The similarities in the five distributions shown in Tables 1, 2, and 3 (the total IAR, positive outcomes, negative outcomes, outcomes due to effort, and outcomes due to ability) indicate that for the sample used in this study, differences with respect to the type of outcome or reason for internal control of the outcome are not reflected in differences in the level of internal control.

The IAR subscales are obtained by combining the classification of items resulting from the division into positive or negative outcomes with the classification of items resulting from the division into outcomes due to ability or effort. The resulting four subscales contain between seven and ten items each. Based on previous uses of the IAR in studies of learned helplessness, the researcher expected that the subscale involving negative outcomes due to lack of effort would be more representative of learning expectations in difficult situations requiring a high level of effort than the subscales containing positive outcomes or outcomes due to ability. Table 4 shows the distribution of

scores for the four IAR subscales. The subscale means expressed as percentages, range from 81.1% to 85.3% and are similar to those previously encountered for the scales.

Tables 2 and 3 show that the positive-negative and ability-effort breakdowns of the IAR did not lead to noticeable differences in the level of positive responses. Table 4 shows similar distributions of scores for the four IAR subscales. Despite these apparent similarities, examining correlations of the subscales with each other and with other variables will allow further consideration of

Table 4

IAR Subscales

Positive Ability (8 items)			Positive Effort (9 items)		
score	number of subjects	percent	score	number of subjects	percent
8	5	27.8	9	4	22.2
7	5	27.8	8	4	22.2
6.5	2	11.1	7.5	1	5.6
6	5	27.8	7	4	22.2
5	1	5.6	6.5	1	5.6
			6	3	16.7
total	18	100.0	5	1	5.6
			total	18	100.0
mean		6.83	mean		7.39
median		7.00	meadian		7.25
standard deviation		.91	standard deviation		1.21
standard error		.21	standard error		.29

Table 4-Continued

Negative Ability (7 items)			Negative Effort (10 items)		
score	number of subjects	percent	score	number of subjects	percent
7	3	16.7	10	2	11.1
6.5	1	5.6	9.5	1	5.6
6	9	50.0	9	4	22.2
5	3	16.7	8.5	1	5.6
4	2	11.1	8	6	33.3
			7	2	11.1
			5	2	11.1
total	18	100.0	total	18	100.0
mean		5.81	mean		8.11
median		6.00	median		8.00
standard deviation		.89	standard deviation		1.42
standard error		.21	standard error		.34

possible differences in learning expectations based on the positive-negative and ability-effort distinctions.

Table 5 shows the correlation matrix for the nine IAR scores: total IAR, the four IAR scales, and the four IAR subscales. Correlations for which there are no common items are shaded. All of the correlations are significant at the .01 level when one element of a pair is contained in the other, such as between a scale or subscale and total IAR score. On the other hand, of the sixteen non-overlapping (shaded) correlations, only one is significant at the .01 level and an additional four are significant at the .05

level. None of the nine correlations between positive and negative outcomes (scales or subscales) are significant, while five of the nine correlations between ability and effort (scales or subscales) are significant. With respect to subscales, there are two significant correlations among the four subscale correlations with a common factor, but the two subscale correlations with no common factors, i.e. positive ability with negative effort and positive effort with negative ability, are not significant. In general, the correlation matrix illustrates substantial differences between positive and negative outcomes compared to differences between outcomes due to ability and effort.

In conclusion, the classification of IAR items into categories determined by positive or negative outcomes and categories based on attributions of self-control due to ability or effort yields IAR scores that show a high level of positive responses across all four scales and four subscales. Correlations are not significant for items across the positive-negative classification, but many of the correlations are significant across the ability-effort classification. On the other hand, differences between mean difference scores for both the positive-negative and ability-effort distinctions are not significant.

Table 5

IAR Correlation Matrix

	pos	neg	abil	eff	pos abil	pos eff	neg abil	neg eff
tot	.80#	.86#	.82#	.93#	.56#	.77#	.82#	.76#
pos		.38	.78#	.67#	.82#	.89#	.46	.26
neg			.60#	.86#	.18	.41	.86#	.95#
abil				.56*	.82#	.55*	.81#	.38
eff					.28	.78#	.68#	.85#
pos abil						.48*	.34	.03
pos eff							.43	.34
neg abil								.66*

* = significant at the .05 level
\# = significant at the .01 level (two-tailed test)

Note: Shaded figures indicate correlations between categories with no common items.

Performance on the Problem Scenario

The problem scenario involved a request to cut a part on a lathe. Subjects were asked to determine the method they would choose to cut the part, use the given information to calculate values needed to set up the lathe, and

demonstrate how they would actually set up the lathe. After the directions were given, subjects were allowed to work independently using a calculator and reference material for as long as they wished until they were ready to demonstrate the setup. Performance was observed by the researcher and major steps were recorded. In addition, any calculations made by the subjects were retained for later analysis.

Table 6 shows the distribution of the results of the problem scenario. The largest number of performances were partially successful, that is, distinguished from successful performance by only a single identifiable error, and the smallest number of performances were successful, that is, characterized by selection of an appropriate method, calculation of necessary values, and use of those values in setting up a lathe. In other words, the problem scenario can be characterized as difficult for the subjects since only three out of eighteen (16.7%) did not make some type of error.

Each of the methods used to calculate the values necessary for setup was characterized by a common error. For subjects attempting to follow the format in the reference material, the error involved using the length of the tapered segment instead of the length of the workpiece when calculating the offset. For subjects attempting to use a

trial-and-error method, the error involved neglecting to divide taper per inch by two in order to obtain the lateral movement of the cutting tool per inch of carriage travel. It was not possible to determine whether these errors were due to carelessness or lack of understanding and whether self-correction would have occurred during an actual cutting operation.

Table 6

Performance on the Problem Scenario

outcome	number of subjects	percent
success	3	16.7
partial success	9	50.0
no success	6	33.3
Total	18	100.0

Selection of Method

This stage involved examination of the given information and selection of a strategy for responding to the situation. Fifteen of the eighteen subjects (83.3%) decided to use the most appropriate method to cut the part. The other three subjects decided to use a method that was not appropriate, given the length of the requested part; these subjects were then faced with calculating the angle of taper, which they did with varying degrees of success.

When spatial information is presented in verbal or written form, diagrams allow the identification of relationships. Seven of the subjects (38.8%) either made their own diagrams or referred to diagrams in the reference material. The form of the diagrams was quite varied: rectangles to show the workpiece before cutting, triangles to illustrate taper per foot, and several diagrams for which neither the purpose nor the shape was clear. Only one drawing showed a symmetrical taper (a cone with the point cut off).

Preparation for Setup

After a method had been selected, subjects found it necessary to obtain the values required for utilization of the method. The reference material contained formulas for different combinations of given dimensions. Seven subjects (38.8%) attempted to calculate the value needed for setup using formulas obtained from the reference material. Two of them did so correctly, while four subjects who located the correct formula used the taper length instead of the workpiece length. One subject used the taper per foot in a formula which called for taper per inch.

Ten subjects (55.5%) attempted to calculate the value needed for implementation of an alternative approach based on the amount of lateral movement of the cutting tool for

each inch of movement along the length of the part. This was an adaptation of the method used previously to set the lathe up for this type of cut. Three of the ten obtained the correct value, while six neglected to divide the taper of the diameter per inch of length by two in order to obtain the taper of the radius per inch of length. The tenth subject did not use the given information correctly. Two subjects attempted both methods of calculating the needed values and made both of the above-mentioned common errors.

Ten subjects (55.5%) attempted to calculate dimensions that were not needed for the setup (such as taper angle or small diameter). Three were successful, and an additional two calculated one dimension correctly while calculating another one incorrectly.

Demonstration of Setup

After the values necessary for the setup had been calculated, subjects were asked to describe how they would use those values in setting up the lathe. Of the twelve subjects (66.7%) classified as successful or partially successful, three demonstrated a method of placing a measuring indicator allowing direct positioning of the tailstock based on information obtained from the reference material, and seven demonstrated a method of placing a

measuring indicator allowing trial-and-error positioning of the tailstock adapted from the method used when this type of part had been cut previously. One subject demonstrated both of these methods. One subject who had correctly followed the reference material in calculating the value necessary for the setup became confused between the two methods of placing the measuring indicator; this subject was the only one whose level of success was affected by the demonstration of the setup.

Of the six subjects (33.3%) who were classified as unsuccessful, three were unable to demonstrate any method because they had been unable to calculate any values which could be used for the setup. The other three demonstrated a method of setting up the lathe that was not appropriate for cutting the part demanded in the scenario.

Results of the Follow-up Interview

The follow-up interview, designed to measure learning from problem situations, was conducted after the response to the problem scenario had been completed. The three questions were based on the application of knowledge from previously encountered situations to the problem scenario. The interviews were tape recorded and transcribed. Following are (1) the criteria that were used to determine a correct response and (2) samples of correct and incorrect

responses. Also, the text of the small number of ambiguous responses is provided in full.

Problem Recognition (Question 1)

Problem recognition involves the ability to determine the general category of a situation. In the first question, subjects were asked to compare the situation faced in the scenario to tapers cut during the lathe unit. The desired response involved recognition of the basic similarity of taper situations as well as differences based on the method of cutting tapers and providing taper dimensions. Responses that stressed similarity were scored as correct. Responses that stressed differences on non-essential factors were scored as incorrect. There were no ambiguous responses.

The following is a sample of correct responses:

"right up the alley";
"very similar";
"you didn't have to use the offset method which is not used much anymore";
"similar except that we used the taper attachment instead of moving the tailstock."

The following is a sample of incorrect responses

"have to do a little more calculating";
"I don't find that you're given the information you need to do what you're supposed to do";
"the one that we did when we first did the lathe, everything was in the proper place";
"instead of a picture, you use words."

Methodological Representation (Question 2)

Methodological representation involves the ability to select among alternative solution paths prior to developing a response to a situation. In the second question subjects were asked to describe guidelines for the use of the different methods for cutting tapers. The desired response involved both the different methods of cutting tapers and the guidelines for their use. Responses that mentioned at least two methods and appropriate guidelines, such as length or steepness of a taper, were scored as correct. Responses that failed to mention a guideline or mentioned an inappropriate guideline were scored as incorrect. There was one ambiguous response.

The following is a sample of correct responses:

"if you don't have a taper attachment, offset the tailstock";
"use compound for short tapers";
"taper attachment would do large tapers, tailstock would do large tapers, compound taper would be [for] small, short taper";
"if the taper attachment didn't have enough length to cut the length that you needed."

The following is a sample of incorrect responses:

"depend on the amount of accuracy required";
"I've never really had to cut tapers";
"I imagine you could shove something in a four jaw [chuck]";
"tailstock, compound rest, and taper attachment."

The following is an ambiguous response:

"what size of a taper you're cutting."

Mathematical Representation (Question 3)

Mathematical representation consists of the understanding of the mathematical relations between the elements of a situation. In the third question, subjects were asked if there was more than one way to give the dimensions of a taper and to describe alternative means of giving the dimensions of a taper. The desired response involved the recognition that relations between taper dimensions create the possibility of different combinations of dimensions for providing the minimum amount of information needed to define a taper. An analysis of the responses determined that this question could be interpreted in two ways; in addition to the desired meaning of completely defining a taper, it was justifiable to interpret the question as referring only to alternative ways of expressing the amount of taper. The second approach was more common, and most of the correct responses simply emphasized alternatives to giving the taper per foot. Incorrect responses contained incorrect mathematical relations between taper dimensions or insisted that there were no alternatives to a particular taper dimension. There were two ambiguous responses.

The following is a sample of correct responses:

> "you could work it out without knowing what your tpi is; you could work it out in trig";
> "you can trig it out if you have the height and one angle or the length; another way is the ratio";

"instead of putting in a taper at all, you could put fore and aft measurements so the person could figure out the taper himself";
"I guess you could give the small [diameter] and the length or the big [diameter] and the length."

The following is a sample of incorrect responses:

"if you want to use tailstock offset, you need tpf";
"I imagine";
"get the angle in degrees or tpf";
"give you the length and you figure out the triangle."

The following are ambiguous responses:

"small or large diameter, tpi or tpf";
"tpf and length of taper."

Learning Scores

A "learning score" was calculated for all subjects based on their interview responses: the three follow-up questions were scored at one point each for a maximum learning score of three. (The small number of ambiguous responses was scored at one-half point).

Table 7 shows the distribution of scores for learning through problem-solving based on the follow-up interview. The mean is somewhat lower than the median indicating a distribution that is skewed to the left (negatively skewed). It can be seen from the distribution that there was a wide degree of variation in learning scores and that the extremes, both upper and lower, were well represented. In other words, despite having completed a common set of

training tasks, the subjects displayed wide variations in their ability to apply their knowledge to new situations.

Table 7

Total Learning Scores

score	number of subjects	percent
3.0	5	27.8
2.5	1	5.6
2.0	5	27.8
1.5	2	11.1
1.0	1	5.6
0.0	4	22.2
Total	18	100.0

mean	1.75	standard deviation	1.14
median	2.00	standard error	.27

Each of the individual learning scores represents a single aspect of the application of knowledge in a particular situation. Furthermore, these aspects contain different degrees of dependence on basic academic skills. In order to determine the level of mastery of the different aspects of learning from problem solving, it is necessary to examine the distributions of individual learning scores.

Table 8 shows the distribution of individual learning scores for each of the three questions constituting the follow-up interview. The similarities among the numbers of correct and incorrect responses for each of the individual

learning scores show that the interview questions represent aspects of learning from problem-solving of comparable difficulty. Furthermore, _t_-tests for dependent means between the pairs of learning scores do not show significant differences between mean difference scores for any of the pairs of learning scores.

Table 8

Individual Learning Scores

Problem Recognition (Question 1)

score	number of subjects	percent
1.0	11	61.1
0.0	7	38.9
total	18	100.0
	mean .61	

Methodological Representation (Question 2)

score	number of subjects	percent
1.0	10	55.6
0.5	1	5.6
0.0	7	38.9
total	18	100.0
	mean .58	

Table 8-Continued

Mathematical Representation (Question 3)

score	number of subjects	percent
1.0	9	50.0
0.5	2	11.1
0.0	7	38.9
total	18	100.0
	mean .56	

Based on the similar means, the individual learning scores appear to represent aspects of learning from problem-solving of comparable difficulty; however, the question remains as to how proficiency in one aspect corresponds with proficiency in the other two aspects. This can be determined through an examination of correlations between individual learning scores. Table 9 shows the correlation matrix for the total learning scores and the three individual learning scores derived from the questions contained in the follow-up interview. All of the correlations between total learning scores and individual learning scores (which are part of the total learning scores) are significant at the .01 level. Of the three correlations between the individual learning scores, only the correlation between problem recognition and mathematical representation is signifi-

cant at the .01 level. The lack of correlation between methodological representation and the other two learning scores means that many of the subjects who were proficient in this aspect of learning from problem-solving were not proficient in the other two aspects of learning from problem solving, an indication of differences in the type of knowledge that was applied, as well as the basic academic skills that are required for application.

Table 9

Learning Scores Correlation Matrix

	Problem Recognition (Question 1)	Methodological Representation (Question 2)	Mathematical Representation (Question 3)
Total Learning Score	.81**	.68**	.81**
Problem Recognition (Question 1)		.26	.58**
Methodological Representation (Question 2)			.29

** = significant at the .01 level
(two-tailed test)

Correlations Between Learning Scores and Performance on the Problem Scenario (Hypothesis 1)

The total and individual learning scores are designed to operationalize learning from problem situations, the application of aspects of knowledge to situations beyond those in which they were encountered. The problem scenario represents an opportunity to apply what has been previously learned under new conditions. The correlation between learning scores and performance on the problem scenario represents a measurement of the degree to which this type of knowledge reflects actual performance in a problem situation.

Table 10 shows both Pearson $\underline{r}$ and Spearman $\underline{\rho}$ correlations between performance on the problem scenario and both individual and total learning scores. The two correlations show the same pattern of statistical significance. Three of the four correlations between learning scores and performance on the problem scenario reach the .01 level of significance. The significant correlations at the .01 level are for problem recognition, an understanding of the overall category of taper problems, mathematical representation, an understanding of the mathematical relationships between taper dimensions, and total learning score. The correlation for methodological representation, an under-

standing of the guidelines for using different methods of cutting tapers, is not significant.

Table 10

Correlations Between Learning Scores and Performance on the Problem Scenario

	Pearson r	Spearman ρ
total learning	.61**	.57**
problem recognition	.64**	.65**
methodological representation	.13	.16
mathematical representation	.63**	.63**

** significant at the .01 level (two-tailed test)

The three significant correlations, total learning, problem recognition, and mathematical representation, provide support for the first hypothesis. These correlations can be explained by the essentially mathematical nature of the problem scenario. Subjects who are proficient in basic algebraic and geometrical operations are more likely to be able to define categories based on geometrical principles and use algebraic operations to respond to variations in those categories than those who are not proficient in these areas.

Correlations Between the IAR and Performance on the Problem Scenario (Hypothesis 2)

As an indication of the degree of self-responsibility for intellectual outcomes, the IAR was used to measure learning expectations. Scores on the four IAR scales and four subscales show the subjects to have a high level of self-responsibility regardless of whether the outcomes of the situations are positive or negative and regardless of whether the outcomes are due to ability or effort. The problem scenario has been shown to represent an application of previously acquired knowledge that is within the capability of some but not all of the subjects.

Table 11 shows Pearson $\underline{r}$ and Spearman $\underline{\rho}$ correlation coefficients between all IAR scores and performance on the problem scenario. The patterns of significance for the two correlations are similar, as they were in the previous section with a single exception: the Pearson $\underline{r}$ correlation between positive ability and performance is significant only at the .06 level while the Spearman $\underline{\rho}$ correlation between the same two variables is significant at the .05 level. The correlation between total IAR scores and performance is not significant. All three significant correlations with performance involve positive outcomes; furthermore, none of the other correlations are significant.

Differences between correlations for positive and negative IAR scales are statistically significant, while differences between correlations for ability and effort scales are not significant. The hypothesis of a correlation between IAR and results on the problem scenario is not

Table 11

Correlations Between IAR Scores and Performance on the Problem Scenario

	Pearson *r*	Spearman *ρ*
IAR total	.27	.26
positive outcomes	.54*	.49*
negative outcomes	-.05	-.10
ability outcomes	.40	.39
effort outcomes	.14	.16
positive ability	.46^	.51*
positive effort	.49*	.48*
negative ability	.18	.12
negative effort	-.19	-.25

^ significant at the .06 level
* significant at the .05 level (two-tailed test)

supported by the total IAR scores. Regarding the IAR subscales, the expectation was that negative effort would be most highly correlated with response to difficult situations, but according to Table 11, of the four subscales, the correlation with the results of the problem scenario is strongest for positive ability while the correlation be-

tween negative effort and performance on the problem scenario is not significant.

Correlations Between the IAR and Learning Scores (Hypothesis 3)

The examination of the potential relationship between learning expectations and learning from problem situations was operationalized through correlations between the IAR (including scales and subscales) and the learning scores based on the follow-up interview. The correlation between total IAR and the total learning scores provides the broadest view of the relationship; correlations involving IAR scales or subscales and individual learning scores provide information about specific aspects of this relationship.

Table 12 shows correlations between all IAR scores (total scores, four scales, and four subscales) and all learning scores (total and individual). The correlation between the total IAR and total learning scores is not significant at the .05 level. With respect to correlations between IAR scales or subscales and total learning scores, there is one negative correlation that is significant at the .01 level: the correlation with the negative effort subscale. There is also one negative correlation that is significant at the .05 level: the correlation with the negative outcomes scale. With respect to correlations between the IAR scores and the individual learning scores,

there are three significant negative correlations at the .05 level: the correlations between the negative effort subscale and both problem recognition (Question 1) and mathematical representation (Question 3) as well as the correlation between the effort scale and methodological representation (Question 2).

In conclusion, the positive and negative outcomes scales of the IAR continue to show different patterns of correlation with variables related to problem-solving. This difference in the behavior of the positive and negative outcomes scales was also noted in the discussion of the previous hypothesis with respect to the correlations between these two scales and performance on the problem scenario. Furthermore, for both of these hypotheses, the negative outcomes scale indicated a lower level of problem-solving ability and a lower level of learning expectations than the positive outcomes scale, despite expectations to the contrary. These results do not support the hypothesized relationship between learning expectations and learning from problem situations. They do suggest that accepting self-responsibility for negative outcomes and accepting self-responsibility for positive outcomes may not involve the same set of attitudes toward difficult situations.

Table 12

Correlations Between IAR Scores and Learning Scores

	total learning	problem recognition	methodological representation	mathematical representation
IAR total	-.27	-.07	-.38	-.17
positive	.16	.32	-.19	.25
negative	-.53*	-.35	-.39	-.49*
ability	-.02	.13	-.12	-.06
effort	-.37	-.17	-.47*	-.20
pos-abil	.24	.30	.03	.22
pos-eff	.09	.26	-.31	.24
neg-abil	-.31	-.11	-.26	-.35
neg-eff	-.62**	-.47*	-.43	-.50*

* = significant at the .05 level
** = significant at the .01 level (two-tailed test)

CHAPTER V

CONCLUSION

Introduction

The purpose of this study was to examine two variables related to the acquisition of problem-solving skills during occupational training. The area of occupational knowledge used for this study was machine tool technology. The variables were learning expectations (an attitude toward using learning strategies to respond to difficult situations) and learning from problem situations (the organization of knowledge from previously encountered situations into categories that can be applied to new situations). Because learning from problem situations occurs as a result of the application of knowledge in a problem situation, performance in a problem situation was also measured. Three hypotheses regarding relationships between these variables were tested by examining the correlations between the measurements associated with each variable.

Learning expectations were measured by the Intellectual Achievement Responsibility Scale (IAR) (Crandall, Katkovsky, and Crandall, 1965), an existing locus of control instrument. In addition to a total IAR score, four

IAR scale scores were reported: positive or negative intellectual outcomes and self-responsibility due to ability or effort. Four IAR subscales, created by crossing the positive-negative and ability-effort classifications, were also reported. All of the IAR scores showed a high level of positive responses. Of the correlations between IAR scores with no items in common, most were not significant.

Performance in a problem situation was measured by asking subjects to respond to a problem scenario created by the researcher which required subjects to apply previously acquired knowledge to a novel set of conditions. The most frequently occurring level of performance was partial success. The least frequently occurring level of performance was success.

Learning from problem solving was measured through a three-question follow-up interview conducted after subjects had responded to the problem scenario. The questions covered aspects of the knowledge needed to respond to the problem scenario at different stages in the problem-solving process. A learning score for each subject was derived from the number of positive responses to the interview questions. The scores for each of the questions were similar; slightly more than half of the responses to each question were correct. Only one of the three correlations

between the pairs of individual learning scores was significant.

Concerning the first hypothesis, the relationship between learning from problem situations and performance in a problem situation, there were significant positive correlations between performance on the problem scenario and total learning scores as well as two of the three individual learning scores. That is, as learning from problem situations increased, so did performance in a problem situation. Concerning the second hypothesis, the relationship between learning expectations and performance in a problem situation, the correlation between total IAR scores and performance on the problem scenario was not significant. In other words, the observed relationship between learning expectations and performance in a problem situation was within the limits of random fluctuation. However, there were significant positive correlations between one IAR scale and performance on the problem scenario as well as between two IAR subscales and performance on the problem scenario; i.e. as particular aspects of learning expectations increased, there was an increase in performance in a problem situation. Concerning the third hypothesis, the relationship between learning expectations and learning from problem situations, the correlation between total IAR scores and the total learning score was not significant.

In other words, the observed relationship between learning expectations and learning from problem situations was within the limits of random fluctuation. However, there were significant negative correlations between one IAR scale and total learning scores as well as between one IAR subscale and total learning scores; i.e. as particular aspects of learning expectations increased, there was a decrease in learning from problem situations.

Discussion of Findings

IAR

The high rate of choice of responses indicating self as opposed to external control on the IAR was not surprising given the previous history of this instrument. The rate of positive responses (over eighty percent) was consistent across all IAR scales and subscales (positive or negative outcomes, outcomes due to ability or effort, and combinations of these two breakdowns). One possible explanation is that an adult's decision to participate in an occupational education program indicates a greater self-confidence in learning ability and more positive attitudes toward learning, compared with a random sample of elementary and secondary school students. On the other hand, the subjects did not have a high level of formal education

beyond high school, and many were returning to school after long intervals.

Correlations between IAR scales or subscales and total IAR scores were significant, but only five of the sixteen correlations between individual scales or subscales when there were no items in common were significant. The two significant correlations between negative ability and both effort and negative effort indicate the unifying influence of negative outcomes, and the two significant correlations between ability and both effort and positive effort as well as the significant correlation between positive ability and positive effort indicate the positive relationship between outcomes due to ability and outcomes due to effort. On the other hand, there are no significant correlations across the positive outcomes-negative outcomes breakdown.

The findings of this study replicate those of the original IAR study, namely that correlations between positive and negative outcomes are not particularly high. Based on previous use of the IAR, it had been predicted that scores for negative outcomes would be better indicators of behavior in problem situations because of the likelihood of initial failure in a new situation and the importance of persistence for successful response to difficult situations. A similar prediction had been made with respect to the ability-effort categorization in favor of

effort because of the importance of high levels of effort for persistence in difficult situations.

Problem Scenario

The problem scenario involved setting up a machine to produce a part similar to one that the subjects had previously cut. However, the method that was best suited to the situation described in the scenario and the combination of given dimensions were different from those that the subjects had previously encountered. Subjects were asked to determine the method they would choose to cut the part, use the given information to calculate any necessary values, and demonstrate how they would set up the lathe. "Partial-success," a performance separated from the desired result by a single identifiable factor, was attributed to half of the subjects, the largest category of performance. One-third of the subjects were not successful in their response to the problem scenario, and one-sixth were successful.

Almost all of the subjects in the "partial-success" category made some type of mathematical error. Since these errors involved the selection and use of numerical values rather than computation, the researcher cannot state with certainty whether these subjects are able to apply what they have learned to new situations. It is possible that some of them would be able to overcome their errors during

the longer amount of time required for an actual performance situation, but for others the errors could reflect a fundamental lack of understanding. What is clear from the results of the problem scenario is that for a group of occupational education students with a common set of learning experiences, there is a high degree of variation in their ability to apply what they have learned to a new situation.

Follow-up Interview

The purpose of the follow-up interview was to measure understanding of the concepts associated with taper turning. Three conceptual areas were identified: problem recognition, the association of similar but not identical situations in a single category; methodological representation, the articulation of guidelines for selecting different methods of response for situations within a broad category; and mathematical representation, the recognition of different combinations of mathematical relations which could be used to define a category of situations. There was a reasonably high level of variation for responses to each of the three questions on the follow-up interview, with between half and three-fifths of the subjects providing the desired response to each question. The correlation between problem recognition and mathematical representation

was significant, but the correlations between these two variables and methodological representation were not significant.

Like the problem scenario, the follow-up interview showed a high level of variation. This can be taken as further support for the proposition that a common set of training experiences does not lead to a common ability to apply what has been learned to different situations. The low correlations between some of the individual learning scores suggest that different aspects of learning from problem-solving should be explored separately. In particular, it may be desirable to look at aspects of learning from problem-solving in which knowledge is organized according to mathematical concepts separately from aspects of learning from problem-solving in which knowledge is organized based on content-related concepts.

Relationship Between Performance in Problem Situations and Learning From Problem Situations (Hypothesis 1)

The significant correlation between performance on the problem scenario and the total learning score (based on the follow-up interview) supported the hypothesized relationship between learning from problem situations and performance in problem situations. With regard to the correlations between individual learning scores and the results of the problem scenario, the correlations for problem recogni-

tion and mathematical representation were significant. Both the correlations for problem recognition and for mathematical representation can be attributed to the mathematical understanding necessary for the desired response to the problem scenario, such as recognition of geometric figures, manipulation of algebraic formulae, and use of proportional relationships.

The correlation between performance on the problem scenario and total learning score can be seen as confirming the relevance of the content of the follow-up interview for the application of previously acquired knowledge. In other words, problem-solving proficiency is accompanied by the ability to organize the knowledge relevant to a particular problem situation.

Relationship Between Learning Expectations and Performance in Problem Situations (Hypothesis 2)

Based on the comparison between the total IAR and performance, the observed relationship between learning expectations and performance in problem situations is within the limits of random fluctuation. Five of the eight correlations between individual IAR scales and performance were not significant. There were three significant positive correlations between performance and IAR scales and subscales. The positive correlations of .54 for positive outcomes and .49 for positive effort were significant at

the .05 level, and the positive correlation of .46 for positive ability was significant at the .06 level.

Although the researcher had predicted that negative outcomes would be more likely to be related to behavior in problem situations than positive outcomes, this did not occur. This finding can be interpreted to mean that a high level of confidence in difficult situations is associated more strongly with responsibility for positive outcomes than with responsibility for negative outcomes.

Relationship Between Learning Expectations and Learning From Problem Situations (Hypothesis 3)

Based on the comparison between the total IAR and the total learning score, the observed relationship between learning expectations and learning from problem situations is within the limits of random fluctuation. However, two significant negative correlations were found between IAR scales and subscales. There were also four significant negative correlations between IAR scales and subscales and individual learning scores.

Two significant negative correlations were found between IAR scales or subscales and total learning score: -.62 for the negative effort subscale (significant at the .01 level) and -.53 for the negative outcomes scale (significant at the .05 level). None of the other correlations between IAR scales or subscales and total learning score

were found to be significant. With respect to the individual learning scores, there are significant negative correlations at the .05 level between negative effort and two of the individual learning scores, problem recognition (-.47) and mathematical representation (-.50). Negative correlations significant at the .05 level were also found between effort and methodological representation (-.47) as well as between negative outcomes and mathematical representation (-.49). None of the correlations involving any of the IAR scales or subscales with positive outcomes are significant.

The significant negative correlations between IAR scores for negative outcomes and total learning scores are an indication that combining IAR scales based on positive and negative outcomes for a total IAR score may not be justified and that separate interpretations of scales for positive and negative outcomes is preferable. The negative correlations for negative outcomes scores can be interpreted to mean that accepting personal responsibility for failure, particularly when the failure can be attributed to lack of effort, is associated with viewing problem situations as isolated performance tests rather than searching for common ground between related types of situations. One possible reason may be that frequent failures in problem situations convince some learners that they are responsible for their failures, but attitudes regarding successful

outcomes are not as clearly developed. Furthermore, failures in situations in which others are observed to succeed would make it difficult to attribute failure to external forces.

Discussion of the Research Design

Learning Expectations

The use of the IAR was based on the assumption that for most people there is a consistent attitude governing responses to difficult situations in a variety of settings. Furthermore, it was assumed that this attitude is reflected in causal attributions for the outcomes of these situations. In other words, a high level of learning expectations would mean that an attribution of self-responsibility for the outcome of a difficult situation is considered a desirable outcome even if the actual outcome of a situation is not positive. A corollary of this assumption is that the IAR scales for positive and negative outcomes as well as outcomes due to ability or effort are aspects of a common category of difficult situations. This set of assumptions was not supported by the differences in correlations with the problem-solving variables showed by the positive and negative IAR scales.

What the assumption about consistency of attitudes toward difficult situations may not take into account is

that for an individual with a high level of learning expectations, a negative outcome will be viewed as a learning outcome, that is to say, an outcome leading to a greater understanding of situations in a particular category, only if the outcome is viewed as temporary, i.e. as subject to reversal through the use of a higher level of effort. On the other hand, if a hypothetical situation with a negative outcome is interpreted as implying that the outcome is not subject to reversal regardless of the level of effort, the response might be that external forces were responsible for the outcome.

An alternative approach to measuring attitudes toward learning would allow subjects to consider the competing claims of a broader variety of attributions than the IAR, such as ability, effort, luck, and task difficulty. Equally important is that the items specify situations but not outcomes. An unresolved question is whether situations on a learning expectations instrument should reflect situations common to any learner or situations from a particular content domain. If the latter approach were chosen, subjects could be asked to describe attributions of tasks they have performed themselves.

Another alternative means of measuring attitudes toward learning is the learning interview. The purpose of a learning interview is to elicit a definition of learning

by asking subjects to describe recent learning activities. In order to avoid inappropriate comparisons between methods of learning in widely disparate situations, it is probably necessary to have subjects with a common set of learning experiences. However, these experiences need not be highly structured or formalized. What is important is that subjects are asked questions that allow them a high degree of latitude in analyzing what they have learned. The greater the opportunity subjects are given to articulate different approaches to learning, the easier it will be to discover differences in their conceptions of the purpose of learning. The higher the level of learning expectations, the greater will be the tendency to relate the importance of what has been learned to its meaningfulness or usefulness.

Learning From Problem Situations

The combination of a content-based problem scenario and a follow-up interview met the most important criteria for measuring learning from problem situations, but there are some aspects that could be improved. For example, using a single problem situation completed in a single sitting may not be the most accurate way to measure problem-solving proficiency. Another area of concern is the scoring of the follow-up interview. While statements containing factual errors can easily be discerned, omis-

sions provide more room for interpretation; larger subject pools would allow greater opportunity for testing the clarity of interview questions.

Developing a domain-specific problem-solving situation requires a high level of familiarity with a specialized content domain. The identification of decision-making situations is a prerequisite for the construction of realistic problem scenarios. Situations combining decision-making with quantitative manipulation offer the best opportunities for studying problem-solving behavior. An even higher level of expertise would be required to evaluate the importance or representativeness of a problem situation for a particular occupational domain. There is some tension between the need for a purely hypothetical situation in order to ensure that subjects will not have encountered the precise combination of conditions and the demand for a realistic application of content knowledge. One solution would be to employ computerized presentation of scenarios which could provide a uniform presentation of problem situations and, for an increasing number of occupations, allow problem situations based on the operation of specialized software.

Despite the labor intensive nature of observations of problem-solving behavior and of interviews concerning problem-solving knowledge and methodology, they are useful

means of investigating problem-solving competency, particularly in combination with the results of problem situations. In order to determine what types of understandings a subject actually applies to the problem-solving process, it would be desirable to integrate observations and interviews more closely. One way of accomplishing this would be to use the "talk-aloud method," instructing subjects to provide running commentary regarding their decision-making process. However, without the use of a structured interview format, it would be difficult to compare what is understood by different subjects. A possible procedure would be to combine observations with a structured interview by asking set questions at various stages during the problem-solving process.

Suggestions for Further Research

This study should be seen as an attempt to apply concepts and approaches that have been developed in other areas of educational research to the acquisition of occupational skills by mature learners. In order to carry this out, the researcher found it necessary to adapt some instruments and create others. Among the obstacles to this type of study are the complications posed by a subject matter that few researchers are likely to be familiar with and the relatively small number of students in a given

occupational area, which makes assembling a sufficient number of subjects difficult.

By employing variables derived from learning and problem-solving research, this study has attempted to apply insights from these areas to the acquisition of occupational skill. The interpretation of learning proficiency as an attitude toward difficult situations rather than a set of specific competencies is an attempt to apply what is known about response to difficult situations and methods of studying to occupational education. Similarly, the use of a problem situation based on the application of knowledge under new conditions is an attempt to apply what is known about the development of expertise in a specific content domain to the acquisition of occupational skills.

Learning Proficiency and the Acquisition of Occupational Skill

Learning skills have traditionally been seen as skills necessary for success in formal learning situations. In recent years, the concept of "learning-to-learn" has been extended to a variety of situations in which learning can serve as a means to a desired end; both self-directed learning and organizational learning represent an expansion of the relevance of learning skills, the former to personal and the latter to job-related situations. By defining learning expectations as a set of attitudes toward diffi-

cult or challenging situations, this study sought to build on the trend toward a broader interpretation of learning proficiency by applying an approach to learning proficiency based on self-concept as a learner to occupational tasks.

Taking into account the variety and magnitude of the correlations between IAR scores and problem-solving-related variables, a goal of future studies should be to refine the concept of learning expectations in terms of the internal and external influences that affect attitudes toward difficult situations. In other words, the expectations that develop when encountering a difficult situation are likely to be influenced by reactions to specific combinations of personal and situational characteristics. This study found that the categories composing the IAR, positive and negative outcomes, and outcomes due to ability or effort are not interchangeable as expressions of learning expectations.

Further studies could help determine factors that influence how learning expectations are formed in different types of situations. Although adults presumably have clearly worked-out conceptions of their intelligence and competence in a variety of endeavors, they are also able to differentiate between types of situations, particularly with respect to factors which have the potential to influence learning expectations, such as consequences of fail-

ure, social and organizational pressures, and perceptions of past performance in similar situations. In other words, while adults may have a consistent set of attitudes toward difficult situations, they are also capable of modifying those attitudes to meet the exigencies of a particular situation. One way of determining whether attributions in a particular setting are subject to a process of development would be a longitudinal study of learning expectations.

In order to test the proposition that learning expectations are conditioned by the characteristics of a particular setting, the use of an alternative to standardized written instruments such as the IAR would be desirable. Instead of using generic intellectual outcomes as does the IAR, a research instrument could ask for explanations of possible courses of action for difficult situations in relevant domains. Willingness to use particular learning strategies is an indicator of a learner's level of confidence in difficult situations; self-confident learners are more persistent and more willing to use a variety of learning resources than learners lacking in self-confidence. A written instrument or interview protocol that asked learners to choose preferred courses of actions in situations with familiar characteristics would provide a more direct means of measuring learning expectations.

Problem-solving and the Acquisition of Occupational Skill

Most studies attempting to describe effective behavior in problem situations have been conducted in contexts that are traditionally associated with response to problem situations, i.e. mathematics, science, or professional education. However, as the distinction between general problem-solving ability and domain-specific expertise declines, opportunities increase for studying problem-solving behavior in a wide variety of situations. In other words, defining expertise as the ability to respond to new situations based on their classification according to key characteristics of previously encountered situations implies a conception of problem-solving that includes both analytical ability and the application of previously acquired knowledge.

The problem scenario used in this study represents an attempt to construct a setting requiring the use of both domain-related knowledge and general problem-solving skill. The knowledge requirements for response to the scenario were based on the knowledge acquired during a common learning experience. The problem-solving skills required for response to the scenario were based on the differences between the conditions encountered in the scenario and those in previously encountered situations. The wide variation in problem-solving behavior shown by the subjects

indicates that a common set of training experiences does not lead to a common level of expertise. Furthermore, the low correlations between the different aspects of learning from problem situations can be interpreted as indications that different aspects of expertise depend on different combinations of analytical skills. While the existence of a general problem-solving skill remains questionable, it is possible to classify problem situations according to the type of analytical skills that are required for a successful response. In other words, problems differ according to their requirements for specific information-gathering and information-transforming techniques. Some examples of these techniques would include reading for information, critical reading, logical reasoning, and manipulating algebraic equations.

Studying the problem-solving process in an employment setting would accomplish several purposes. First it would allow the use of problem situations that are within the scope of a particular type of occupational expertise as it is defined by an existing organization. In other words, a problem scenario could be constructed to answer the question: what type of expertise does a particular organization expect for a particular job classification? Second, the use of an organizational setting for this type of study would allow the construction of problem scenarios that are

relevant to the interests of a particular organization. This would allow organizational characteristics such as flatter organizational charts and employee empowerment to help determine the types of problems that an organization expects its employees to respond to. The third justification for conducting a problem-solving study in an organizational setting would be to obtain a more appropriate reflection of the conditions under which the application of occupational knowledge to new situations takes place. For example, although this study was limited to individual problem-solving behavior, group problem-solving activities would be appropriate in many organizational contexts.

The type of follow-up interview used in this study measures the availability rather than the actual use of knowledge during the problem-solving process. A more direct approach to measuring the use of concepts could be accomplished through the use of methods requiring a higher level of intervention in the problem-solving process (as well as the use of a private laboratory-like setting for the study). It would then be possible to ask subjects to perform limited segments of the problem-solving process and to observe the verbal, written, and physical behaviors that are displayed. For example, subjects could be instructed to think about a problem until they had decided how to solve it, or they could be instructed to identify the

information they would need to solve a particular problem. Studies of group problem-solving behavior would provide a natural example of the think-aloud method. Artificial pauses could also be introduced, at which time individual subjects would tape record their thoughts about a problem. The purpose for these interventions would be the same as for the follow-up interview, namely to determine the degree to which subjects were able to manipulate and transform the given information of a problem situation in terms of the desired result.

Implications for Practice

Learning expectations and learning from problem situations can be seen as aspects of broader categories. Learning expectations are a component of attitudes governing response to difficult or challenging situations, and learning from problem situations is a factor in the ability to apply general principles derived from one type of situation to a similar but identical situation. Attitudes toward difficult situations and understanding of general principles can be of potential importance for occupational education programs as well as employer-sponsored training. (The growing involvement of educational institutions in contract and customized training programs is minimizing the distinction between occupational education and employer-sponsored

training.) Attitudes toward difficult situations and understanding of general principles can affect assessment, determination of program content, and the selection of instructional methods, particularly in environments characterized by world-class competition, self-managing teams, and constant improvements in quality, all of which demand a multi-skilled and flexible workforce.

For learning programs in which application of knowledge to new situations is important, selection of participants can be improved by examining willingness to cope with difficult or novel situations. Measurements of the level of self-control in difficult situations could be used in conjunction with exposure to some type of simulated problem situation based on entry-level competencies. Measuring performance in a problem-solving situation can only measure skills in a single content domain; measuring attitudes toward learning in conjunction with problem-solving could indicate the likelihood of improvements in problem-solving skill. Attitudes toward difficult situations could also be evaluated by comparisons of ability versus effort as explanations of initial failure or setbacks. Assessments of attitudes toward learning could also be used to assess the effectiveness of exposure to instructional programs designed to improve problem-solving skills. It is important to note that attitudes toward difficult situations are

generalized response tendencies based on available knowledge and skills; attitudes are more resistent to change than knowledge or skills, but it would be a mistake to equate attitudes with fixed personality traits.

The incorporation of problem situations into occupational education or training content can be a means for promoting improvements in both attitudes toward learning and understanding of general principles. The initial steps in accomplishing this goal involve locating actual problem situations and modifying them for incorporation into learning programs. Problem situations could be compiled by identifying practitioners who display positive attitudes about difficult situations and asking them to describe situations in which they have employed decision-making, selection of skills, or consideration of alternative approaches. An interview schedule could contain questions similar to the following: Can you describe any situations which made you stop and think before you did anything? Can you describe any situations in which you thought that what you were doing might not be the best way to do things? Can you describe any situations where you had to decide between more than one possible course of action? Once situations have been identified, it would be necessary to turn them into usable content. This would require an identification of the prerequisite skills, creation of a written form

complete with any necessary visual aids, and determination of acceptable responses.

The instructional methods used in conjunction with the incorporation of problem situations into learning experiences also have implications for the promotion of improvements in attitudes toward learning and understanding of general principles. It is important that problem situations are not approached as occasions for immediate response (as might be done for skills that must be performed with a high degree of predictability precision). Instead, problem situations should be approached as situations requiring a multiple-stage response process consisting of identification of relevant information in the problem situation, selection of possible target situations, and evaluation of proposed solutions. The use of a multiple-stage problem-solving process could be encouraged through a variety of means: modeling of such behavior by expert performers, incentives or requirements for the production of intermediate products such as suggestions of multiple courses of action, and the use of problem-solving groups. A particularly effective method of combining attitudes toward learning and general understanding would be to ask the participants at each stage of the problem-solving process to explain the reasoning behind their courses of action up to that point. This would make apparent both the

attitudes and the knowledge required for a successful response to a difficult situation.

APPENDICES

Appendix A

Intellectual Achievement Responsibility Scale
(Revised for Adults)

Directions: Consider what would be your reaction IF any of the following situations ever happened to you. Circle the letter of the choice that best describes how you would explain the situation.

Key	
P = positive outcomes	**A** = outcomes due to ability
N = negative outcomes	**E** = outcomes due to effort

P A 1. If an instructor gives you a passing grade at the end of a course, would this happen

a. because the instructor liked you, or
b. because of the work you did?

P E 2. When you do well on a test, would this happen

a. because you studied for it, or
b. because the test was especially easy?

N E 3. When you have trouble understanding something in class would it be

a. because the instructor didn't explain it clearly, or
b. because you didn't listen carefully?

N E 4. When you read a newspaper or magazine article and can't remember what you read, would it be

a. because the article wasn't well written, or
b. because you weren't interested in the article?

P A 5. Suppose someone in your family says you are doing well in your courses. Would this happen

a. because you are really doing well, or
b. because they are in a good mood?

P E 6. Suppose you did better than usual in a course. Would this happen

a. because you tried harder, or
b. because someone helped you?

N A 7. When you loose a game of cards, would this have happened

a. because the other player is a good card player, or
b. because you didn't play well?

N E 8. Suppose a person doesn't think you are very smart,

a. could you change that person's opinion of you, or
b. are there some people who will think you're not very smart no matter what you do?

P E 9. If you happen to solve a puzzle or brainteaser quickly, would it be

a. because it wasn't a very hard, or
b. because you worked on it carefully?

N A 10. If someone ever told you that you were not very smart, would this have happened

a. because they were mad at you, or
b. because you did something that wasn't a very smart thing to do?

N E 11. If you decided that you wanted to become a lawyer, scientist, or doctor, but you couldn't, would this have happened

a. because you didn't want to work hard enough, or
b. because you would have needed some help from other people?

P E 12. When you learn something quickly in class, is it

a. because you paid close attention to it, or
b. because the instructor explained it clearly?

P A 13. If an instructor says to you, "You're doing a good job," would this be

a. something instructors usually say to encourage students, or
b. because you actually did a good job?

N E 14. When you find it hard to work math problems for a class, would it be

a. because you didn't study well enough before you tried them, or

b. because the instructor gave problems that were too hard?

N E 15. When you forget something you heard in class, would it be

a. because the instructor didn't explain it very well, or
b. because you didn't try very hard to remember?

P E 16. Suppose you weren't sure about the answer to a question your instructor asked you, but your answer turned out to be right. Would this happen

a. because the instructor wasn't very fussy about the answer, or
b. because you gave the best answer you could think of?

P E 17. When you read a newspaper or magazine article and remember most of it, would this be

a. because you were interested in the article, or
b. because the article was well written?

N A 18. If someone in your family tells you that you're acting foolishly and not thinking clearly, would this be

a. because of something you did, or
b. because they happen to be feeling cranky or tired?

N E 19. When you don't do well on a test, is it

a. because the test was especially hard, or
b. because you didn't study for it?

P A 20. When you win a game of cards, would this happen

a. because you play well, or
b. because the other person doesn't play well?

P A 21. If people think you're smart, would this be

a. because they happen to like you, or
b. because you usually come across that way?

N A 22. If an instructor doesn't give you a passing grade, would this be

a. because the instructor "had it in for you," or
b. because your work wasn't good enough?

N E 23. Suppose you didn't do as well as usual in a course. Would this happen

a. because you weren't as careful as usual, or
b. because something distracted you and kept you from working?

P A 24. If another person tells you that you are smart, would this be

a. because you had a good idea, or
b. because they like you?

P E 25. If you had become a lawyer, scientist, or doctor, would this have happened

a. because other people helped you when you needed help, or
b. because you worked very hard.

N A 26. Suppose someone in your family says you aren't doing well in your courses. Would this happen

a. because your work isn't very good, or
b. because they are feeling cranky or tired?

N A 27. Suppose you are showing a friend how to play a game and he or she has trouble with it. Would this happen

a. because your friend wasn't able to understand the game, or
b. because you couldn't explain it well?

P E 28. When you find it easy to work math problems for a class, would it be

a. because the instructor gave you especially easy problems, or
b. because you studied how they were done in the text before you tried them?

P E 29. When you remember something you heard in class, would this be

a. because you tried hard to remember, or
b. because the instructor explained it well?

N A 30. If you can't solve a puzzle or brainteaser, would this happen

a. because you are not particularly good at solving puzzles or brainteasers, or
b. because the instructions weren't clear enough?

P A 31. If someone in your family tells you that you are smart, would this be
a. because they are feeling good, or
b. because of something you did?

P A 32. Suppose you are explaining how to play a game to a friend and he or she learns it quickly. Would this happen

a. because you explained it well, or
b. because your friend was able to understand it?

N E 33. Suppose you are not sure about how to answer a question in class, and the answer you give turns out to be wrong. Would this happen

a. because the instructor was very fussy about the answer, or
b. because you answered too quickly?

N E 34. If an instructor says to you, "Try to do better next time," would this be

a. because the instructor is always saying this to get students to try harder, or
b. because your work wasn't as good as it could be?

Source: Crandall, V. C., Katkovsky, W., & Crandall, V. J. (1965). Children's beliefs in their own control of reinforcements in intellectual-academic achievement situations. In Child Development Vol. 36. Chicago, IL: The Society for Research in Child Development, Inc., pp. 95-97.
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Appendix B

Methods of Cutting Tapers

I. Taper Attachment

A taper attachment forces the carriage (the part of the lathe containing the cutting tool) to take an angled path as it moves along the length of a workpiece. This method can be used to cut internal and external tapers up to an angle of about ten degrees as long as the taper is not longer than the bar on the taper attachment.

II. Compound Slide

Using the compound slide, involves keeping the carriage at a fixed position against the workpiece and moving the cutting tool at an angle across the workpiece by hand-cranking the compound slide (located at the top of the carriage). The compound slide can be set at any angle but has only a limited range of travel, limiting this method to short tapers.

III. Tailstock Offset

Offsetting (moving off center) the tailstock (the support for the workpiece at the far end of the lathe from the power source or headstock) involves turning the tail-stock alignment screws to move the top of the tailstock in relation to the base. The left side of Figure 1 shows a centered workpiece (revolving parallel to the lathe bed).

The right side of Figure 1 shows an offset workpiece (revolving at an angle to the lathe bed).

Since the amount of offset is limited, the amount of taper that can be obtained is small, but the length of the taper is limited only by the maximum distance between the lathe centers. Tailstock offset can be used to cut slightly angled external tapers on a lathe that does not have a taper attachment. Tailstock offset is seldom used when a taper attachment is available because the lathe must be recentered after it has been offset, a matching internal taper cannot be machined, and the offset method is not suited to production of more than a single taper.

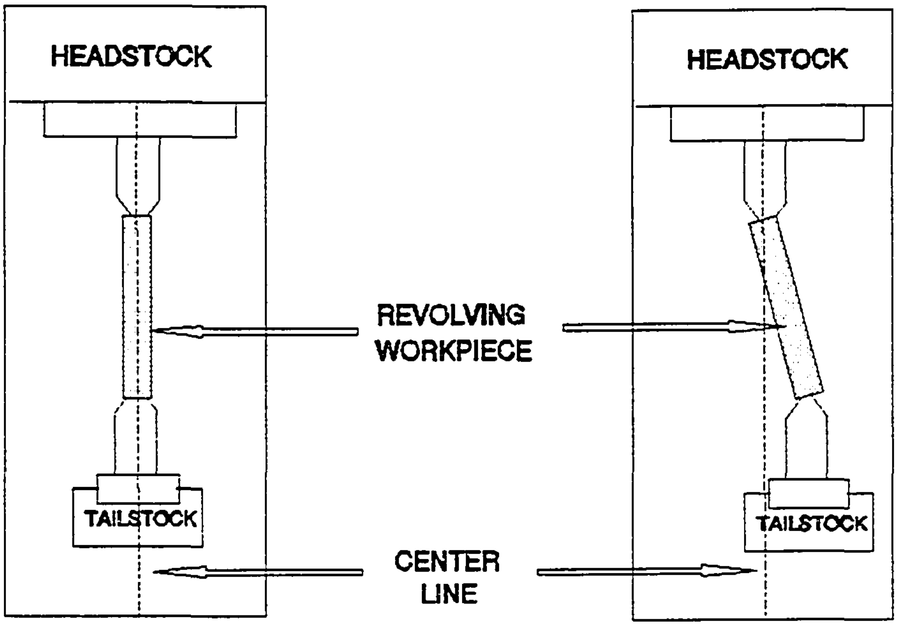

Figure 1. Overhead View of Lathe with Centered Tailstock (left) and with Offset Tailstock (right)

Appendix C

Representation of Taper Dimensions

The most common method of representing a taper in a drawing is as a triangle with one end cut off. This is similar to representing a cylinder as a rectangle and a cone as a triangle (Figure 2). Because tapers used in machining are less than an inch per foot with taper angles between one and two degrees, it is not practical to make scale drawings; drawings usually represent tapers with much steeper angles. (By comparison, roof pitch commonly involves angles between ten and thirty degrees.)

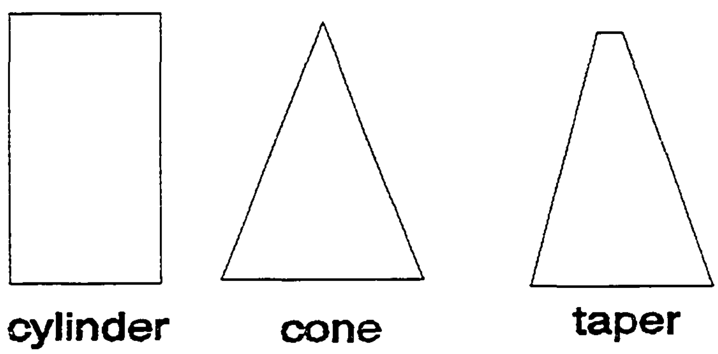

Figure 2. Two Dimensional Representations of Three Dimensional Curved Surfaces

Taper dimensions that can be represented on the type of drawing found in Figure 2 include large and small diameters, length of the taper, workpiece length, amount of taper, and angle of taper (Figure 3). Rate of taper, amount of taper per inch or per foot, can only be represented on a separate drawing of a taper with the respective

unit as the taper length. A separate drawing would also be required to represent a taper ratio, the length required for a taper of one unit. The triangles on each side of the center line represent amount and angle of taper "per side" (half of the total or "included" value).

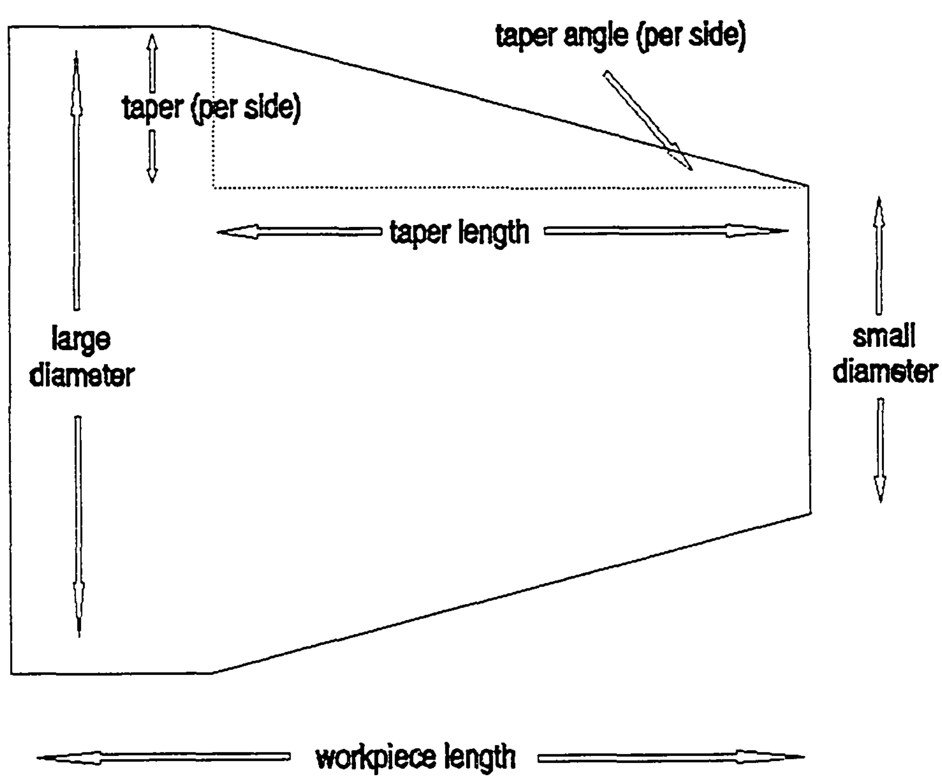

Figure 3. Taper Dimensions

Appendix D

Relations Between Taper Dimensions

If taper per inch is known, the basic offset formula is

(1) $$S = \frac{T_{pi} * WL}{2}$$

S = tailstock offset T_{pi} = taper per inch
WL = length of workpiece

If taper per foot is known, taper per inch can be calculated

(2) $$T_{pi} = \frac{T_{pf}}{12}$$

T_{pi} = taper per inch T_{pf} = taper per foot

Equation 2 can be combined with Equation 1:

(3) $$S = \frac{T_{pf} * WL}{24}$$

S = offset T_{pf} = Taper per foot
WL = workpiece length

If length of taper and both diameters are known, taper per inch can be calculated:

(4) $$T_{pi} = \frac{D-d}{TL}$$

Tpi = taper per inch D = large diameter
d = small diameter TL = length of taper

Equation 4 can be combined with Equation 1:

(5) $$S = \frac{D-d}{TL} * \frac{WL}{2}$$

S = offset D = large diameter d = small diameter

TL = length of taper WL = length of workpiece

If one diameter and amount of taper are known, the missing diameter can be found by addition or subtraction. If one diameter and taper per inch are known, the missing diameter can be calculated using one of the following:

(6) $$D = d + T_{pi} * TL \quad \text{or} \quad d = D - T_{pi} * TL$$

D = large diameter d = small diameter
T_{pi} = taper per inch TL = length of taper

The following combinations of dimensions represent the minimum amount of information required to describe a taper. If the offset method is to be used, the length of the workpiece must also be known.

Combination 1: Length of taper and both diameters

Solution: The offset can be calculated using Equation 5.

Combination 2: Length of taper, taper angle, and one diameter.

Solution: The tangent function can be used to calculate the amount of taper per side (the side opposite the taper angle). The unknown diameter can be obtained by adding or subtracting the amount of taper. The offset can be calculated using Equation 5.

Combination 3: Taper angle and both diameters.

Solution: The taper per side is half the difference between the diameters. The tangent function can be used to calculate the length of taper (the side adjacent to the taper angle). The offset can be calculated using Equation 5.

Combination 4: Length of taper, amount of taper, and one diameter.

Solution: The unknown diameter can be obtained by adding or subtracting the amount of taper. The offset can then be calculated using Equation 5.

Combination 5: Length of taper, rate of taper, and one diameter.

Solution: If taper per inch is given, Equation 1 can be used.

Solution: If taper per foot is given, Equation 2 can be used to calculate taper per inch or Equation 3 can be used to calculate the offset directly.

Solution: If a taper ratio is given, the taper ratio can be substituted for taper per inch in Equation 1.

Appendix E

Problem Scenario

You are a maintenance machinist for Amalgamated Widgets. The machine shop in your factory is very poorly equipped; your <u>only</u> lathe is a small blue Clausing that is exactly like the one in the machine shop at the RMTC. You have just come in to work and find the following note from the machinist on the last shift:

> A little while ago the boss brought in this piece of stock and said there was an urgent need for an 8.65 inch long taper with a taper per foot of .6223 inches. I faced the piece off to 10.75 inches, put in the center holes, and measured the diameter (1.023 inches), but I had to leave early because my kid is in the school play. I'm sure you'll be able to finish the job.

Using the above information and this lathe, determine how you would cut the taper and demonstrate how you would set up the lathe.

Please do not consult with anyone while working on this activity. You may refer to the section on tapers from <u>Turning Technology</u> by Krar and Oswald. You may also use a calculator. Please put any calculations you make on this page or on the next page.

(This activity will conclude when you complete the setup; it is not necessary to turn the lathe on or to insert a cutting tool.)

Appendix F

Analysis of Performance on Taper Problem

I. Selection of method

Y N — A. The offset method is selected.

Y N — B. A diagram is drawn or reference is made to an existing diagram.

Y N — C. A decision is made to calculate the offset directly and the correct offset formulas are located in reference material.

or

Y N — D. A decision is made to calculate the taper per inch in order to offset the tailstock by trial and error to obtain the needed taper per inch.

II. Preparation for setup

Y N — A. The given information is correctly used to set up the equation(s) for obtaining the offset value and the correct offset value is obtained.

or

Y N — B. The taper per inch is calculated by dividing taper per foot by 12 and the taper per side was calculated by dividing taper per inch by 2.

III. Demonstrating the setup

Y N — A. With the lathe centers aligned, an indicator is positioned to move **across** the tailstock spindle to measure the correct amount of offset.

or

Y N — B. After some way to measure an inch of carriage travel is devised, an indicator is positioned to move **along** the workpiece to measure the taper per inch. The offset is adjusted to yield the correct amount of taper when the carriage moves an inch.

Appendix G

Solution to Problem Scenario

Given dimensions:

taper per foot = .6223 inches
workpiece length = 10.75 inches
taper length = 8.65 inches
large diameter = 1.023 inches

Calculation of Tailstock Offset

$$offset = \frac{.6223\ (10.75)}{24} = \mathbf{.279}$$

Calculation of Taper Per Inch Per Side
for Alternative Method

$$taper\ per\ inch = \frac{.6233}{12} = \mathbf{.052}$$

$$taper\ per\ inch\ per\ side = \frac{.052}{2} = \mathbf{.026}$$

Calculation of Other Dimensions

$$amount\ of\ taper = \frac{8.65}{12}\ (.6223) = \mathbf{.449}$$

$$small\ diameter = 1.023 - .449 = \mathbf{.574}$$

amount of taper per side $= \frac{.449}{2} =$ **.225**

angle to center line $= \arctan\frac{.225}{8.65} =$ **1.49°**

included angle $= (1.49°)\ 2 =$ **2.98°**

hypotenuse of tapered segment $= \sqrt{(.225)^2+(8.65)^2} =$ **8.652**

Appendix H

Follow-up Interview

I. Comparison of Simulation and Previously Encountered Situations:

HOW WOULD YOU COMPARE THIS SITUATION TO THE TAPERS THAT YOU CUT DURING THE LATHE UNIT?

The differences involve method of cutting tapers and dimensioning.

II. Taper Cutting Methods:

CAN YOU TELL ME WHEN YOU WOULD USE THE DIFFERENT M-ETHODS FOR CUTTINGS TAPERS?

Tapers can be cut by the following methods:

taper attachment -- (if available) used for slight tapers up to the length of the taper bar
cross slide -- used for steep tapers up to the amount of travel of the cross slide
offsetting the tailstock -- used for slight tapers up to the amount of offset of the tailstock

III. Dimensioning Tapers:

CAN YOU TELL ME WHAT DIMENSIONS YOU WOULD NEED TO KNOW IN ORDER TO BE ABLE TO CUT A TAPER? CAN YOU TELL ME MORE THAN ONE WAY TO GIVE THE DIMENSIONS FOR A TAPER?

Tapers can be described by the following combinations of dimensions:

length of taper and both diameters
length of taper, one diameter, and rate of taper,
length of the taper, one diameter, and amount of taper
* both diameters and angle of taper
* length of the taper, one diameter, and angle of taper

* trigonometric functions required to obtain missing dimensions

Appendix I

Participant Information Sheet

Name ______________________________ Age ________

Why are you in the Machine Tool Technology program?

________ to improve skills for my current job

________ to qualify for a promotion or new job with my present employer

________ to obtain the skills necessary to enter the machine trades

________ as part of an apprenticeship program

________ a different reason from those given above (Please specify.)

How many years of work experience in do you have in the following areas?

________ machine trades (skilled)

________ machine trades (semi-skilled)

________ other manufacturing

________ non-manufacturing employment

What is your current level of education?

________ completed two or more years of college

________ completed less than two years of college

________ high school graduate (or GED)

________ not a high school graduate

Check any of the following math course that you have had in high school or college:

______ algebra

______ geometry

______ technical or shop math

______ trigonometry

Appendix J

Approval Letter From the Human Subjects Institutional Review Board

Human Subjects Institutional Review Board

Kalamazoo, Michigan 49008-3899

WESTERN MICHIGAN UNIVERSITY

Date: March 19, 1993

To: Michael Krischer

From: M. Michele Burnette, Chair MMB

Re: HSIRB Project Number 93-03-19

This letter will serve as confirmation that your research project entitled "Learning expectations and performance on problem-solving tasks in pre-employment training" has been **approved** under the exempt category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the approval application.

You must seek reapproval for any changes in this design. You must also seek reapproval if the project extends beyond the termination date.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: March 19, 1994

xc: Brinkerhoff, EL

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