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PROBLEM SOLVING OF MACHINE OPERATORS WITHIN THE CONTEXT OF EVERYDAY WORK: LEARNING THROUGH RELATIONSHIP AND COMMUNITY

By

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ABSTRACT

PROBLEM SOLVING OF MACHINE OPERATORS WITHIN THE CONTEXT OF EVERYDAY WORK: LEARNING THROUGH RELATIONSHIP AND COMMUNITY

by

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Informal learning constitutes the bulk of learning that takes place within the workplace and occurs most often when an individuals job scope expands. Organizations are increasingly expecting their frontline employees to solve operational problems, creating a "new" space for learning to occur. Problem solving, by virtue of its action orientation, provides the opportunity for creating experiences that lead to informal learning. However, problem solving represents one of the most neglected areas of research in the workplace, particularly within the context of manufacturing. Further, the literature has failed to capture, from the standpoint of the workers themselves, the intersection between the gaining popularity of knowledge management and the increased expectation for frontline employees to solve operational problems on their own.

The purpose of this qualitative study was to explore the informal learning associated with the problem solving process of machine operators within the context of their everyday work. Hence, the research question: What is the nature of the informal learning associated with the problem solving process of machine operators within the context of their everyday work? Using the critical incident technique, twenty machine operators from three manufacturing organizations were interviewed individually, with eight of the twenty participating in a follow-up focus group session.

The findings show that first, learning is perceived by machine operators to be intimately bound up with problem solving. Second, the problem solving process is triggered by an incident which leaves them frustrated, confused and uncomfortable. The process of regaining equilibrium or certainty is inherently social in nature and is guided by personal strategies to achieve balance. Third, problem solving and learning are part of an ongoing process of becoming a machine operator, with three definable phases. Fourth, the consequences of the learning process results in several kinds of knowledge. The main conclusion of this study was that nature of informal learning of machine operators is shaped by the dialogic relationship between the worker, the task and the machine, within a broader community of practice.

This study has enhanced the understanding of the informal learning associated with the problem solving process of machine operators within the context of their everyday work. This enhancement of understanding has implications for both theory and practice. The implications for theory center upon the integration of cognition and social theories of learning, while the implications for practice range from how work is structured to the use of authentic problems in higher education. Recommendations for further research touch upon both methodology and theory.

I dedicate this research study to the individual men and women I interviewed for sharing their time, knowledge and experience with me.

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CHAPTER ONE

THE RESEARCH PROBLEM

"Learning is too important to be left to educational institutions and in-house training departments." (Boud and Garrick, 1999, p.4)

Introduction

The purpose of this study is to explore the nature of the informal learning associated with the ill-structured problem solving process of production machine operators within the context of their work. My interest in exploring informal learning related to the problem solving process stems from my experiences inside the manufacturing work context in the use and application of the problem solving process on operational and organizational shop floor issues.

Manufacturing organizations, in their efforts to remain competitive, are strategically pushing problem solving and decision making to the frontline production employee. It is no wonder that manufacturing facilities across the U.S. report increasing requirements in open skills such as problem solving, decision making and interpersonal communication (Imel, 1999; AFL-CIO, 1999; NRC, 2001; Schmidt, 2000). In fact, employees and work teams are taking on the responsibility of supervising themselves, and they are being given more leeway in how procedures are implemented (Yelon and Ford, 1999; Applebaum, et al, 2000). More specifically, frontline non-supervisory employees- those who are closest to the product and/or customer- are increasingly expected to be more autonomous and to apply both technical and problem solving skills to multiple situations (Imel, 1995). Problem solving on the shop floor "saves time and minimizes disruptions by decreasing the need to summon supervisors or specialists, or to send problems up and decisions down a hierarchical line of authority." (Applebaum, etal, 1999, p.210). Problem solving skills, once reserved for those in management, are now considered necessary for individuals in all levels of employment (Clagett, 1997).

Recent empirical studies report that the majority of what employees need to know to perform their work requirements is acquired through informal learning in the workplace (Verespej, 1998; Leslie, 1998; Livingstone, 2001). Garrick (1998) argues that it is the informal learning that workers do within their own workplace communities that provide the most basic knowledge ingredients for successfully performing their job. Work-related knowledge and skills gained by employers' training programs is regarded as important by a small minority of workers (Livingstone, 2001), though U.S. industry spends more than $120 billion annually on formal training programs and related costs (Day, 1998). These studies have caused a disruption in the practice of workplace education as it forces practitioners to question the applicability of formal workplace education and training. Hence, these studies have also led to increased efforts among researchers to study informal learning in the workplace.

Garrick (1998) argues that "what happens in an individual's engagement with their problems, tasks and dilemmas at work is fundamental to learning about much more than merely work tasks." (p.20). In other words, as workers attempt to resolve problems which were previously outside of their control and responsibility, a "new" space is being created for learning to occur. Problem solving, by virtue of its action-orientation, provides the opportunity for creating experiences that lead to informal learning and hence, new knowledge and skills. Much of this learning, however, is not directly observable within the work tasks being performed. This type of "invisible" learning is referred to in the literature as informal learning (Livingstone, 2001; Marsick and Watson, 2001). "Capturing" workers informal learning for the purpose of increasing their knowledge and skills has been discussed at length by researchers and practitioners alike. However, this discourse sheds little light on the actual work and learning practices of most workers, the practices that are most directly constitutive of everyday life at work (Livingstone, 2001).

The Problem Statement

While the majority of what employees need to know to perform their work requirements is acquired through informal learning, most research focused on learning in the workplace has more in common with the formal educational practices of schooling and higher education. In addition, problem solving represents one of the most neglected areas of research on informal learning in the workplace, particularly within the context of manufacturing. Further, the literature has failed to capture, from the standpoint of the workers themselves the intersection between the gaining popularity of knowledge management and the increased expectation for frontline employees to solve operational problems on their own.

My curiosity about informal learning, ill-structured problem solving, the expectations of frontline workers, and the breadth and depth of knowledge/skills they possess, has consistently taken me down a path which leads to an unanswered question: What is the nature of the informal learning associated with the ill-structured problem solving process of production machine operators within the context of their everyday work?

Background and Rationale

Broadly defined, post secondary education includes organizations other than higher education which provide education for the adult learner. Organizations within business and industry fall within this category. Merriam and Caffarella (1999) define these types of organizations as formal, though non-educational institutions, in that their primary mission is not educational. Rather, they are profit oriented and view education (often referred to as training) as a means to some other end. Paradoxically, the workplace is THE source of further education for the majority of adults within the United States (Watkins in Rowden, 1996).

Though the workplace (organizations-for-profit) has profit as its main goal, workplace education is increasingly being folded into the strategic organizational agenda. Workplace education's "gaining of prominence" is triggered by economic, social and technological changes affecting the survival of the workplace, as knowledge is increasingly being recognized as holding "strategic advantage". Though education and learning are, in reality, two sides of the same coin, they have generally been treated in the literature as separate entities. Education is defined as, "The act or process of training by a prescribed or customary course of study or discipline." (Zimmerman, 1999, p.1), and "as the means by which we systematize the situations, conditions, tasks, materials and opportunities by which learners acquire new or different ways of thinking, feeling, and doing." (Fincher,1985, p.58). Learning, on the other hand, is defined as, "An enduring change in behavior or in the capacity to behave in a given fashion, which results from practice or other forms of experience." (Schunk,1996). Therefore, education in the workplace is distinct from learning in the workplace. My study is generally informed by the workplace learning literature.

Informal learning is defined as "learning that is predominantly unstructured, experiential and noninstitutional." (Volpe and Marsick, 1999, p4). Beckett and Hager (2002) describe the characteristics of informal learning as holistic, contextual, experience-based, arising in situations where learning is not the main purpose, activated by individual learners rather than by trainers, and is often collaborative/collegial. The majority of informal learning in the workplace occurs in the course of the routine social and individual work activities through which employees interact, share ideas and resources, and perform their jobs (Leslie, 1998).

Though informal learning constitutes the bulk of learning that takes place within the workplace, it is the least recognized in the literature and in practice. This "lack of recognition" is highlighted by both researchers and workers alike. Though workers today are increasingly highly educated, increasingly participating in adult education courses and devoting substantial amounts of their time to work-related informal learning activities outside organized education and training programs, they are neither fully recognized by employers nor given prior learning credit by educational institutions (Livingston, 2001; NRC, 1999). Further, U.S. workers say that their knowledge and skills are not being used in the workplace. It is reported that, from 1985 to 1996, craftsman, laborers and operators were increasingly 1) dissatisfied with how well employers are using their skills and abilities and with the opportunities to improve their skills (NRC, 1999; Freeman, 1999).

In comparing studies that have conducted empirical assessments of the utilization of knowledge by different occupational classes, Livingstone (1999) found that industrial and service workers spend similar amounts of time in employment-related informal learning as corporate executives, managers and professional employees but that they have been much more likely to be enabled to apply their general work-related learning in their jobs. Work-related knowledge from the standpoint of workers comes from their own independent, informal training/learning efforts, followed by informal education by their co-workers. In the growing reality of a 'learning society', there is a sizeable pent-up demand among industrial and service workers to link their extensive informal knowledge with more equitable formal education access and recognition; with more discretionary control of their jobs commensurate with their existing knowledge and skill (Livingstone, 2001); and with more participation and influence at the workplace than they have now (Freeman and Rogers, 1999).

Though it is clear throughout the literature as well as within the rhetoric of the business community that machine operators, laborers and craftspeople are increasingly expected to be today's operational problem solvers and that, "a literate, educated, inquisitive, problem solving workforce is essential to the survival and competitiveness of business and industry" (Rowden, 1996, p.3), it also seems true that workers' work-related knowledge and skill gained from informal learning experiences are being underutilized from both the perspective of researchers as well as workers. All of this suggests that there is major untapped potential in workers' knowledge and skill that can be mobilized for mutual benefit of the organization, the individual worker and the adult education community. While learning through work is being increasingly regarded as THE strategic competitive advantage, the majority of what constitutes learning, informal learning, is not recognized. Hence, organizations do not benefit from capturing it, employees are not recognized for developing it and adult educators are unable to use it to inform their practice.

Research on the informal learning of workers within the context of the industrial environment has been scant, though there continues to be an increased emphasis and interest within the past 5 years. This section of the chapter will highlight that research.

Between 1990 and 1996, within the transfer of learning literature, no studies were conducted on unsupervised workers performing open skills such as problem solving (Yelon and Ford, 1999). Of course, this is only a portion of the literature base on the dynamics of worker's learning. A systematic search of the 6 most inclusive electronic text and journal databases covering the past 12 years in the areas of education, psychology, sociology and business and using keywords such as "worker"; "problem solving"; and "informal learning", produced over 250 "hits", with 15 research papers directly and indirectly relevant to my study of the informal learning associated with the problem solving activities of workers. After reviewing the 15 studies only a few were directly relevant. Each is briefly described below.

Quarter and Midha (2001) found that the informal learning processes of eight members of a natural foods store cooperative acquired their knowledge through informal learning processes such as learning from experience, discussions during meetings, and questions to internal experts. One study focused on what workers learn as they negotiate workplace change (Foley, 1998; Skiba, 2000), finding that workers' efficacy in mastering change varied with the degree to which their organizations were involved in change. Billett (1993) interviewed skilled mine workers, suggesting that informal learning enables authentic activities, access to experts, and a sociocultural environment conducive to development of expertise. Interestingly, in a search of the 65 papers presented at an international conference titled 'Working Knowledge: Productive Learning at Work', only one paper focused on worker's learning (Payne, 2000). In this paper, Payne (2000) concluded that printing workers, among other things, were "convinced of the value of 'tinkering' (honing new skills) and attending courses in order to learn and apply new skills (p.573). We learn from this research that workers do learn informally, that their informal learning affects and is affected by what is happening in their environment, and that informal learning enables a number of beneficial activities for workers. What these studies do not tell us, however, is the specific informal learning experiences as those experiences are related to their problem solving activities. Schon (1983) did, however, painstakingly transcribe practitioner's dilemmas in situ, however, all of his practitioner participants were described as professionals: an architect, a doctor, a psychotherapist, an engineer, to name a few. He did not choose to conduct his research with workers. Findings from Schon and others who have researched the informal learning within a variety of different occupational settings (Yelon, 1997; Clark, 1998; Andrew,1998; Schon, 1983; Siebert, 1999; Marsick, 2001) suggests that the role of context becomes vitally important in defining ill-structured problems and that what is learned tends to be more situated (Jonassen, 2000). Because of the situated nature of learning and the situated nature of work environments, it makes sense that the informal learning of workers differ from that of individuals within other occupations as well as across environments within the same occupation.

Moreover, the one commonality among all of these research studies on worker's informal learning is that they have been conducted within one industrial site. My study, on the other hand, will cut across at multiple ten manufacturing sites, providing a more comprehensive view of the informal learning of workers within and across several contextual environments. This is an important distinction as the same activity acted upon within different organizations will result in different learning opportunities (EDC, 1998).

Some studies, however, do cut across multiple sites. Research conducted by the Education Development Center (1998) studied informal learning within eight manufacturing sites. Results from this study are quite comprehensive, detailing specific informal learning that occurs during specific activities at work. However, they categorize these activities broadly. For example, they studied the informal learning that occurs as a result of performing one's job. One of the four skills learned was identified as 'problem solving'. My study, on the other hand, views problem solving as a space where informal learning occurs- not as a learned outcome of one's daily work. The EDC study also states that 'For the purposes of this project, we will focus on learning that is beneficial to organizations and will not address workplace learning that is destructive or otherwise inconsistent with the organization's goals." (p.35). I would argue that this severely limits the depth and breadth of informal learning which occurs in the workplace. Further, I would argue that organizations would benefit from understanding 'destructive or inconsistent learning' as that too directly affects the workplace- beneficially. My study will make no such discrimination.

Scholars have repeatedly called for further research in the areas of informal learning (Marsick and Watson, 2001). "Changing the images of work and going beyond abstract arguments about trends in skills requires detailed and rich description and data reported from direct experiences of workers. Thus the sociological and anthropological traditions of <u>detailed narratives describing the actual experiences of workers</u> needs to be encouraged." (NCR, 1999, p.10). At the same time, Martinez (1998) argues that "Citizens of the 21st century must become adept problem solvers, able to wrestle with ill-defined problems. Problem solving ability is the cognitive passport to the future." (p.605). Some even say that most important kinds of human activities involve accomplishing a goal without a script- in other words, the problem solving process (Gagne, 1980). Clearly, the manufacturing world is quickly applying for and being granted this "passport". It is no wonder that scholars continue to call for further research on everyday problem solving (Foxx and Faw, 2000; Roth, 1997; Jonassen, 2000). Problem solving, by virtue of its action orientation, provides the opportunity for creating experiences that lead to informal learning (Walker and Marsick, 2001). Even within the classroom, problem solving scenarios are most often used by educators to create opportunities for student learning (Roth,1997). In addition, a recent comprehensive study of 1000 workers concludes that it is mostly through informal learning that employees learn the intrapsychic skills for successful problem solving (Verespej, 1998). Therefore, using problem solving as a "backdrop" for studying informal learning is quite appropriate.

Unfortunately, the literature has failed to capture the intersection between the gaining popularity of knowledge management and the increased expectations for problem solving activities placed upon workers, from the standpoint of the workers themselves. This compounds the necessity and rationale for supporting my study of the informal learning associated with the problem solving activities of the production machine operator. The data for this study will be collected and analyzed from the standpoint of machine operators as "empirical studies conducted from the standpoints of ordinary people are a necessary supplement to dominant discourses and scholarly critiques in order to comprehend the contemporary character of work and learning." (Livingstone, 2001, p.21). In sum, it appears that no research to date has investigated the informal learning associated with the problem solving activities of production workers.

Conceptual Framework

Related to informal learning are the concepts of self-directed learning (Knowles, 1970); action science (Argyris, 1974); action learning (Revans, 1982); reflection-in-action (Schon, 1983); vicarious learning (Bandura, 1986); situated cognition (Lave and Wenger, 1991; Scribner, 1986); experiential learning (Boud, 1996); and communities of practice (Wenger, 1998). All of these concepts have their roots in whole or in part within the writings of John Dewey (1859- 1952), arguably the most influential thinker on education in the twentieth century.

The first comprehensive description of self-directed learning as a form of study is attributed to the work of Tough and Houle (Merriam and Caffarella, 1999). Writing about the same time, Knowles proposed that one of the hallmark assumptions of adult learning is that learners become increasingly self-directed as they mature (Knowles, 1970). Action learning (Revans, 1982) argues that the real world, and hence, the workplace, needs to be considered the most favorable location for learning. As a strategy, it seeks to generate learning from human interaction arising from engagement in the solution of real time (not simulated) work problems (Raelin, 2000). Similarly, action science (Argyris, 1982) is a methodology which seeks to produce valid generalizations about how individuals and social systems can design and implement intentions in everyday life. "Whereas action learning seeks to contextualize learning, action science decontextualizes practice so that learners can become more critical of their behavior and explore the very premises of their beliefs." (Raelin, 2000, p.93).

Schon (1983) argues that workplace learning develops through reflection in the "swamp of uncertain, ambiguous, contradictory dilemmas of practice." Reflection during and after action is considered an important mental process required to transform experience into knowledge (Fenwick, 2001). Critics argue that, though an important contribution to the workplace learning literature, reflection as knowledge production is simplistic and reductionistic. Bandura (1986) would describe this form of informal learning as vicarious learning, such that the individual will imitate another's behavior if they possess the characteristics that the observer finds attractive or desirable.

Situated cognition research supplements the social nature of learning as it distinguishes between the application of knowledge and skills across different contexts (Lave, 1984). Informal learning is therefore a function of the context in which both the organization and the individual operate (Leslie, 1998). Boud, Cohen and Walker (1996), as is true for informal learning, suggest that learning by experience is one aspect of learning which receives much less attention than does formal learning. Experiential learning recognizes that outcomes of learning are socially and culturally constructed and that learners make sense of their own experience in the context of their social and cultural values. Within this tradition, Wenger (1998) found that informal learning has been shown to take place within communities of practice (Wenger, 1998). Within the workplace, communities of practice are naturally occurring informal groups that develop, evolve, and disperse according to the rhythms and energies of the participants.

These theories have contributed to our understanding of informal learning as a self-directed activity which can be enhanced through reflection; as contextual due to the psychological, social and cultural factors with one's environment; and as arising from experience and involvement within a community of practice.

Summary of Past Theory and Research

Taken together, all of the above theories and corresponding research provide a comprehensive, though incomplete, collection of concepts and findings which help us to better understand the nature of informal learning. Over time, ideas and theories connect to form more ideas and theories, in an attempt to fill yet another piece of the curiosity puzzle. Informal learning is no exception. In fact, we see in the definition of informal learning pieces of the theories described in the previous section: as informal learning is described as "learning that is predominantly unstructured, experiential and noninstitutional." (Volpe and Marsick, 1999, p.4). Beckett and Hager (2002) describe the characteristics of informal learning as holistic, contextual, experience-based, arising in situations where learning is not the main purpose, activated by individual learners rather than by trainers, and is often collaborative/collegial. However, these definitions and corresponding characteristics are derived from studies which fail to compare and contrast informal learning as it occurs within one occupation, one activity field, across multiple contexts within the same industry.

Research Question

Therefore, my research question is: What is the nature of the informal learning associated with the ill-structured problem solving process of production machine operators within the context of their work?

Significance of the Study

This research can be applied to both theory and practice. Given the changing nature of work for frontline employees within the manufacturing sector, the importance of lifelong learning, and the survival of industry in general, a deeper understanding of the informal learning and the resultant development of new knowledge and skills have the potential to be applied toward strengthening the link between the complex relations of learning and work. (ASTD, 2002) There remains a significant knowledge-to-practice disconnect in the learning community (Baldwin and Ford, 2000). The lack of a prescriptive, action-oriented focus characterizes much of the academic literature and often reflects an appropriate conservatism and reluctance to go beyond the data. The more ways we have to analyze and measure the complex process of everyday problem-solving and the informal learning which takes place during such an experience, the more likely we are to understand it well. Understanding the process can help to fill the gap between theory and much needed practice based upon theory and research. Further, educators, managers, training and development practitioners, and employees, may be better able to design, provide or seek workplace curricula most suitable to employees and to their organization and industry." (Casey, in Boud, 1999, p.15). As Ottoson (1995) so accurately professes, " it is time to reclaim application for the social process it is...if what happens after adult education programs matter, it is time to stop looking only at the products of technology and start seeing the process: in essence, to see application." (p.28)

A study of the informal learning associated with the ill-structured problem solving process of production machine operators within the context of their daily work is important for several reasons. First, workers may benefit from the recognition of their informal learning activities possibly through increased control over their work, job security and increased pay. Second, managers may experience increased performance and hence, profits, by capturing and utilizing a breadth and depth of knowledge and skills not previously recognized by the organization. Third, adult educators may use the results of the study to further inform their practice and educational delivery methods. Fourth, researchers may add the results of this study to the current knowledge-base on the informal learning. Fifth, the engagement of workers in discussing their problem solving experiences and the learning inherent in the process can inform higher education' current conversation about Practice-Oriented-Education, discussed fully in Chapter Five. Sixth, I will use the experience and results of the study as a first step in my future research agenda:

1. To inform educational practice in teaching problem solving.
2. To challenge the assumptions of the breadth and depth of applicable knowledge and learning in the workplace.
3. To further the democratization of the workplace to design jobs that fit the individual.
4. To develop a database which may be used to add to the transfer of learning/situated cognition literature.

Delimitations and Limitations

As a qualitative study, my intent is to understand deeply the nature of the informal learning associated with the ill-structured problem solving process of production workers within the context of their daily work. Following is a brief explanation of the scope of this study (delimitations) and the potential weaknesses of this study (limitations) (Creswell, 1994).

This study will confine itself to critical incident interviews with production machine operators across several manufacturing sites in Michigan. The ability to enter a site and to access study participants is dependent upon the approval of a site manager. Therefore, I may be unable to completely meet the criteria I have set for site and participant selection.

Due to the narrow scope of this study in terms of number of participants as well as the limited context within which informal learning is located, this study does not meet the rigorous criteria for statistical generalizability as in a quantitative study. However, it is recognized within qualitative tradition that the research is generalizable to the extent that the reader finds it so. "The responsibility for judgment about logical generalization resides with the reader rather than the researcher. The reader must examine the circumstances of the case to determine the ways in which the case fits the circumstances of the reader's own situation." (Erikson, 1985).

CHAPTER TWO

LITERATURE REVIEW

Literature reviews in exploratory research are carried out to demonstrate that little or no work has been done on the group, process or activity under consideration (Stebbins, 2001).

> "The procedure I have followed over the years is first to search for the study or studies that come closest to examining what I want to examine and then to show how these studies leave unexplored certain critical aspects of that phenomenon. In the literature review, I devote the greatest amount of space to these works, after which, proceeding as if by concentric rings, I devote less and less space to works increasingly removed from my project." (Stebbins, 2001, p.43)

In following with Stebbins (2001) literature review design, I will cover the changes that have taken place in the workplace followed by its impact on the concept of learning in the workplace. It is at this time that I discuss informal learning and the research associated with it. Then I will move to a different line of research regarding everyday problem solving. I discuss everyday problem solving since it is the activity within which this study is situated. I will then attempt to explain the intersection of learning and problem solving, and the appropriateness for using problem solving as an activity within which to study informal learning in the workplace. Finally, I provide a summary of the limitations of the research to date, ending the section with the need for my exploratory study on the informal learning associated with the ill-structured problem solving process of machine operators within the context of their everyday work.

Change in the Nature of Work for Frontline Manufacturing Employees

"The need to train for higher order cognitive skills, such as problem solving and troubleshooting, is largely the result of changes in the workplace (eg., technological innovation, self-directed work teams, and the multiskilling of jobs)." (Ford, et al, 1997, p.10). In the first two-thirds of the century, jobs were defined in the context of Frederick Taylor's scientific management system, which emerged out of the industrial revolution. In this system, jobs were narrowly defined and consisted of the "one best" method of performing a task. The jobs were designed so that frontline workers could perform these specific tasks with no input into the process and as little thought as possible. The phrase,
"leave your brains at the gate" characterizes the scientific management approach to manufacturing. Management was responsible for all critical thinking and process design. Scientific management was "effective" in mass production systems where economies of scale could be realized, and when companies could control pricing and had a large internal market for standardized products (Marshall, 1994). Though the foundations of scientific management remain the dominant practice within manufacturing (due to the extent of change required), a growing number of manufacturing organizations have questioned the effectiveness of this model. Hence, we see in the past 30 years a significant change in both the social and technical realms of manufacturing organizations, especially as related to the frontline worker.

Manufacturing organizations, in their efforts to remain competitive, are strategically pushing problem solving and decision making to the frontline production employee. It is no wonder that manufacturing facilities across the U.S. report increasing requirements in open skills such as problem solving, decision making and interpersonal communication (Imel, 1999; AFL-CIO, 1999; NRC, 2001; Schmidt, 2000). In fact, employees and work teams are taking on the responsibility of supervising themselves, and they are being given more leeway in how procedures are implemented (Yelon and Ford, 1999; Applebaum, et al, 2000). More specifically, frontline non-supervisory employees- those who are closest to the product and/or customer- are increasingly expected to be more autonomous and to apply both technical and problem solving skills to multiple situations (Reese, 2001). Problem solving on the shop floor "saves time and minimizes disruptions by decreasing the need to summon supervisors or specialists, or to send problems up and decisions down a hierarchical line of authority." (Applebaum, etal, 1999, p.210). Problem solving skills, once reserved for those in management, are now considered necessary for individuals in all levels of employment (Clagett, 1997), as organizations begin to realize that they can no longer be successful by separating the thinkers from the doers (EDC, 1998). Manufacturing organizations attempting to move away from the scientific management method of work design to a more participatory design are referred to in the literature (and in practice) as high performance organizations (Applebaum, 1999) or learning organizations (Senge, 1990). Garvin (in EDC, 1998) states that these types of organizations are skilled in five main areas: 1) systematic problem solving, 2) experimentation with new approaches, 3) learning from their own experience and past history, 4) learning from the experiences and best practices of others, 5) knowledge creation and transfer, with all employees committed to continuous learning and teaching.

Learning in the Workplace

Though the literature distinguishes between formal learning, informal learning and non-formal learning, there is "little agreement about how these terms should be defined, bounded or used." (Colley, 1999, p.2). However, within the workplace, these distinctions become less ambiguous. I will be using these terms to refer to the various kinds of learning and the ways in which learning is organized and structured. I will attempt to lend some clarity to the distinctions, using examples to support the definitions.

Formal learning in the workplace is generally referred to as a consequence of formal education, or 'training'. Eraut (in Colley, 2001) presents five features of formal learning. They are: 1) a prescribed learning framework, 2) an organized learning event or package, 3) the presence of a designated teacher or trainer, 4) the award of a qualification or credit, and 5) the external specification of outcomes. Examples within the workplace, to name only a few, may include safety training, communication skills training, total quality awareness training, etc. It is clear that Eraut does not distinguish between formal education and formal learning. The European Commission (in Colley, 2001), on the other hand, does make distinctions. The EC defines formal learning as learning that is typically provided by an education or training institution and is intentional from the learner's perspective. The development and assessment of formal education, hence, formal learning, is the focus of the majority of workplace learning in theory and in practice. However, the recent educational and psychological literature suggests that what is taught in formal education (training) in the workplace rarely transfers to job performance (Foxx and Faw, 2000; Broad, 1997; Holton, 2000) due largely to the incongruence between what is taught and what is functional (Livingstone, 2001). More specifically, the research assessing problem solving skills in the workplace reports that little is known about the transfer of skills from formal problem solving training to actual job problem solving performance (Foxx and Faw, 2000). In fact, a comprehensive study of informal learning in the workplace reports that employees believe that formal training did not prepare them with the problem solving skills necessary to perform their job (EDC, 1998).

Non-formal learning is defined as a learning process that is initiated and controlled by learners and not always structured (McGivney, 1999) and may be provided through activities of civil society organizations and groups, such as trade unions (Colley, 2001). For example, workers may gather together after a union meeting to discuss and receive updates on an upcoming arbitration. The third kind of learning, informal learning, is the focus of my study and will therefore be described in more detail.

Informal Learning

Informal learning is defined as "learning that is predominantly unstructured, experiential and noninstitutional." (Volpe and Marsick, 1999, p.4). Beckett and

Hager (2002) describe the characteristics of informal learning as holistic, contextual, experience-based, arising in situations where learning is not the main purpose, activated by individual learners rather than by trainers, and is often collaborative/collegial. The majority of informal learning in the workplace occurs in the course of the routine social and individual work activities through which employees interact, share ideas and resources, and perform their jobs (Leslie, 1998). A frontline worker's informal learning occurs most often when there job scope expands to include more skills and responsibilities than they had previously performed and/or mastered, such as increased responsibility to solve operational and/or organizational problems (EDC, 1998).

Much of the research on informal workplace learning was stimulated by Scribner and Cole's (1973) work demonstrating that cross-cultural learning differences cannot be attributed to differences in cognitive abilities. Scribner and Cole (1973) and Lave (1988) demonstrate that learning differences can be attributed to selective use of particular learning strategies, strongly influenced by the sociocultural context in which the learning occurs. Scribner's (1986) landmark study of dairy workers extended this line of research. Scribner demonstrated that formal training does not account for much workplace learning; rather workers look to the environment for important cues and information. Scribner called the kind of thinking embedded in a larger purposive activity "practical thinking", and distinguished it from the thinking involved in isolated cognitive tasks performed as ends in themselves.

At this point, researchers studying learning in the "real world" began to question even more the applicability of generalizing findings from research conducted in the laboratory to a naturalistic context. One of the first empirical studies to attempt to estimate the extent of informal learning activities among adults was the 1961-62 U.S national survey of voluntary learning (Livingstone, 2001). This survey found that the incident of self-education throughout the adult population was much greater than anticipated. Tough's early case studies on informal learning found that well over two-thirds of most adults intentional learning efforts occurred completely outside of institutionalized adult education programs (Brookfield, 1981). Livingstone (2001) provides a detailed outline of past surveys on informal learning. These surveys have consistently highlighted that the vast majority of people of all occupational and formal education levels are engaged in substantial ongoing informal learning activities, and that much of this learning is related to their paid work. "The 'knowledge' economy appears to be much wider and deeper than current popular accounts which focus on the continuing job and product-specific training of managers and professional employees in the 'learning enterprise'." (p.18). Surveys and other research highlighting the sheer amount of informal learning within the workplace, coupled with the move toward qualitative research within naturalistic settings, led the way for field research on informal learning in the workplace.

Research on informal learning in the workplace has burgeoned in the past 20 years, focussing upon the informal learning of individuals within a variety of occupations while performing a variety of different activities (Yelon, 1997; Clark, 1998; Andrew,1998; Schon, 1983; Siebert, 1999). More recently, Walker and Marsick (2001) describe manager's informal learning within the context of decision making. Jannings and Armitage (2001) report the informal learning occurring within the collegial relationship between clinical nurse consultants and field nurses. Coyle and Ellinger (2001) investigate the informal ways in which female entrepreneurs learn when they initiate their business ventures. Garrick (1999) conducted a study within which two human resource managers provided insights into their informal learning about their professional roles, the interaction of corporate culture with their individual beliefs and values, and the subtle influences of the hierarchies of work-power on their behavior. We have learned from these studies that informal learning is prevalent in the workplace. The research to date suggests that informal learning 1) cuts across a variety of occupations, 2) is contextual, 3) involves engagement among and between persons, 4) varies among individuals, and 5) requires reflection on the experience. What seems to be missing, however, is an analysis of the way the social and cultural context interacts with the informal learning associated with a particular activity. For example, Walker and Marsick's study used the activity of decision making as a context to study informal learning. However, the analysis of critical incidents was content oriented, and therefore failed to tie the informal learning with social contextual factors of the organization. What also seems to be missing is an analysis of the informal learning of frontline employees. Critical educators, such as Foley (1999), continue to argue that much of the literature on informal learning is treated as a technical process, to be facilitated by professionals on behalf of management. Garrick (1998) concurs, suggesting that informal learning is currently being defined narrowly and instrumentally. The contradictory and contested dynamics of workplace relations are not explored in depth. The notion of workers' learning being autonomous and resistant barely appears in the literature (Foley, 1999). Critical educators argue for a model that places more attention on the "kinds of work individuals are asked to perform and the ways in which that work is structured and organized. These issues provide opportunities for workers to engage in thoughtful, meaningful and critical ways of learning and influencing their work environments." (Dirkx,1996, p.46). Some studies, however, are attempting to capture the informal learning experiences of workers within industry.

Quarter and Midha (2001) found that the informal learning processes of 8 members of a natural foods store cooperative acquired their knowledge through informal learning processes such as learning from experience, discussions during meetings, and questions to internal experts. A couple of studies focus on what workers learn as they negotiate workplace change (Foley, 1998; Skiba, 2000), finding that workers' efficacy in mastering change varied with the degree to which their organization was involved in change. Billett (1993) interviewed skilled mine workers, suggesting that informal learning enables authentic activities, access to experts, and a sociocultural environment conducive to development of expertise. Payne's (2000) study of a printing business concluded that printing workers, among other things, were "convinced of the value of 'tinkering' (honing new skills) and attending courses in order to learn and apply new skills (p.573). Livingstone's (2001) comprehensive survey of Canadian workers found that the incidence of informal learning is not closely related to either prior formal educational participation or most socio-demographic differences. These studies are important as they encourage a dialogue regarding the informal learning of frontline employees. However, they lack sufficient depth within a particular activity (such as problem solving) which is 'new' and therefore problematic for the worker. It is under these conditions which most learning occurs, as problem solving, by virtue of its action orientation, provides the opportunity for creating experiences that lead to informal learning (Walker and Marsick, 2001). These studies also fail to compare informal learning experiences across multiple sites within one occupational group. In response to this shortcoming, the Education Development Center (1998) studied informal learning within eight manufacturing sites. Results from this study are quite comprehensive, detailing specific informal learning which occurs during specific activities at work. However, they categorize these activities broadly. For example, they studied the informal learning which occurs as a result of performing one's job. One of the four skills learned was identified as 'problem solving'. My study, on the other hand, views problem solving as a space where informal learning occurs- not as a learned outcome of one's daily work. The EDC study also states that 'For the purposes of this project, we will focus on learning that is beneficial to organizations and will not address workplace learning that is destructive or otherwise inconsistent with the organization's goals." (p.35). I would argue that this severely limits the depth and breadth of the informal learning which occurs in the workplace. Further, I would argue that organizations would benefit from understanding "destructive or inconsistent learning' as that too directly affects the workplace- beneficially. My study will make no such discrimination.

Learning From Experience

Informal learning is experience-based (Marsick and Watkins, 1992). Though Dewey (1916) did not speak specifically about informal learning as such, his theories about learning emphasize experience as central to learning. According to Dewey (1913), "To 'learn from experience' is to make a backward and forward connection between what we do to things and what we enjoy or suffer from things in consequence." (p.164). The literature on learning from experience provides a clear foundation for understanding how individuals make experience meaningful. It further suggests that making experiences meaningful is central to learning and that learning from experience plays a central role in adult development. Boud, Cohen and Walker (1985) state, "We found it to be meaningless to talk about learning in isolation from experience. Experience cannot be bypassed; it is the central consideration of all learning. Learning builds on and flows from experience..." (p. 8).

The ability to reflect upon one's experience is fundamental to learning (Boud, Keough and Walker, 1985). Reflection constitutes the ability to uncover and make explicit to oneself what one has planned, observed or achieved in practice; therefore it is concerned with the construction of meaning (Raelin, 2000). The meaning of an experience may be transformed over time, and by linking new experiences with prior experiences, the learner can acquire new ways of knowing (Merriam and Clark, 1991).

Schon (1983) describes processes of learning from experience called reflection-in-action and reflection-on-action. Reflection-in-action is the process of thinking about practice while engaged in that practice. Reflection-on-action involves thinking about a situation after it has happened. Schon's work describes in detail these processes as they occur for those in professional practice.

A number of scholars have attempted to develop models of how individuals learn from experience. Perhaps the most frequently quoted model is Kolb's (1984) Learning Cycle. Kolb, building primarily on the work of Dewey, Piaget and Lewin, suggests that there are four stages which follow from each other: concrete experience is followed by reflection on that experience which is then thought about in an abstract way and actively experimented upon. Others have built upon this model. For example, Jarvis (1998) restructured Kolb's diagram to include more of the processes. He defines experiential learning as, "The process of creating and transforming experience into knowledge, skills, attitudes, values, emotions, beliefs and senses."(p. 47).

The research on learning from experience has led to new ways of talking about experience and new ways of using experience for practical use. For example, Raelin (2000) has focused on what he calls work-based learning. "Work-based learning serves to bring together a number of otherwise disparate learning processes, each of which has its own justification as a basis for learning within work." He outlines three principle collective learning types: action learning, community of practice and action science. Action learning (Revans, 1982) describes an educational strategy that seeks to generate learning from human interaction in authentic situations. Communities of Practice (Lave and Wenger, 1991) describe learning as occurring among other members of a community who share the same history and culture. Action Science (Argyris, 1974) is a work-based intervention for helping learners increase their effectiveness in social situations through heightened awareness of their assumptions.

Experience is of central importance to any discussion about learning, especially as it pertains to informal types of learning. Informal learning is predominantly experiential in nature, non-institutional and self-directed (Garrick, 1998).

The next section briefly discusses everyday problem solving and its associated research. I include a discussion of problem solving because it is the activity within which I will study informal learning.

Everyday Problem Solving

The problems we face in the real world can be described as being complex and dynamic and having no single well-defined goal (Dorner, 1996). The problem solving literature defines these "real world" problems as everyday problems, and the problem solving which follows, as everyday problem solving. Everyday problem solving is defined as the reasoning processes and strategies individuals use to solve problems that have more direct pertinence in their lives than problems traditionally used in problem solving research (Berg and Klaczynski, 1996). Problem solving research has traditionally studied an individual's problem solving process using well-structured problems. Well-structured problems are problems which, 1) present all elements of the problem to the learners; 2) require the application of a limited number of regular and well-structured rules and principles that are organized and predictable and prescriptive ways and; 3) have knowable and comprehensible solutions where the relationship between decision choices and all problems states is known or probabilistic (Wood, 1983).

It is recognized, however, that every day problems are most often ill-structured. "Ill-structured problems... are the kinds of problems that are encountered more often in everyday and professional practice, so they are typically emergent, unpredictable and nonconvergent. They may also require the integration of several content domains." (Jonassen, 2000). Kitchner (1983) defines ill- structured problems as those in which contradictory evidence and opinions exist, for which there is not a single, correct solution. Ill-structured problems are context dependent (Lave, 1984).

Most researchers studying mental operations proceed by giving people isolated mental tasks to accomplish. Though this approach has many important achievements, it fails to capture significant aspects of human mental functioning. "Memory and thinking in daily life are not separate from, but a part of, doing. We understand cognitive tasks, not merely as ends in themselves, but as means for achieving larger objectives and goals; and we carry out these tasks in constant interaction with social and material resources and constraints." (Scribner, in Tobach, 1997, p297).

Extensions of the logical/rationalistic model of thinking to the study of everyday activity in natural or work settings have been particularly problematic (Laufer and Glick, 1996). Foxx and Faw (2000) report that performance in actual problem solving situations has rarely been studied and that studies on the activity of everyday problem solving itself is rare (Llorente,1996). My own systematic search of the 6 most inclusive electronic text and journal databases covering the past 12 years in the areas of education, psychology, sociology and business and using keywords such as "worker" and "problem solving", produced only a handful of research papers. Of this handful, only 2 to 3 articles were relevant to the problem solving processes used by workers. The leading researchers in the "field" of problem solving have consistently called for more detailed research into the everyday problem solving processes of various occupations (Jonassen, 2000).

Thinking is intricately interwoven with the context of the problem to be solved (Rogoff and Lave,1984). The context includes the problem's physical structures, conceptual structures, the purpose of the activity and the social milieu in which it is embedded. In fact, the person's <u>interpretation</u> of the context in any particular activity may be important in facilitating or blocking the application of skills developed in one context to a new one (Rogoff and Lave, 1984). Researchers who believe in the contextual influences of cognition tend toward conducting their studies with actual participants working within their everyday setting.

Everyday problem solving as discussed in the literature routinely deals with ill-structured problems:

> Approaches to problem solving in these situations appears to be highly contextually constrained. Rather than being an exclusively or even predominantly logical exercise, everyday problem solving becomes enmeshed in the subjective social and affective world of adult adaptation. As adults attempt to solve everyday problems, they are confronted by the relative nature of truth, contradictions within and between knowledge systems, and a need to integrate across domains to arrive at workable, if not "correct", solutions. (Sinnott, 1989, p.35)

Everyday problem solving appears to represent unsystematic movement back and forth between various steps. In fact, in her study on problem solving processes of individuals of various ages, using the think-aloud method, Sinnott (1989) recognized that respondents' thoughts sometimes worked forward and sometimes worked backward:

> He worked out the essence of the problem, the goals, the criteria for selection of goals and solutions, the solutions, and ways around difficult emotional and cognitive points. Many of his statements dealt with emotions, his past cognitive or emotional history, or his present roles in life; all these factors became part of the decisions about problem parameters or strategies for proceeding in the task. (p.80)

In Lee's (1989) documentation of teacher's ill-structured problem solving process, she observes that, " The teachers experienced their practical problems as ambiguous, convoluted, and spiraling, not as linear, sequential, or governed by specific procedures." (p.251). In fact, most of our studies virtually ignore the social and interpersonal influences on everyday problem solving, which, if conducted, could help us to better address the process of everyday problem solving skills and the motivation behind these skills (Sinnott, 1989).

A handful of researchers have studied the everyday problem solving processes of workers within their work setting. Scribner's (1984) study of dairy preloaders and drivers, found that practical thinking is goal directed and varies adaptively with the changing properties of the problem and changing conditions in the task environment. Brightman's (1978) study of lower and upper managers concluded that strategic and operating problems differ, and hence, require different intellectual skills. Solving operating problems requires description and analysis; solving strategic problems requires design and synthesis. Llorente's (1998) study of a builder designing an octagonal corner observed that he developed an organizing cognitive activity when solving task-oriented problem situations and when doing so, frequently utilized information available in the social setting. He describes this information as being assimilated by the builder's cognitive structures and accommodated to the particular features of the real event.

Laufer and Glick's (1996) study of office workers within five industrial precision-parts distributor companies, found that differences existed in expert and novice telephone sales clerks problem solving abilities. These studies suggest everyday problem solving as an "activity space" within which to study a variety of concerns. However, no study has informed us about the informal learning which occurs within the problem solving activity.

Learning Associated with the Activity of Problem Solving

"Research on human learning and research on problem solving are finally meeting in the current research on the acquisition of cognitive skills." (Anderson, 1993, p.35). Anderson (1993) argues that research on human problem solving would have benefited from an attempt to incorporate ideas of learning theory. More so, he says, research on learning would have borne more fruit had researchers not cast out problem solving. Anderson gives evidence of the powerful practical applications that can be achieved if the fields of problem solving and learning listen to each other. Tolman (1932, in Anderson) insisted long ago that learning is separate from performance, and that it is goals that trigger the conversion of what has been learned into performance. "It is the <u>problem solving method</u> that converts what is learned into performance in service of a goal." (Anderson, 1993, p.37). Problem solving is a powerful activity that triggers learning.

Still research on how problem solving and learning interact within an activity field in the everyday context of work is scant. The majority of research which combines learning and problem solving within the last 15 years is about the transition that is made from novel to routine problem solving. A great deal of this research has taken the form of comparing subjects who are relative experts at a problem solving task with subjects who are relative novices at the task (Anderson, 1993). Most of these studies have been conducted in laboratory settings with well-defined problems, so their implications for the workplace are diluted.

It is recognized throughout the literature that problem solving as an activity space for studying informal learning is quite sound. Raelin (2000) argues that, "real-time experience, especially problems within one's own work setting constitutes a good part of the subject matter of lesson." (p.67). Problem solving, by virtue of its action orientation, provides the opportunity for creating experiences that lead to informal learning (Walker and Marsick, 2001). Even within the classroom, problem solving scenarios are most often used by educators to create opportunities for student learning (Roth,1997). In addition, a recent comprehensive study of 1000 workers concludes that it is mostly through informal learning that employees learn the intrapsychic skills for successful problem solving (Verespej, 1998). In addition, Jonassen (2000) suggests that the role of context becomes vitally important in defining problems and that what is learned tends to be more situated. Therefore, using problem solving as a "backdrop" for studying informal learning is quite appropriate.

Summary

In the beginning of this report I made a case for the importance of further understanding of informal learning within the problem solving activities of workers in manufacturing. In brief, researchers have found that 70-80% of what employees need to know to perform their work requirements is acquired through informal learning in the workplace. Hence, a better understanding of informal learning is warranted. Moreover, the research to date fails to locate informal learning within the activity of problem solving- an increasingly important knowledge and skill requirement within manufacturing today. As frontline workers' informal learning occurs most often when their job scope expands to include more skills and responsibilities than they had previously performed and/or mastered (EDC, 1998), problem solving, as a "new" requirement for frontline employees, has created a "new" space within which informal learning can be studied. I have attempted to show, through numerous existing studies on informal learning in the workplace that little is known about the nature of informal learning as applied to the activity of problem solving and little is known about the actual incidents of problem solving as experienced by the workers as problem solvers.

Therefore, my research question is: What is the nature of the informal learning associated with the problem solving process of production machine operators within the context of their everyday work?

CHAPTER THREE

METHODS AND PROCEDURES

The purpose of this study is to explore the informal learning associated with the problem solving process of machine operators within the context of their everyday work. The following question has guided this exploration:

- What is the nature of the informal learning associated with the problem solving process of production machine operators within the context of their work?

Organization of the Chapter

As I began this study, very little empirical evidence existed to inform my understanding of machine operators' perceptions of their experiences associated with solving operational problems during their everyday work activities. Further, a review of the current literature failed to reveal a useful protocol to gather the data needed for this study. It was recommended that I conduct three pilot interviews to test the appropriateness of the data collection instrument, procedures and analysis, identifying preliminary themes that could further guide my data collection and analysis efforts. From this analysis, data collection procedures and protocols were judged appropriate for the study. This chapter is divided into four sections. The first section presents my assumptions and theoretical position. The second section follows with a presentation of the research design. The third section presents the data collection procedures, followed by a review of my data analysis procedure for this study.

Assumptions and Theoretical Position

Behind every method lies assumptions and theoretical positions which implicitly and explicitly guide the researcher in their quest to find "answers" to the research question(s) they pose. The interpretive approach, constructivism and situated cognition are three broad traditions within which my assumptions and theoretical positions lie.

I hold two main assumptions which may not be explicitly apparent within my findings or my interpretation of findings. First, not all problems machine operators encounter on a day-to-day basis are ill-structured. Again, ill-structured problems are typically defined as the kinds of problems that are encountered more often in everyday practice, so they are typically emergent, unpredictable and nonconvergent (Jonassen, 2000). The nature of problems that can be faced by machine operators within the everyday context of their work can be structured or ill-structured, each of which could be described as routine or non-routine. Further, the nature of the structure and the routineness of problems changes over time as machine operators become more experienced on a particular job or in a particular skill. The vast literature on the learning and progression of novices becoming experts within the context of work clearly illustrates this very point (Foshay and Kirkley, 1998, Lave, 1991; Daley, 1999) and is mentioned in more detail later in this chapter.

The second assumption is the recognition that individual differences exist among machine operators within and across organizations. Individuals, in general, hold different values, beliefs, learning styles, and attitudes toward work, to name only a few. These differences will no doubt have an affect on the individual's learning process. Billett (2001) suggests that how individuals engage in workplace activities such as problem solving and the learning that results from these activities is unlikely to be uniform. Likewise, it is recognized that machine operator participants who work within the same organization may have differing experiences with environmental factors such as work structure and supervision. Differing experiences will also add to individual differences in how problems are approaches and resolved.

Within the qualitative tradition are several approaches, each with their own particular ontology, epistemology and methodology. The interpretive approach is one which has gained relevance for this study. Researchers working within the interpretivist approach assume that people's subjective experiences are real and should be taken seriously (ontology), that we can understand others' experiences by interacting with them and listening to what they tell us (epistemology), and that qualitative research techniques are best suited to this task (methodology) (Blanche and Kelly, 1999).

Constructivism is an approach which, in general, assumes that individuals construct their own views of the world in ways that are meaningful to them. An individual constructivist orientation (Bruner, 1990; Piaget, 1966; Dewey, 1916) argues that learners construct their own knowledge from their experiences. A social constructivist (Vygotsky, 1978) orientation provides insight into learning as meaning-making within a social context. Constructivists believe that learning is not understanding the "true" nature of things, but rather a personal and social construction of meaning out of the array of sensations which have no order or structure besides those explanations which we fabricate for them.

Situated Cognition Theory (Brown, Collins and Duguid, 1989; Lave and Wenger, 1991) suggests that learning is inherently social in nature. The major assertion of these theorists is that thinking or knowing is situated. That is, it is dependent on the particular situation at hand (Woll, 2002). Learning is shaped through the nature of the interactions among learners, the tools they use within their interactions, the activity itself, and the social context in which the activity takes place.

Research Design

If the purpose of my research is to understand the nature of informal learning of machine operators during the problem solving process, then it necessarily requires an approach which will capture the process of learning within problem solving of the individuals themselves.

Qualitative research is especially useful in the "generation of categories for understanding human phenomena and the investigation of the interpretation and meaning that people give to events they experience." (Polkinghorne, 1991, p.112). The qualitative researcher seeks a psychologically rich, indepth understanding of the individual (Rudestram, 1992). This study is exploratory in nature. Vogt (1999) explains that, " social science exploration is a broad-ranging, purposive, systematic, prearranged undertaking designed to maximize the discovery of generalizations leading to description and understanding of an area of social or psychological life." (p.105). Further,

> Exploration, with its open character and emphasis on flexibility, pragmatism, and the particular, biographically specific interests of an investigator, is arguably a more inviting and indeed accurate way of representing social research than treating it as a narrowing, quasi-rule bound and discipline-based

> process that settles and confirms rather than unsettles and questions what one knows. (Stebbins, 2001, p.v).

The qualitative technique which seemed best suited for my study was the Critical Incident Technique, a technique used as "an investigative tool in organizational analysis from within an interpretive or phenomenological paradigm." (Chell, 1998, p.51) and most often used in multi-site studies (Chell, 1998).

> The critical incident technique is a qualitative interview procedure which facilitates the investigation of significant occurrences (events, incidents, processes or issues) identified by the respondent, the way they are managed, and the outcomes in terms of perceived effects. The objective is to gain an understanding of the incident from the perspective of the individual, taking into account cognitive, affective and behavioral elements. (Chell, 1998, p.56).

Research Context

Manufacturing was an appropriate context within which to place this study. The incidence of most alternative workplace practices, characteristic of high performance work organizations, ie, problem solving by frontline employees, is more common among manufacturing firms than among nonmanufacturing firms (Bassi, 1996). In addition, according to a recent survey by the National Association of Manufacturers, more than 80% of firms report facing a shortage of qualified machinists, craft workers and technicians. Although manufacturing will not grow much overall over the next decade, a rapidly aging workforce will create more than 2 million job openings for 'blue collar' workers (Thomas, 2002). In sum, the manufacturing industry has been a leader in providing problem solving training due to its attempt to compete in the market, and the turnover within the next decade will cause a new generation of machine operators to exist within the workplace-- employees who will most likely benefit from problem solving training of which this study, in part, seeks to inform. The manufacturing sites chosen for this study were producers of either durable or non-durable goods. Durable goods are products which are stable and relatively permanent, ie., steel, while non-durable goods have a short "shelf-life", ie, food. In addition, the sites chosen for this study were necessarily workplaces whose management was, to some extent, attempting to push problem solving responsibilities to machine operators, since my premise is that this 'new' expectation has created a unique space for informal learning to occur.

Machine operators were chosen as my primary data source following consideration of other types of occupations of frontline employees within manufacturing. Machine operators most often have greater mobility within their workspace, they are responsible for on-line production, they are generally regarded as highly skilled within their area of operation and are often expected to resolve a multiplicity of issues or problems. In addition, the job of operating a machine can generally be found across multiple sites, whereas other jobs, due to the nature of the product being produced may vary.

Data Collection

Selection of Participants

My initial discussions with the three organizations who approved access to interview machine operators included the selection of participants. The basic criteria for selection was that participants were currently employed by the organization, currently working as a machine operator, responsible for solving work-related organizational and/or operational problems, and they were willing to be interviewed. I also explained my objective of having a group diverse in gender, race and years of machine operating experience. The actual selection process was different in each of the three organizations. At Emmer Corporation, I was invited to conduct a 15 minute presentation of my research study to all shift employees. They were then given an opportunity to sign up with their supervisor if they were interested in participating in my study. At NICO, Inc., the employer asked various individuals if they might be interested in talking with me- these individuals were chosen to reflect varying years of experience on their current job. At The Gant Company, participants were selected according to my criteria, also varying the areas within which they work and their ability to be replaced during the hour interview. All interviews took place during the participant's work day and all participants were paid their usual hourly rate while being interviewed.

The sample of participants reflected the gender, race and age of the overall population of machine operators in the United States. According to the U.S. Bureau of Labor Statistics (2001), 15% of all non-farm employees within the U.S. work in the manufacturing industry; 61% manufacture durable goods and 39% make non-durable goods. The manufacturing category is separated into 3 different classes of occupations, one is that of machine operators. The participants in this present study are classified within this occupational class. In terms of gender, 64% of the total number of machine operators in the U.S. are men, while only 36% are women. As for race, 79% are white, 15% are black, and the remaining percent include Hispanic, Asian, Native American, etc. The age of individuals who are machine operators varies widely, though the majority fall between the ages of 25-54 years. The sample also intentionally approximated diversity of experience as it has been widely reported that the amount of experience (novice vs. expert) individuals have has a strong impact on how problems are solved (Khaney, 1993). In sum, 20 machine operators were interviewed, resulting in 71 critical incidents.

Data Collection Instruments

My primary data source was 20 production machine operators both as individuals participating in the critical incident interviews and as members of a focus group interview. The instrument I used to collect data was the semi-structured interview of the Critical Incidents Technique. This required two different protocols. One protocol (Appendix E), attempted to elicit effective incidents of problem solving activity, while the second protocol (Appendix E) sought to elicit ineffective incidents of problem solving activity. My data collection consisted of 3 pilot interviews, 20 individual interviews and a focus group session. The pilot interviews afforded me an opportunity to "practice" the interviewing process as well as to "test" my protocol and to begin initial analysis of the data. Based upon the pilot interviews, I slightly modified the protocols. Upon completion of the 20 individual interviews, a focus group was conducted with eight of the 20 participants to help verify the trustworthiness of the data and to ask questions which furthered my understanding of responses during the individual interviews. For example, a typical response to a variety of questions during the individual interviews was, "I learn through experience." I had not followed up with the question, "What do you mean by experience?" Therefore, I asked this question during the focus group session.

Data Collection Procedures

The individual interviews were held in a private space within each manufacturing organization. At Emmer Corporation, I interviewed some of the participants in a conference room located in the front office area and some of the participants in small resource library directly located on the shop floor. At NICO, Inc., and the Gant Company, I interviewed participants in similar size conference rooms. Following the explanation and signing of the Informed Consent letter, all participants were asked to complete the demographic information (Appendix D). All participants agreed to be audiotaped. Each critical incident interview lasted approximately one hour. The interviews were taped and transcribed.

The procedure used for the focus group was also a semi-structured interview, though the questions flowed from the initial analysis of the individual interviews. The focus group session took place at a convenient location in Jackson, Michigan. I chose this location because it was central to the individuals I interviewed and easily accessible. Though I had planned to conducted two focus groups to accommodate the participants shift schedules, eight of the 20 individuals who agreed to meet with me preferred the afternoon focus group, leading me to cancel the evening focus group. The focus group interview was tape recorded and transcribed. In addition, the Chair of my committee, Dr. John Dirkx, co-facilitated the focus group interview. An independent set of "eyes and ears" can be helpful in the later stage of data analysis. Dr. Dirkx is an expert in workplace issues, adult learning and group facilitation. It should be noted at this point that the first 35 minutes of the two hour focus group session was not tape recorded, because I failed to press the 'record' button along with the 'play' button. Fortunately, I, along with Dr. Dirkx took freehand notes during that time and so were able to piece together the essence of the conversation.

The critical incident method was very effective, however, only a handful of operators responded to the second protocol which asked them to describe a problem solving situation in which they felt they did not resolve well or were unable to resolve. Traditionally, the critical incident method is used to study the effectiveness and ineffectiveness of strategies around a given task. For machine operators, the resolution of a problem they are having is not viewed by them as a strategy, but as a dilemma which must be solved. For them, ineffectiveness means failure. Ineffectiveness is not an option for them. Machine operators view themselves as problem solvers. Ineffective doesn't make sense to them because the learning is what happens when you try to solve the problem- one is intricately dependent upon the other- they are one in the same. It is interesting to note that, when trying to elicit an answer to the 'ineffectiveness protocol' from Dale, a machine operator at NICO, Inc., he relayed an incident that happened in his work area.

> ...the people in the maintenance department wanted to shut down a certain piece of machinery in the mill if this alarm goes off. Myself and a few other people in the mill do not think this is the best thing to do. We think it will cause more problems if these pieces of machinery get shutdown in the mill...we were just kind of told that that's the way it was going to be...I don't think I learned anything new. From my experience of 30 years here it just seemed to add to the list to me that around here we seem to have a very hard time ever listening to the people who are actually on the job.

For others who attempted to answer this protocol question, the incident usually ended with assistance from others and the resolution of the problem.

After conducting the 7th interview at Emmer Corporation, I took some time to conduct an initial analysis of the transcribed data and to also review the interview process itself. My advisor, John Dirkx, and I decided to modify my interview introduction (Appendix C) by eliminating any reference to 'learning' as we felt that it may be having a leading effect on how participants were responding to interview questions. In addition, I expanded that notion to include a slight modification of the wording in the last two questions of the protocol (Appendix E) to read, "What did you gain or understand as a result of the outcome?" and "What did you gain or understand from this problem solving experience?" Even with these changes, however, there appeared to be no observable differences regarding participant's reference and use of the word 'learning' in their responses associated with a problem solving incident.

Data Analysis

The notion of reliability in quantitative research depends on repeatability. Qualitative research, however, seeks to describe and explain a phenomenon from the perspective of those most closely involved. The researcher interprets these perspectives or understandings and reports them as findings. Because multiple interpretations of the same data are possible, it is not possible to achieve reliability in the traditional sense. Therefore, rather than demanding that outsiders get the same results, the researcher strives for consistency and dependability (Merriam and Clark, 1991). "Data analysis requires that the researcher be comfortable with developing categories and making comparisons and contrasts." (Creswell, 1998, p.153). This comfort level is especially important for analyzing the critical incident interview.

Data was coded and re-coded using Hycner's phenomenological analysis of interview data as a guide (Hycner, 1985).

Data Analysis for Critical Incident Interviews

My analysis of the individual interview transcripts was an intensely inductive process aimed at respecting the thoughts and experiences of the participants. During and after the individual interviews, I was careful to take notes of general observations I made about my impressions of the participants as well as the surrounding environment. This was useful in capturing information for later use in describing my findings. After receiving the typed transcripts I read each one while simultaneously listening to the taped transcript. This not only began the process of becoming familiar with the transcripts but it also allowed me to correct any errors that the transcriptionist made due to her unfamiliarity with spoken words. For example, she may have typed "C and C" when in fact what was actually said was "CNC", the name of a machine used to make steel parts. I then began the process of initial analysis by reorganizing the transcripted discussion in several ways.

First, since my protocol was organized to capture critical incidents of problems faced by machine operators, the transcripts could be divided in this way, broadly capturing each critical incident as described by the machine operator. Each critical incident was numbered to reflect the individual, the organization within which they worked and the critical incident number. For example, 01E#1, was my first interview at Emmer Corporation, critical incident #1. While compiling all of the critical incidents, I read each of them many times, taking notes on the right hand margin next to words or phrases which seemed relevant to the phenomenon of study.

Second, I attempted to aggregate the transcribed information according to the protocol. So, for example, I would pull together all of the problems that machine operators experienced in their daily work or I would compile all of the responses to the question about what they learned while resolving the problem. Though helpful in some ways, this reorganization decontextualized the discussions, distancing me from the meaningfulness of the situation as a whole.

It was at this time that I decided to read the transcripts and listen to the tapes once more, recontextualizing the information and paying close attention to what the machine operators were attempting to communicate through their own words. During this process themes began to appear. Four more readings through the transcripts led to four different iterations of thematic analysis, each time gaining a clearer understanding of what machine operators were telling me. Also during this time of thematic analysis my committee chair, John Dirkx, also read samples of the transcripts. His comments and questions proved to be extremely helpful in this stage of analysis as well as in all other stages of analysis and interpretation.

Data Analysis for Focus Group Interview

Following the initial analysis of the individual interviews, I conducted, transcribed and analyzed data from one focus group interview session. The purpose of conducting the focus group session involved asking questions to test the trustworthiness of my initial analysis and to provide an open discussion of the particular themes and sub-themes initially created. I again immersed myself, with the aid of my independent observer, in the transcribed notes and the freehand notes taken during the first 35 minutes of the focus group session.

Role of the Researcher

The role of the researcher in a qualitative study is inclusive rather than exclusive, as in a quantitative study. In a qualitative study, the researcher is physically present within the setting being studied and is active in observing and recording behavior within the subject's natural setting (Creswell, 1994). Clearly, this method of study brings to light the value-laden biases which the researcher holds, and therefore, the researcher must clearly state those biases.

The biases I hold include: 1) perception equals reality, 2) machine operators have knowledge and skill related to their work responsibilities that are not acknowledged or recognized by management or supervision, 3) most individuals within organizations are interested in enhancing and recognizing the capabilities of employees, though their motivations differ, 4) manufacturing is a dynamic, complex environment, 5) learning is a continuous process, 6) thought and behavior affect the environment and the environment affects thought and behavior, a continuous dialectic.

My practical experience in manufacturing as an industry, with employees at all levels of the organization and with related trades, afforded me a familiarity with the topic and the context within which the research participants work. This holds advantages and disadvantages for the researcher. Familiarity has the advantage of providing an internal comfort level which will enhance the intense listening needed during a critical incident interview. Another advantage is the familiarity with the 'language', as I was able to follow the conversation closely and hence, ask questions which have more to do with the substantive nature of my study versus spending time trying to understand the words being said. Familiarity also has its disadvantages. One disadvantage is in creating assumptions based on past experiences. Familiarity may also "dull" the senses causing the researcher to miss important points given by the interviewer.

The researcher must also attend to ethical issues. Ethical issues regarding access to participants must pass the approval process of MSU's Institutional Review Board. The Chair of the IRB required a signed approval from the management of all manufacturing sites prior to entering the site and interviewing production machine operators. In addition to gaining approval from the site, I sought approval of machine operators to be interviewed.

Limitations of the Study

The use of in-depth interviewing in research involves personal interaction and cooperation from the research participants who may be unwilling or uncomfortable sharing all that the researcher aims to explore (Marshall and Rossman, 1995).

The majority of research documents critical incidents <u>after</u> the incident has passed. Schon (1983) refers to this documentation as reflection-on-action. This reflection, coupled with the Critical Incident Technique, inherently contains several drawbacks.

First, 'coached' reflection (reflection-on-action) represents only one side of the reflection coin. Equally important to individual learning in organizations is the unstructured reflection that employees naturally engage in while confronting challenging experiences. This type of reflection involves the way frontline employees try to make sense of what they are experiencing while they are in the midst of experiencing it. This informal type of reflection (reflection-in-action) involves spontaneous mental engagement with a situation. Though most research identifies reflection-on-action rather than reflection-in-action (Schon, 1983), this domain of analysis cannot fully capture the thought processes which are occurring during the action itself. Therefore, it is recommended that the interviewer uses probing questions such as : *What* happened next? *How* did it happen? *Why* did it happen? *With whom* did it happen? *What* did the parties concerned *feel*? *What* were the consequences- immediately and long term? *How* did the respondent cope? *What* tactics were used? (Chell, 1998).

Second, participants may reply with stereotypes, not the actual event. Using more structure in the form may improve this.

Third, effective reporting of a critical incident depends on the ability of the participant to recognize and report the incident in detail. Hartson and Castillo (1998) found that participants with the barest minimum of training in critical incident identification can identify and report their own critical incidents. This result is important because success of critical incident technique depends on the ability of the participant to recognize and report critical incidents effectively (Hartson and Castillo, 1998).

CHAPTER FOUR

THE CONTEXT

To many, the world of manufacturing brings with it images of dark work areas, monotonous work, deafening noises, pungent smells, and conflictual situations. Though these images are more than perception, the manufacturing world, to me, also brings with it images of energy, creativity, vividness of color and sound, and artistry. From the moment I entered a peanut processing plant in Georgia at the age of 10 years old, I have been drawn to the manufacturing industry.

We have seen a steady decline in the number of manufacturing facilities over the past 30 years mainly due to efforts to remain competitive in the global marketplace. However, manufacturing continues to be a staple industry of the U.S. economy. In fact, today manufacturing is the second largest generator of gross product in the US economy and the third largest employer (Hill, 2004).

Participants in this study are each employed by one of three manufacturing organizations. Manufacturing was an appropriate context within which to place this study. The incidence of most alternative workplace practices, characteristic of high performance work organizations, is more common among manufacturing firms than among nonmanufacturing firms (Bassi, 1996). Alternative workplace practices may include problem solving at the shop floor level, worker involvement in decision making, alternative compensation practices and others (Bassi, 1996). In addition, according to a recent survey by the National Association of Manufacturers, more than 80% of firms report facing a shortage of qualified machinists, craft workers and technicians. Although manufacturing will not grow much overall over the next decade, a rapidly aging workforce will create more than 2 million job openings for 'blue collar' workers (Thomas, 2002). In sum, the manufacturing industry has been a leader in providing problem solving training due to its attempt to compete in the market, and the turnover within the next decade will cause a new generation of machine operators to exist within the workplace- employees who will most likely benefit from problem solving training which this study, in part, seeks to inform.

Machine operators were chosen as my primary data source following consideration of other types of occupations of frontline employees within manufacturing. Machine operators most often have greater mobility within their workspace, they are responsible for on-line production, they are generally regarded as highly skilled within their area of operation and are often expected to resolve a multiplicity of issues or problems. In addition, the job of operating a machine can generally be found across multiple sites, whereas other jobs, due to the nature of the product being produced may vary.

The purpose of this chapter is to provide the context of this study, setting the stage for the following chapters. First, I will provide a description of each manufacturing organization, keeping the description broad enough for the organizations to remain anonymous. Second, I hone in on the job of operating a machine and what it means to be a machine operator, as described by the participants themselves. Third, I summarize the various daily problems encountered by machine operators and how they attempt to resolve those problems. This chapter should provide the reader with a sense of the context within which this study is situated. The names of the organizations and participants have been changed for confidentiality purposes.

The Manufacturing Organizations

Throughout my career as an employee, a consultant and instructor within the manufacturing industry, I have had the opportunity to tour over 50 facilities nationwide. It has been my experience that no two manufacturing facilities are the same. Each facility has its own unique history; it's own unique culture; it's own sights, sounds and smells and its own unique working structure. Even with these differences, however, researchers have identified similarities of work operations and structure across manufacturing organizations by taking a "birds eye view" of the industry. Three manufacturing organizations approved access to interview machine operators at their facility:

The Emmer Corporation

The Emmer Corporation is a three shift operation located in the central midwest, producing a variety of parts for the aerospace industry. The machinists who participated in my study make these parts by operating state of the art Computerized Numeric Control machines, otherwise known as CNC machines. Most machining operations are arranged in "cells", otherwise known as cell manufacturing. Basically, cell manufacturing is on the opposite end of the work structuring continuum from traditional assembly line manufacturing. A traditional assembly-line work structure employs individuals to handle one aspect of the production of a unit to be sold, whereas a cell manufacturing work structure requires one individual to handle most of the operations necessary to make a single unit of product. Though each shift employs one supervisor, machinists at Emmer Corporation work autonomously, some stating that there are days when they have no contact at all with supervision.

NICO, Inc.

NICO, Inc. is a three shift operation located in the central midwest, producing wheat and flour for the cookie, cracker and baked goods industry. Of the five machine operators I interviewed, three have responsibilities to operate the flour mills and two machine operators are responsible for a variety of jobs within the finished product warehouse. Like most secondary food manufacturers, NICO runs a continuous operation. Components within this type of operation are in an operational state at all times. Operators are assisted by programmable logic computers (PLC's) which are located within a closed room with large plexiglass windows near the equipment they tend. Operators spend just as much time "watching" the computer screens as they do physically walking through their areas to check on the equipment and the product itself. The operators at NICO, Inc. work closely with their supervisors, though supervision is regarded as integral to the successful operation of the product and experts in flour production. Many of the supervisors are graduates of Kansas State University's Milling Science Program.

The Gant Company

The Gant Company is a three shift operation located in the central midwest, producing transportation vehicles. All interview participants use a variety of small machines to assist in assembling vehicles. Each participant is responsible for one part of the assembly operation and is physically stationed in one area of that operation. Some of the operators work within a team structure lead by a team coordinator (TC) with rotating job responsibilities, whereas some of the participants work individually with little to no rotation. These operators, as well as those working with the team are highly supervised compared to the machinists working for Emmer Corporation and NICO, Inc. In fact, several agreed in the focus group session that their supervisors "keep an eye on them" and are quick to discipline if problems occur.

Being a Machine Operator

The three manufacturing organizations that approved access to interview machine operators at their facility all asked me to define the type of machine operator I was interested in interviewing. I told each of them that I was liberal in my definition in that anyone who used a machine to assist them in the bulk of their work would fit the criteria of "machine operator". I took this liberal definition to my first site where I was asked to present my research study to machine operators on all three shifts so that they might understand the nature of the proposed interview. As they left the meeting, the machine operators were told that if they were interested in participating as an interviewee they should sign up with their shift supervisor. Following the meeting, I was given a tour of the operation, which consisted of visiting each "cell", with the operator in charge of that "cell" explaining his operation. During my tour one of the machine operators approached me, took me firmly by the arm and proceeded to say, "I will not volunteer to be interviewed by you because I was offended by your calling me a machine operator. I am a machinist, not a machine operator." Though my liberal definition of what constitutes a machine operator may be used for the purpose of this study, machine operators do not always describe themselves in that way. Though my incident with the machinist may be trivial to some, it is a perfect example of the potential differences that exist between the "observed" and the "observer" and the value of providing information from the point of view of the participants themselves. Throughout this study I experienced similar types of situations-situations which triggered a more expansive understanding of the context within which this study is placed.

This incident also seemed to communicate, through tone and non-verbal behavior, the pride involved in machining. Through my words, I had not only offended him, but I had hurt his pride. Machine operators are proud of the work they do and the product they make. One of the focus group participants enthusiastically commented, "I made something from nothing!" Another focus group participant said:

> ...now you can see exactly how it fit, to me I think that's awesome. I think it's great to see something at its finish and I know what it looked like in the beginning and what that one part can do. I think that's cool.

During the individual interviews, machine operators clearly expressed how they felt about their work. The words they use illustrate both how they relate to their work as well as how they define themselves within their work. Rod says, "I'm more hands on as far as machining problems, I just love those. You know, that's my nature." And "We are problem solvers- that machinist no matter from first getting the job to 20 years- we're all problem solvers and we love it." About solving problems, Harry comments, "It makes me feel good, if you've got a problem and I can solve that problem." About the work itself, Tim says, "Well it's an art to spot what different types of corrections to make on that wheat and the different percentages to add..."

One machinist told me a story which describes how an "outsider" might view his work:

> ...we have people come down from upstairs and take a tour and one guy came down and he had a group of people and he was our personnel director. And he stopped at the automatics and he said now the bars go in those tubes back there and the parts come out here. And then he walked away. And it's like wow, that's what they see and it was a real revelation there that they have no clue what it takes for the bars to go in there and then come out here and look all nice and pretty. Have no clue.

Learning to be a machine operator is a function of on-the-job-training and experience on the job. On-the-job training typically consists of several weeks of working with an experienced operator on the particular machine that the trainee will soon operate by themselves. Participants unanimously felt that on-the-job training was the best way to learn how to operate a machine as opposed to learning through formal means such as reading "how to" manuals, watching videos and/or interacting with computer-based interactive scenarios. As instructors themselves, machine operators agree that on-the-job-training is critical to a machine operator's success. Rod spent one semester teaching machining at a nearby Community College.

> But then from that (teaching) I learned, yeah, you can't do it with just books and tapes. You know they had some books and some videotapes that I was showing the guys when they first come in and then we had a couple of screw machines there and first couple of days that's all I was doing. I was showing them tapes, because I thought at the time they needed to see the movement of the machines that I wasn't prepared to show them out there. Well I could see that wasn't working, eventually the feeling that I got was what in the hell are we looking at? And so then I had to backtrack and say I need to set one of these things up, so they could see it for real.

Learning to be a machine operator is also a function of experience. To machine operators, experience means making mistakes. When specifically asked, "What does experience mean?" participants were not hesitant to offer a definition. Dale was quick to respond, "You have to go down there and open the basement and pull these big steel plates out and shovel all of that wheat out of there, it's about 800 bushels. So that's experience." Others commented, "You experience a problem that keeps coming and you have to keep fixing it, sooner or later it sinks into your brain and it's there and it doesn't go away." And "If you don't make a mistake you're not going to learn a lot. I learn the most when I make a mistake and I will never make that mistake again because now I have the experience." As the previous participant mentioned, "You experience a problem…" Problems are described as the triggers to everyday learning on the job. On-the-job experience is discussed more fully in Chapter Five.

The Everyday Problems Encountered

Once on the job, the vast majority of the problems encountered in a machine operator's day-to-day work are operational in nature. Operational problems are those related to the operation of the equipment and the product during the production process. The operator is the mediator between the equipment and the product.

Operators within each of the three organizations presented a variety of different operational problems they encounter, though one problem emerged as "typical" due to the nature of the work itself. For example, at Emmer Corporation a common problem machinists described was chatter on the part they were trying to produce.

Chatter can occur when the insert or tool meets with the steel part, producing a rough cut. In machine shops aiming to minimize hand finishing, machining surfaces have to be smooth. Penny describes such a situation.

> Well one scenario is if you have an insert go wrong, whether it be an OD finisher or boring bar, get a little chatter on it like ripples. And that will indicate that there's like a little chip in the corner of it that isn't cleaning up what it is supposed to.

At NICO, Inc. a typical problem encountered is referred to as choking. Tim describes this problem:

> At that point, that's where the enrichment is added to the flour, the vitamins. Sometimes you- up there there's like a bottle that it goes down through and sometimes it chokes up. Yeah. Usually by humidity or something like that…at that point you've got to go over there and unchoke it.

At Gant, due to the nature of their work, machine operators more often described a typical problem as encountering difficulty while attempting to place parts on a moving vehicle. Dano, a solid and seemingly strong man, complains of a situation on the line:

> Sometimes that part right there is closed and you have to open it up. Okay? So that you can put your bolt- you've got a gun with a bolt and then you go inside the door. You've got to stick your hand in-between where the window goes up and down. And you've got to stick your hand inside there and then you've got to put that baby right there and then you nail it to the side- to the centerpiece of the post of the car where the doors come together in the middle right there that's the centerpiece and you've got to bolt that. Well, sometimes this thing is too hard where your fingers can't pry it open…people were being hurt by it and had to go to medical…

Only a handful of the 70 problem incidents describe non-technical problems like problems with ergonomic issues, co-workers and other departments For example, when asked to describe a problem she encounters while working, Linda relied, "My problems that I usually encounter are that I'm shorter than the average person and so when you go to certain jobs...some jobs are better for people who are taller and not so, well- shorter." Jackie told of a problem she encountered with another co-worker,

> ...we are men and women working together and it causes problems sometimes. One Christmas he bought me a present...I opened it up an there's a thong! I really was just too embarrassed to say anything to him...after that he could see that I wasn't interested and he just quit coming over to the machine."

In terms of other departments, Bud commented,

> ...we have four different departments I guess in this plant, well maybe five. But at any rate, sometimes we don't always work real good together. It's like each department for themselves. And sometimes Department A, doesn't exactly see the problem that Department B is having you know and so sometimes the problems can be dealing with the other people from other departments that don't exactly know what you're striving for right at the moment.

Though the number of incidents of these types of problems is few within this study, it in no way diminishes their importance to the individual experiencing the problem.

Structure and Supervision

The way these problems are experienced and resolved are affected by the work structure and supervision.

The work structure seems to affect strategies for solving problems. As previously mentioned, the work structure at Emmer Corp. is built around cell manufacturing. Machinists at Emmer experience their production from the raw material stage (steel rod) to the finished product (high tolerance component parts). They rely on other machinists in other "cells" to assist them in solving problems. The literature would refer to these machinists as self-managed (Bassi, 1996). In fact, during the focus group session, a machine operator from Gant made the following comment to an Emmer Corp machinist,

> But I do kind of think in your way, you are more empowered yourself in your own problems and probably you have had more satisfaction than say those of us who are forced there- well, we're forced to problem solve... if (Jackie at Emmer) knew how to fix it, she'll fix it. That's it. In my case, we've got to do the paperwork to get it fixed. We've got to meet with our team to get it fixed. And then the 'fix-it' we're suggesting may not be adopted.

As a reminder, those who work at Gant are expected to physically remain in their station and have little control over stopping and starting production. Because of this difference in work structure, problem solving strategies differ.

The role of the supervisor also seems to have an effect on how participants solved problems and their willingness to explicitly communicate those problems. At Emmer Corp., the majority of supervisors are thought to have knowledge regarding the operation of machines as many of them were once machine operators themselves. Dan said, "I learned that my supervisor knew more than I did." Though they are sought after to help resolve problems, their inaccessibility decreases the frequency of assistance.

At NICO, Inc., supervisors are regarded as experts in the process of producing the product they make, though less so with the machinery itself for which the machine operators are the experts. This creates more of a complementary relationship as the operators and supervisors have identifiable strengths. Tim was quite verbal about the help he receives from his supervisor, "Supervisors over there are pretty smart when it comes to things like that...If you have any problems they'll help you. They'll explain it. A lot of times they'll go with you and show you." Supervisors at NICO are said to be accessible, fair and supportive in solving operational problems.

For most of the machine operators working at Gant, supervisors are viewed as lacking knowledge of operator's everyday work and are therefore not a part of the everyday problems which occur on the line. One Gant focus group participant commented, "Our supervisors don't know anything…" and "A lot of times we'll tell the supervisors where the problem is- they could correct it, but they don't listen to us." During their "formal problem solving process", the supervisor's role is to facilitate and support the process, though the level of support differs across supervision. Some operators at Gant have experienced negative reactions from supervisors when problems occur, hence, they are less sought after for assistance.

Machine Operators…The Study Participants

I spent the summer of 2003 contacting manufacturing organizations for approval to interview machine operators within their organization. Of the 29 manufacturing organizations I called, three came forth as willing partners to my study. Emmer Corporation granted me access to ten machine operators. NICO, Inc. granted me access to five machine operators and Gant Company granted me access to five machine operators. Machine operators were chosen to reflect variability in gender and experience. I defined the job of machine operator in the broadest sense of the classification, as any individual whose job depended on operating a machine to perform their work. Most of the participants described their job title as a machine operator, though one participant made it quite clear that he should not be referred to as a machine operator, but as a machinist. He drew a clear distinction between the two in terms of skill level.

Following initial analysis of the individual interviews I invited all 20 of the study participants to one of two focus group sessions in order to accommodate their work schedules. Eight participants accepted my invitation and chose to meet during the 11:00am to 1:00pm timeframe.

Of the twenty participants in this study, thirteen were white male Caucasian, five were white female Caucasian, one was an African American female, and one was a Mexican American male. With fourteen male and six female, the sample approximated the U.S. population of all machine operators (U.S. Bureau of Labor Statistics, 2001).

Two participants were in their early 30's, twelve in their 40's, four in their 50's and one participant in his 60's. In terms of their current position, six participants have held their machine operator position less than three years; seven participants have held their position between four and seven years and seven participants have held their position for eight or more years.

In terms of their seniority as machine operators overall, four have operated a machine less than three years, three have operated a machine between four and seven years and eleven for eight years or more.

For more detailed information about each participant, please refer to Appendix H in the Appendices section. For purposes of confidentiality, the names of all the participants and their employer have been changed.

Summary

The context in which this study takes place is manufacturing. Three manufacturing organizations participated in this study, agreeing to allow me access to interview machine operators. Because the broad definition of 'machine operator' was used in the selection of participants, participants differed in the complexity of the machine they operated. However, across all machine operators there was a sense of pride regarding their work and the product they produced as well as an identity as a problem solver. The three organizations, though similar in many ways, differed in the types of problems that occur, the work structure, and the role of supervision in the problem solving process.

CHAPTER FIVE

FINDINGS

The purpose of this study is to explore the nature of learning associated with the problem solving activity of machine operators in industry. This chapter describes the findings that were revealed through an analysis of the data collected through one-on-one interviews with 20 machine operators from three different manufacturing organizations and one 2-hour focus group session with eight of the twenty operators attending. The following question guided this exploration:

- What is the nature of the informal learning associated with the ill-structured problem solving process of production machine operators within the context of their work?

Machine operators find learning to be a positive aspect of their work and a positive experience for themselves personally. According to the machine operators I interviewed, they are learning all of the time and have no interest in seeing that change. This observation is similar across experience levels and includes operators across the three organizations participating in this study. Machine operators are not only frequently learning, they also report learning they encounter through problem solving. In fact, the 70 problem incidents produced a description of 81 various significant learning events. Further, operators describe themselves and their fellow operators as problem solvers.

Four findings revealed themselves upon completion of the individual and focus group interviews and the analysis of the interview data. First, learning is perceived by machine operators to be intimately bound up with problem solving. Second, the problem solving process is triggered by an incident which leaves them frustrated, confused and uncomfortable. The process of regaining equilibrium or certainty is inherently social in nature and is guided by personal strategies to achieve balance. Third, problem solving and learning are part of an ongoing process of becoming a machine operator, with three definable phases. Fourth, the consequences of the learning process results in several kinds of knowledge.

Chapter Overview

I drew my findings from the interview and the focus group transcripts, being quite careful not to place my own interpretation upon the transcripted voices of the participants. This chapter consists of three major sections. Each section is consistent with my four findings, with the third and fourth finding being collapsed within the third major section heading. The first major section depicts data describing the machine operators account of both the frequency of learning and their attitude towards learning. The second major section describes in detail the components of the problem solving process for machine operators which includes the trigger event, responses to the trigger event, the dynamics of emotion and interpersonal relationships, and the role of feedback and recognition to the problem solving process. The third major section collapses my third and fourth findings, highlighting the three definable phases of becoming a machine operator and the types of knowledge gained through the problem solving process. The phases and knowledge gained intersect to define the process and learning necessary to become a machine operator.

Learning

Machine operators widely report that they learn all of the time. At Emmer Corp., Patty, with less than one year experience, says, "As time's gone on it gets better and better- I have gone home every night with a headache- but everyday is a learning experience. There's always something." Carla, with five years experience, mentions, "There's so much to learn. You can't learn all at once, it takes a long time because each job is different." Judy, with six years experience, says, "I learn something every day if I can, you- learn something new out there that will help me be even better and not be so dependent on someone else for their knowledge, but have the knowledge to share with others." Daryll, with seven years experience, remarked, "I learn stuff everyday. There are still things I have questions on and I probably will because I learn things every day." Hank, the most experienced operator among the participants with 23 years experience, commented, "Even though I've run the machine for years and years, I still made a mistake- something I never thought of before and my boss helped me out. I like to learn something everyday- whether it's big or small."

At NICO, Inc., Taylor, with one and a half years experience, says, "But throughout the course of a day, a week, months there is always something you need to learn." Blake, with four years experience, says, "You know I learn something different every week, something happens that I haven't seen before and then I try to put it back in my mind so that the next time it happens, I remember what to do."

Operators working for Gant Company also commented that they are continually learning. However, the nature of their continual learning results from being placed on new jobs as well as picking up new responsibilities on their current jobs. One Gant operator has the following experience, "Well, usually they'll put me on a different job. So it's always a new experience." For other Gant operators, frequent learning is a result of new job responsibilities, "And then in our area, they (management) are always changing things...right when you think you are getting really good at it (the job)...they come in and mix it all up...so you might have a different part, they might even take the one part and put a different part in."

It is interesting to note that I did not ask any of the participants questions about the frequency of learning- these comments were all volunteered by participants during our interviews. The frequency of learning was also touched upon during the focus groups, again, with no direct prompting. A focus group participant commented that, "There are all sorts of things that could go wrong. That's a learning in itself." and "If you think you've learned it all, you just better get out of there." In other words, there is always something to learn no matter how many years one has as an operator. For example, Casey, a 20 year machinist remarked, "I just learned how to check some drops on bent parts..." All of these comments regarding the frequency of learning and their attitude toward learning were all in response to a protocol which focused on problem solving within the context of their everyday work. This suggests that the relationship between learning and problem solving is intimately bound together.

The Problem Solving Process

The actual problem solving process involves several key components made visible by analyzing the transcripts from the interviews with machine operators. These components are summarized under five broad headings, followed by several subheadings. The five broad headings are: the trigger event, responses to the trigger event, adjustments as a strategy to the trigger event, feedback and recognition, and emotional and interpersonal dynamics.

The Trigger Event

The event which triggers the problem solving process is referred to as the 'trigger event' throughout this study. The trigger event begins a process of learning which is made visible by the consequence or outcome which occurs following the event. Sometimes the consequence is immediately visible, while for others, the consequence is delayed. Various things happen from the point the trigger event occurs, to the point of consequence, bringing 'closure' to the problem resolution cycle. The purpose of this section of the chapter is to illuminate the nature of learning during this process.

Kinds of Problems. In the previous chapter, I outlined the kinds of problems machine operators face during their day-to-day work. The vast majority of the problems encountered in a machine operator's day-to-day work are technical in nature. Only a handful of the 70 problem incidents describe non-technical problems like problems with co-workers, other departments and/or ergonomic issues. Though the number of incidents of these other types of problems is few within this study, it in no way diminishes their importance to the individual experiencing the problem. In fact, the process of resolving these types of problems revealed significant learning. However, since the bulk of the critical incidents were technical and operational in nature, I chose to focus only upon these incidents.

Causes of the technical problems, as described by the operators, involve both controllable and uncontrollable variables. Judy describes her frustrations with the temperature, "Every time I take a break I come back and set it. It (the setting) changes through the night as it gets colder." Carla, on the other hand, due to her inexperience on a particular machine, describes another variable. She states, "And you know, you've got to learn that machine, its little quirks...they say the machines are the same, but they are each a little different."

Causes of problems can be typical or atypical. For example, a typical cause might be related to the raw material. Doug told me that, "The thickness of the metal might vary." Other causes, however, are atypical. Reed shared a story of one of these causes.

> There was a machine that had a chatter problem and that's when a tool vibrates against the part and it leaves marks on it and it's not acceptable. And it was what was called chatter time. Everyday at the same time, that machine would chatter for a certain amount of time and then it would stop and it would be fine the rest of the day. And this went on-I don't know, I can't remember the story or how long it took. But the root of the problem was it was a train traveling down the tracks within a certain vicinity at that time of the day that made that machine chatter. Because it got so bad that they would shut it off at chatter time, well it's time to shut the machine off. Now that's way out there. But somebody figured that out.

<u>Awareness of the Problem</u>. Throughout this section, I describe the trigger events which prompted machine operators to actions of problem resolution. A trigger is an event which occurs that gains the attention of the machine operator- a signal that a problem has occurred. Of the 70 critical incidents, I identified 49 triggers.
Of the 49 triggers, 19 occurred <u>during</u> the machine operator's activities associated with making the product. Whereas, twenty triggers occurred <u>after</u> the machine

operator's activities associated with making the product. For example, some triggers occur <u>during</u> an operator's work. Larry's harrowing experience began when the dust started flying.

> And what happened the fellow that trained me said, Larry, after we back this trailer in, I'm going to take a break. You go in and program it. I said, yeah, okay. I went in and I started programming it and hit the button, started dropping. I looked around, dusty all the way to the to the side of the building, dust! You couldn't see out the window. Dust!

Reed, a machinist at Emmer, Corp., describes what happens when they notice a drilling problem has occurred.

> And the parts started falling out of his shoot with the drill wandering out the side of the part. It was a fairly lengthy part too. And of course when it happened we both knew what it was. It was he had a drill that was going too deep after cutoff and leaving that drill point in the bar end. And once it started to wander, you see that.

Other triggers occur after the task is complete. Carla shared with me that, "The operator on first shift told me I did them wrong and he had to redo my parts." Blake is alerted to a 'plug up' when "...a little alarm will come up and then I have to go and investigate it and see if it's something I can take care of myself or whether we need to shut the process down..."

Machine operators become aware of a problem in a number of different ways. Some operators **visually** observe that a problem exists. For example, Carla was alarmed when she saw smoke coming out of her machine. "It was smoking quite a bit. I didn't like that." or Mel who told me that, "If you have a choke, the sock would be bulged out." In this case, the pipe that the product goes through is plugged and so it builds up inside the fabric-like bag that is attached to the plugged pipe. Other operators discussed an **internal 'gut' feeling** that something wasn't right. Judy remembered the day she was machining a part and "it didn't feel right. It just felt something is wrong. I didn't know what. I didn't know what." She later told me that she should have gone with her gut feel! Sometimes operators become aware of a problem when they endure **physical pain** as in Doug's case, "Well, sometimes when you try to pry it open it hurts your fingers."

Lack of a familiar noise, a breakdown of machinery, a note left from the previous shift are among other ways that machine operators become aware the a problem exists.

Associated with the trigger event is emotion. Though in the individual interviews, I did not specifically ask how participants felt during a trigger event, it became clear that for many of the machine operators, emotion was connected. Feelings of frustration and confusion were two of the most frequently mentioned emotions. Others, however, spoke of fear, anger and panic. The spoken word, however, doesn't portray emotion like that of unspoken gestures and tone of voice. This is what a researcher picks up during the face-to-face interviewing process coupled by listening to the audiotaped interview afterwards. Doug, a machinist at Emmer Corp., tells a story about a problem he encountered.

> But it's (the machine) very quiet about it. It doesn't go choooo, it doesn't make that air release or anything like this you know. It's sneaky about it. So I'm standing there and all of a sudden this starts to come across and I know that it's not the right time for it to come across. He's (another operator) standing right next to me and I'm hitting the button that I think is going to stop this. It doesn't stop it. So I'm hitting those other buttons. Finally just bang! It hits the back of the turn at once.. …I thought I was hitting the right button you know, he said I didn't want to get in the way, your hand was all over that panel.

The entire time Doug is relaying this story he is sitting upright on the front edge of his chair, making hand movements which replicate how he was hitting the buttons. His voice grows loud as he describes how the part hit the back of the turn, "BANG!". His voice begins to soften after that and he sits back in his chair as he explains what happened after the part hit the turn. The only words describing his emotion are, "all of a sudden I hear bang, and it's oh, oh, what did I do this time? You know so there was a time when I thought, yeah, I've got machining background but I'm not sure I'm ready for this."

Another operator, Larry, describes his emotion which accompanied his crisis at the dumping station.

> Oh my gosh, out here where these trucks back into the feed shed? Right down below here. They throw their tarp back and they back into the shed and you lower the dispenser down, we come into his little office and program the computer, how much feed do you want to drop into this trailer. Hit the button and it's automatic, it starts dropping. And what happened the fellow that trained me said, Larry, after we back this trailer in, I'm going to go take a break. You go in and program it. I said, yeah, okay. I went in and I started programming it and hit the button, started dropping. I looked around, dusty all the way to the side of the building, dust! You couldn't see out the window. Dust! I said, my god, what am I going to do? What am I going to do? I'm running around looking, scratching my head, well what am I going to do? Somebody was walking by, I didn't even know who it was. I just said come here! How do you shut this off? Quick, quick, quick! What happened is the truck driver, when he backed in, he did not throw his tarp back over his trailer and we loaded the disperser down on top of the tarp and I hit the button, this feed was just hitting this tarp and dropping over to the side. I had a mountain as big as this room, all of this room. Boy I shut it off. Oh man, the truck driver was embarrassed. I was embarrassed. I was mad at myself. I freaked out. Oh god, but it's one of the things that you learn when you're operating. You figure sooner or later you're going to mess up, I don't care how good you are, you're going to mess up. Whatever job you get, if you try it, sooner or later you're going to mess up. And that's what happened to me. I freaked out.

Not only does Larry talk about the emotions he felt during and after the incident, but his face even turned a darker shade of pink as he recalled the incident.

The focus group session gave me an opportunity to explore emotion further and so I asked the question, "How do you feel when you suddenly realize that you have a problem?" Focus group members did not hesitate to offer the following descriptors-frustration, fear, embarrassment, momentary depression in that they "felt bad", and guilt as in "I feel like I've done something wrong."

Responding to the Trigger Event

After the trigger event and the associated emotions have occurred, machine operators work to resolve the problem. The machine operators I interviewed revealed several concrete events which facilitated the movement from trigger event to the consequential event. Aaron, an experienced operator, sums up the experience of most machine operators I interviewed by stating that, "I learn how to solve problems through past experience, other operators, and job training… Most of it is just from working." Machine operators across all three organizations attempted to use a variety of strategies to solve the problem at hand and/or personal strategies which allowed them to be proactive in an attempt to lessen or eliminate future problem incidents. The nature of these strategies seems to point toward the desire for self-sufficiency. Operators were also clear of their reliance on others to assist them in resolving problems.

Relying on Self. The pivotal point in the problem solving process is, as might be expected, the individual themselves. Machine operators relied on both internal and external resources to solve everyday problems while performing their work. Three kinds of resources were identified: 1) **prior knowledge,** 2) **use of printed material,** and 3) **personal strategies** in working through the problem solving process.

Machine operators use their own prior knowledge to assist them in solving problems. Their prior knowledge is mainly derived from past experience through making mistakes, broad exposure to the production process, stories from others, watching others perform their work, receiving feedback while doing the work, job aides, homework, and simple trial and error. Explanations and examples of each of these areas will follow.

Machine operators derived **prior knowledge** from past experience. Past experience was defined by the operators during the focus group interview. When asked, "What do you mean by 'experience'?", there was no hesitation among participants to provide me with the answer. "You experience a problem that keeps coming and you have to keep fixing it, sooner or later it sinks into your brain and it's there and it doesn't go away.

Another operator told about her frustration with an operation she was trying to perform,

> It happened several times and I said to Char, I said what am I doing wrong here-because it wasn't hurting anything. It was just making the buzzers go off. And she goes you're doing it too quick and they couldn't light. Well that was really simple. I never did it again after that and now every job that I go onto, I make sure they light. I just felt what is going on? So I learned and now every time I go on a job I look for it. I have experience.

One focus group participant summed it up by stating that her experience came from,

> The learning, the education and the ups and downs and trial and error-making mistakes. If you don't make mistakes you're not going to learn a lot. I learn

> the most when I make a mistake and I will never make that mistake again because now I have experience.

Many operators spoke of experience is this way. To them, experience consists of making mistakes while performing the work.

Not only do machine operators gain knowledge from their prior experience and prior mistakes, they also expand their knowledge through a broad exposure to the production process. Denny, a machine operator from Nico, Inc., commented,

> I was fortunate to work all the way through because you see the start and the end… I learned the flow on my own. So I was proud of that. I had a notebook and I wrote stuff down and I drew diagrams to help me learn my job better and learn the flow. And that helped me out in the long run.

He continues to explain that knowing the entire process helps to reduce problems discovered after-the-fact. In a continuous process environment, a small problem might occur at the start of the process, and, having worked its way through the system, can become a big problem later in the process- an avalanche effect so to speak. Denny explains the consequences of not having a broad knowledge base. "So if I screw up over there…by the time it is all said and done, I've created probably 15 other people extra work." Others thought that having a broad perspective personally helped them to catch problems before they became unmanageable. Mel mentioned,

> If you really want to know your job well you have to know the flow of the mill. And if they make changes, you need to keep up on them. I got this from Kelly's Hero, a Clint Eastwood movie, okay? I want to get my ass out of the trouble just as quick as I got into it. So the more you know you help yourself on the job.

Prior knowledge which operators relied on to solve problems also came in the form of stories they heard from others. At Emmer Corp., Todd heard stories about the strength of the UAW and assumed that those stories would apply to his organization. His expectations were not met as he worked through a grievance situation- a problem he encountered as a union representative. The UAW stories served as a backdrop for his current problem solving experience, triggering a change in perspective with respect to his local union. At Gant Company, Laura is reminded of a story with respect to the job she was running. Laura's work station is located on a slow moving belt. She explained that sometimes, the belt does not stop at the required stopping point causing the person on the belt to fall off the end of it.

> I've never had it where it doesn't even stop, it goes right off the end. Somebody told me about that story. They said you want to make sure that- there's a button they push I guess when they're fixing it and it keeps you going to the point where it doesn't crossover. And if you come in, that's one of the things you should look at to make sure that they haven't stopped it, because otherwise you'll just go right off the end.

Machine operators related these stories to the problem incident they were describing during their individual interview. The stories help to form machine operator's prior knowledge.

Prior knowledge which operators relied on to solve problems also came from watching others perform their work. Blake stated, "I saw other employees doing it, when they trained you for a job and they told you about chokes and spouts...they showed you how to take care of it. Yeah, and that's how I learned I guess to do it." Reed mentioned that, "I watched him. And he went back through his production and you could just see where the problem started." Others learned to handle problems of a non-technical nature by watching others. For example, Todd, an Emmer Corp. machine operator and union representative learned how to handle his first disciplinary case through watching, “I’ve been watching people go along, how they’ve handled situations.”

Not only do machine operators gain prior knowledge from watching others, they also gain it from having others watch them performing their own work, coupled with feedback from the more experienced operator. For example, one focus group participant shared the following story.

> I had a guy went out and keep filling hoses, he let me sit there for 45 minutes trying to put a drive wire into a part and I kept hitting the thing and turning. Finally-he’s sitting there watching, the guy had been here for about 40 years. And he walks up to me and he says, come here. I want to show you something. He walks over to the fixture and screws it on, tightens it onto the fixture, it doesn’t turn anymore. And I said, why in the heck didn’t you tell me that 45 minutes ago? He said, because it wouldn’t have been set in your brain. And I will never forget that. That was in 97’. I haven’t been in there since 97’ and I still remember that.

Carla, another machine operator, told me that she prefers being monitored by a more experienced operator versus watching someone else perform the work. In other words, she would rather be the one doing the work while a more experienced operator stands by.

> You can ask him anything and he’s right there to help you and he’ll show you—he likes to get in there and just do the buttons. You’re sitting there trying to see what he’s doing, so sometimes we have to ask him well what did you do? You know? And he has been told to stand there and tell us what to do, you know? Let them push the button-let them do it.

Another way that many of the operators remember their prior experience is to write it down in the form of notes. Operators use this strategy to avert problems or to be proactive in taking care of problems that might occur. Denny mentions that “When I get it to work, I write that down on the tool sheet- the next time the job comes up I can look at it.” Blake writes himself a note regarding causes of a particular problem, “I write myself a little note telling me what went wrong so that I won’t forget and then I have to manually take care of whatever the problem is.” Judy decides when she needs to write things down, “So I will learn and there are some things I’ll write down and some things I just have in my head and I’ve learned a lot from it. It helps me.” and Carla states, “Sometimes we write it down so that we can do it the next time.” The majority of operators physically wrote notes to themselves.

For some operators new to machining, homework is an important tool. Judy was quite explicit in that,

> I’d go home and study my report. Every night you have these books, you learn new stuff everyday. I’d just go home and just study and try to get it in my head. I wanted it really bad. But one day a light bulb went off and I’m like, this isn’t hard. And then it kind of came together.

When Reed began working at Emmer Corp., he was enrolled in a training program to learn CNC machining. He commented that it was hard getting back into the ‘rhythm of learning’, “…there was some bookwork there and I did take some of that home…and I realized just how hard it was to get back into that rhythm..and since I have talked to other people and my eyes were open to that’s not a new or uncommon thing. That’s life.”

Lastly, machine operators gain prior knowledge from simple trial and error. There are times when operators do not choose to seek help from others or do not have time to seek help when something is going wrong with their operation. One experienced operator told me, “You have to play with your feed and speed to find the right combination where you don’t have the chatter.” In this operation, the feed is the rate at which one inserts the raw material to be tooled, and the speed is how fast the part is turning. Another operator mentioned, "… sometimes it's just panic. Something happens and you start hitting a couple of buttons and luckily it turns out right for you, you know, dumb luck I guess."

In sum, machine operators rely on themselves and their prior knowledge to assist them in responding to a problem incident. However, they also use **printed material** to supplement the knowledge they have previously gained. Machine operators spoke of using operations manuals, machine blueprints, checklists and other types of procedure manuals. The section of the operations manual used most often was the troubleshooting section, "I'd have to look at the manual again if it happened again- maybe once or twice to memorize it all. They have a troubleshooting section of the book…" Judy is called into the supervisors office because she made a shifts worth of bad parts, but she did not get disciplined for poor performance because she wasn't properly trained by a fellow operator. She commented that, "They should have shown me the bunch of papers that tell you about the part and everything…" Blueprints are important at Emmer Corp., for many of the machine operators who work there. In terms of checklists, some operators follow a standard checklist provided by the employer, while others make use of their own checklists, "We all have our own little checkdowns I guess, a little list. That list depends on the problem and where it occurs. " and "At one time there was a checklist I'd go through- but now I skip steps- though there are times that I overlook things."

Other information comes in the form of procedures: the grievance procedure, the job task procedure, and the programming procedures, to name a few. However, these forms of information are said to be more theoretical than practical. "And theoretically, you should arrive on a job and be able to look at these documents. In the real world, it does not happen that way. Instead, a TC (team coordinator) comes out and shows you how to do it and you would watch them."

Similar to using a checklist are the **personal strategies** that machine operators use to find the cause of a problem. Reed starts by "...walking back through..." the process to find the cause of the problem. Similarly, Corey, a Gant operator, told me, " We try to backstep you know, to see...the last station, what did they do in that station? Okay, so we go to that station and we watch it." Aaron, an experienced Emmer operator uses the "process of elimination." I found it quite interesting to hear the different ways machine operators rely on themselves to solve problems and the variety of strategies they use.

Relying on Others. One theme that became clear quite early on in my analysis was the role of others in seeking solutions to problems. Who was involved? Why were they sought after? What did they learn from others? At what point were others sought? These questions were all indirectly addressed through the interviews.

Despite the increase in technology and the move toward automation, manufacturing is still highly labor intensive. Out of all the individuals who support the manufacturing process, machine operators choose other operators and supervision to contact when a problem occurs. Machine operators viewed more experienced operators as critical to their success in resolving problems, though supervisors, if they are perceived as knowledgeable about machine operations are also sought.

Across all operators and organizations, the most sought after is the experienced machine operator. In fact, Carla stated that, "You've got to be real patient and don't be afraid to ask for help, because that's what the other experienced operators are here for." Another told me, "It's the operators that give me knowledge, not the office people (management)."

It is recognized that information sharing from operator to operator is critical for gaining knowledge in that, "(Learning) is a together process…so if I learn something from someone, then you remember it and you tell somebody else about it. It's kind of a continuation. It's like a drag bucket I guess." The 'drag bucket', a large bucket that scrapes dirt across the ground, is a metaphor he uses to describe the movement of information created when people share their knowledge. Reed, another operator, exemplified this effect when he says, " People before me passed on things to me and I have always told people that have gone on after me- if you have any questions and I can help…" Denny suggested, "When you learn a little trick, you pass it down to the next worker that is coming on the job- if you don't work together you'de go nuts. This guy, he liked me, so he showed me every trick."

The most prevalent kind of information shared through the 'drag bucket effect' is described by the term, 'tricks of the trade' and is mentioned throughout the individual interviews and the focus group session. One focus group participant defines 'tricks of the trade' as, "…an operator who does the job everyday, everyday, everyday. And by the time they've learned, they've been on the job for a while, they're more comfortable with the job and they can do it in their sleep. They pick up little shortcuts for the whole technique…little helpful hints." Though 'tricks of the trade' are heavily relied upon, operators also discussed the downside of relying too heavily upon those operators who know the 'tricks'. "Sometimes they don't air the tricks of the trade and you're not sure why…I think a lot of times it's just an unconscious thing because they do it automatic without even realizing that they are doing their job." Interestingly, this thought was independently confirmed by an experienced operator at Emmer Corp.

> I try training somebody and I can't tell them because half the time I don't know what I'm doing, but my hands you know-my hands just go ahead and do it. I mean there's—I've done it for so long, I can be thinking about something else and go right ahead and do something else. I mean I can be thinking about what am I going to do next? What's my next job going to be? And I can still be working on the first job and my hands are doing you know I might be burning parts or things like that, something simple. But I try to—I've been on two NG training teams, okay. And I've talked to some of the people, some of the older people that are here and ask them, do you ever pay attention to what you actually do? I said, you know you go step by step, by step? Do you ever pay attention to what you actually do and realize that you're doing things that you don't know that you're doing? Because I do, I mean it's just so automatic that I don't even have to think about it.

Operators are sought for several different reasons. One reason is to draw from others' direct experiences. Doug states, "And like I said, that's what you're drawing from is the other person's experience and maybe a different point of view looking at the problem-different point of view. Because everybody has a different thought process they go through, I think approaching a problem." Another operator mentioned, "Get a more skilled operator if you've tried everything first yourself. They may have an idea you haven't worked through yet." and, "Another operator and I got together, we looked the situation over, we brainstormed and figured out what to do." One clue as to why operators seek out other operators may have something to do with how they define each other. Reed points out:

> Time and time again, we are problem solvers. We really are…that machinist, no matter from first getting the job to the person who has 20 years experience

> than I do. We're all problem solvers in our own way and we love it or we wouldn't be here.

Experienced operators also offer their operational expertise and comfort to novices. "I don't feel comfortable enough messing with that. I will get somebody who is a lot senior to do that. I get somebody every night if I have a question."

> So I was having just a dickens of a time trying to get this off and I'm like scratching my head and I'm like man, oh man, am I just having like one of these days, like everyday? So I went and I got Todd (operator) and I said Todd, you know I just don't know what's going on. He said, well did you try reprobing it? And I said no, but I will.

Often times, experienced operators will seek out other experienced operators to think through a problem, "So another operator and I got together and we looked the situation all over and we made a picture in the machine so we could run these parts." and "...and so a lot of times it's the three of us. You know we have three heads is better than one at times." Other operators are also used for a reality check, "And they've always been pretty honest with me and tell me whether I'm way off in the deep end someplace or whether I've got—what I'm talking about is legitimate."

Supervisors are also relied upon by machine operators to resolve problems. Machine operators seek out supervisors who are both knowledgeable and accessible. The machine operators most likely to seek assistance from supervision were those at NICO, Inc. because they are perceived as both knowledgeable and approachable. "Supervisors over there are pretty smart when it comes to things like that. They're all easy to talk to. If you have any problems, go to them for help. They'll explain it. A lot of times they go with you and show you. They've been through all this already." and, "...if we do make a mistake you know you're not going to get into trouble for telling the boss. It's not like the old theory was oh, you get a hammer on your head. It's not that way anymore. We have a very open relationship. So they'll come in and say okay, you made a mistake." Machine operators at Emmer Corp., found some of their supervisors to be knowledgeable, but at times, inaccessible. "But when we got in that position it was time to get somebody who was a little more knowledgeable and my boss came out to help us..." An experienced operator at Emmer Corp. confided that his supervisor knew much more than he did, "And my boss and I discussed it and I never even thought about it, but he said why didn't you trim the bar sock off so you knew it would come completely out of the collate. So you know-and I never thought about that." However, supervisor accessibility is seen by some as an issue as in the case of one focus group member from Emmer who stated, "Sometimes I have to page my supervisor to find him." Supervisors at Emmer have expanded responsibilities which require them to cover multiple operational departments. The focus group members from Gant Company felt that their supervisors were neither knowledgeable nor accessible. As one focus group member stated, "They don't know- the supervisor wouldn't know. They would never know. They think they like to think they know. But they don't...You never learn tricks of the trade from your supervisor." Operators at Gant rely on their team coordinators (senior hourly employees) and other operators for gaining knowledge.

For some operators, supervisors are information conduits as in Taylor's case,

> ...then the foreman comes back to me and made me understand...so after they got back to me and explained to me the reason behind it when you can understand a little better, but when they keep you in the dark that's no good for anybody. Because then you think well what the hell, if they don't care, we'll market that stuff. But after they came back to me and explained to me the reason why, then I guess I could accept it a little better.

Though not prominent in the interviews, maintenance was identified by many operators as being quite helpful in resolving problems. In some cases, maintenance assistance was required because they were more knowledgeable about certain technical issues than the operators. In other cases, their assistance was contractually required due to the union/management collective bargaining agreement.

> So we had to get the maintenance people and they have a special counter that goes in head one and then they have got this funky apparatus thing or whatever, somehow they figure out what everything is… They had to fix it. And after they fixed it, it's fine.

Operators also mentioned the advantage of learning from other operators' mistakes. One example from each organization will serve to illustrate this. At Emmer Corp., Todd learned from another operator he was training, "I hadn't seen anyone do it- I told her, you're the first one. That's the benefit of having mistakes- if you don't make any you'll never learn. I seen what she had done and the mistake she had made." Doug told me, " I even learned from the fellow who got his fingers stuck." Hank says, "I watched him- and he went back through his production and you could just see where the problem started." At NICO, Inc., due to the nature of the operation, one mistake can cause an avalanche of product to spill on the ground. Denny is telling me about his experience with these types of problems, "It's at the end of the shovel experience, because when Casey goofs up we're all at the end of the shovel." At Gant Company, Laura is reminded of a story with respect to the job she was running, "… if you come in, that's one of the things you should look at to make sure that they haven't stopped it, because otherwise you'll just go right off the end. And it's like that's not fun…"

Adjustments as a Strategy of Response

Sometimes operators' personal strategies for solving problems requires adjustments to their operation. Adjustments are made because the problem continues to occur as in Blake's case, "But after so many times of it not being resolved, like I said before, it becomes common practice so we all know what to do to get around the errors in the program." Another operator stated, "So we just deal with it and fix it as best we can." Corey confided in me that, "We used to put popsicle sticks- the side molding on a car and the chrome piece did not fit flush and so we end up using popsicle sticks as shims. They wouldn't listen to our problem so we adjusted."

Other times adjustments are made on an as needed basis. " It will call for a specific tool, but sometimes they don't always work so I have to adjust." Two operators from Emmer said that, "At first it's like, do not touch the programs. Keep your fingers off. They don't like you to touch them. But I have enough confidence in myself now- I'll go in there and I'll change things." And, "The way I would get around it is I learned- I would go into the program and I would change it myself."

Within these personal strategies machine operators use to resolve problems, there is a sense of reflection. Certainly, by participating in the interview, machine operators are reflecting upon a problem incident that they have experienced. The personal strategies reveal that machine operators are also reflecting about reflecting. This is often revealed in the self-talk they describe when reflecting upon the problem resolution experience. For example, one operator is explaining to me the process they used to resolve a problem. She says, "We try to backstep you know, to see- okay I didn't- okay, the last station, what did they do in that station? Okay, so we go to that station and we watch it." Here she is retracing the last few steps of the product to find where the problem started. Another example, Doug reflects upon the learning he experienced within a problem resolution activity, "So I think there was more learning that took place back then, you know when you had some sort of ability to be a little creative with it." (03p1)

<u>Emotional and Interpersonal Dynamics</u>

The final key component of the problem solving process as expressed through an analysis of the interview transcripts are the emotional and interpersonal dynamics during problem solving incidents. For example, Blake describes his reaction to problem situations,

> I'm a person who likes to think that I'm never wrong. That what I think is right is going to be right for everybody. But normally, when something—when I think something is a real problem, I give my view of it and then a lot of times when somebody doesn't agree with me, I'll be quite honest with you, I get mad… I've got a temper that will flash up …over the years I've had a few good friends that I've worked here that I will go and bounce what's going through my head off of them. And they've always been pretty honest with me and tell me whether I'm way off in the deep end someplace or whether I've got—what I'm talking about is legitimate.

Interpersonally, information seems to be liberally shared <u>between</u> operators. In a couple of instances, however, operators told of the consequences to those who either don't share information or announce that they don't need help. Carla says,

> I go to a machinist that has the experience, because I'm not one of these people who think they know it all. Because if you make that remark out there, well I know—I don't need any help, I know how to do that. They're not going to help you. The word gets around that you made that remark and you think you're a know it all. There was this one guy and he's on 3rd, his nickname

> ended up being crash because he crashed every night. He wouldn't listen. So they just said okay, there you go.

Information is also shared between operators and management. Though operators will continually complain about the lack of information from management, the reverse is also true as in Hank's case, when he and his fellow operators withhold information from one of the organization's engineers, saying,

> Four of us got together and put our heads together and looked this thing all over and used the expertise that we had and made the parts that he had been working three months on… But anyway we were working 3rd shift then and things were kind of down and somebody said let's make some (elbow parts). Are you crazy? We can do it. So each one of us took our little specialty and we figured out what had to be done, so we made 50 of them, put them on a pin rack, cleaned them and put them over. We never did tell him how we did it. Because he's got the big diploma and all this stuff, he's a certified engineer and he's been doing this thing for probably three months trying to make these parts and in one night the four of us get together and we made 50 of them for him.

This story conveys several important messages besides the rewards of drawing from others' experiences. Hank is quite proud of the fact that he and his co-workers were able to produce a part that the certified engineer could not. This resistance to share information is often the result of machine operators 'punishing others' for not respecting their knowledge. For example, Casey's experience with a CNC programmer would often result in his withdraw from the problem solving process altogether. "I would try to explain to him (the programmer) and he would throw it in my face as though I didn't know how to run the machines. So I backed off." Blake, a machine operator working in a different organization from Casey, mentions the same type of reaction when working with a PLC programmer. "They like to use the term 'operator error'. They like to say that we did something wrong. Then sometimes I guess I get frustrated and not really wanting to talk to them anymore about the situation." Blake continues, "It seems like they never ask our opinion- if you are going to put in something new, you should ask the people who are working with it."

The importance of the sharing of information between operators and across the labor/management divide is a theme which runs throughout the machine operator interviews. Poor interpersonal relationships caused undesirable emotional and operational consequences.

Feedback and Recognition

Six machine operators, representing all three organizations, most novices, mentioned that feedback from other operators facilitated the learning process.

Some of the feedback came in the form of advice. Patty says, "Glen (an experienced operator) told me, the machine will do what you tell it to do. You are the one that controls what goes on. Glen said I was harder on myself than what he had ever seen anybody be." Patty explained to me in the interview that following Glen's comments she would calm herself down by saying to herself, "You know, quit being so tough on yourself and just relax and go with it." She continues, "I quit beating myself up mentally."

Blake, an operator for four years, receives advise from his co-workers when his solutions to problems are not accepted by the majority. He says that, "Over the years I've had a few good friends that I've worked here with that I will go and bounce what's going through my head off on them…they've all been honest with me." Daryll, a novice machine operator from NICO, Inc., was having a problem with new job instructions in the binning area. He commented that,

> After they got back to me and explained to me the reason behind it when you can understand a little better- after they come back to me and explained the reason why, then I could accept it better.

Two other operators, Patty and Hank, also receive feedback from their fellow operators. Patty says, "I haven't had anybody come back to me yet saying they have a problem with the part." Hank says, "When something went wrong, the other one over there is snickering." Most interesting in all of the comments related to feedback is the source. The source of feedback is other machine operators.

Recognition as a positive form of feedback was mentioned by a few machine operators. Hank says, "If you did something really great on a machine, you know we'de let the other one know about it. You know, toot our own horn a little bit." Jan felt particularly good when other operators on her team confirmed her confusion about a job she was asked to perform.

> So I said how am I going to keep these straight? Well, I asked him finally to write something out—put something on the floor because if you run that job maybe only one time or maybe you don't run it like once every couple months or so, it's a difficult thing… And I talked to one of the other operators and they said that's exactly what they had to do too, because yeah—I was glad they said that. I wish I had talked to them first…so I felt better after they had told me that. That's exactly what they have to do.

Recognition also comes in the form of management support.

> Well what I'm saying is they would give us control and they'd give us support. This thing is so broad you know because we were allowed to look at machining magazines and things like that and they give us at that time, they give us ownership over that machine. When that machine came in, the guy said Hank, that's your machine. We bought it but that's your machine. And there were two of us at that time. There were two of us on that machine. That was our machine. It wasn't anybody else's. That was ours. We were given ownership, care, we were to take care of it. Just like the machine belonged to us. And that made a big difference. It made a big, big difference because we didn't want to do anything to hurt the machine. We took care of it. And all of those people will tell you they were spoiled. They were spoiled because they were basically their own boss and the salary people were there to support us.

> And if somebody got out of line, we took care of it. Not the salary people, we took care of it.

Though feedback and recognition was not explicitly cited by the majority of machine operators, it seemed quite important within the critical incident contexts of these operators for resolving their problem at hand.

Prior to moving on to the final major section of this chapter, it is important to review the main findings. Up to this point in the chapter, I have described the high frequency of and positive attitude toward learning as experienced by the machine operator participants in this study. I have also highlighted five components of the problem solving process: the event that triggers the process, responding to the trigger event, adjustments as a strategy of response, emotional and interpersonal dynamics as related to the problem solving process and the role of feedback and recognition. Next, I collapse the third and fourth findings of this study, highlighting the three definable phases of becoming a machine operator and the types of knowledge gained through the problem solving process. The phases and knowledge gained intersect to define the process and learning necessary to become a machine operator.

Learning to Become a Machine Operator

The third major finding from the analysis of the individual and focus group transcripts was that problem solving and learning are part of an ongoing process of becoming a machine operator. In addition, as with the trigger event, emotion plays a part in this process. A detailed discussion of the phases of expertise, what operators come to know as a result of solving problems and the connected emotion will follow.

Three distinct phases of expertise arose out of focusing upon the various problem solving and learning experiences of individual operators. One clue which led me to thinking about the various levels of expertise was the way in which operators talked about other operators within their organization. Below are the three definable phases: the newcomer, the novice, and the expert machine operator.

The Phases

The Newcomer. On-the-job training was, by far, the type of training regarded by machine operators as critical for success on the job as well as for subsequent problem solving. On-the-job training means two things to machine operators. It is the training that initially takes place when someone is new to the job and it is also the location of learning to gain experience as a machine operator. This first meaning has its limitations for subsequent problem resolution as is clearly pointed out by Mel when he says, “Even when I’m training someone, there’s no- that doesn’t mean there’s going to be chokes all the time, so they would have to learn the flow on their own.” In other words, problems which new operators may run into will not always take place during the initial training period of several days or weeks. It makes sense, then, that for the purposes of this study, the second meaning of ‘on-the-job training’ becomes paramount. Taylor is explicit about this when he mentions, “It’s just going through it everyday, everyday, everyday. Being shown, if not, asking questions.” Daryll reminds us, “There’s no substitute for on-the-job training. If something happens, you take a look at the situation and try to resolve it.”

Newcomers face many obstacles as pointed out by more experienced operators. For example, Reed clearly explains that lack of problem solving ability is not due to lack of comprehension, but the fact that newer operators haven't yet experienced a variety of problems on the job, "And I see that a lot out here...one of the basic things that our newer operators- I'm not going to say they can't comprehend it or don't comprehend it, it's not something that they see often enough that can be a problem." Casey, one of the most experienced operators suggested that newcomers don't yet understand the tooling and are therefore not aware of a problem,

> I would show them (the programmers) the rougher, how it was all beat up and try to explain to them it wasn't cutting enough material...people that have one year- I mean six months experience, maybe three months, they're not going to say nothing. They think it's normal to sit there and take a brand new insert, out it in, run five pieces, put another one in, run five pieces...when you should at least get 15-20 pieces per point.

Two of my study participants have been performing their current job for less than one year and would be regarded as newcomers to machine operation.

The Novice. Novice machine operators have been on the job long enough to work on their own, yet still require constant assistance with problems they encounter. Daryll, a machine operator with seven years experience, relayed a situation that he found himself in just recently. He was faced with a drill that was "not cutting right". He tried several things to resolve the problem like readjusting the speed of the drill, looking at the sharpness of the drill and the type of drill he was using. He explained,

> ...you know what to do. Whereas an inexperienced operator, they wouldn't know how. They would try this and they would try that and try this maybe six or seven times down the road until they finally get it. And once they finally get it, then they should know the next time they see the situation what to do.

In this case, the novice operator knows that there is a problem and attempts to correct it, but does not have the knowledge about causes of the problems- a case of 'shooting in the dark'. This is similar to when Blake recalls "just hitting the buttons" in a panic to stop the problem from continuing.

Assigning machine operators to the "novice phase" is much more difficult than assigning operators to either the newcomer or experienced phase. When does one stop being a newcomer and when does one become experienced? The demarcation lines for the novice operator are not at all fixed and my analysis of the transcripts did not add any clarity to this concern. However, one clue to assigning the novice operator could be gleamed from some of the operators testimony as they reflected upon their trials and tribulations as a newcomer. For example, Judy, a machine operator with five years experience, walked me through a situation she had when first on the job,

> I didn't know how to read a mel (micrometer). I'd go to my dad and ask him. I was just so bound and determined to get it, no matter how hard it was....one day a light bulb went off as far as reading the mel and the blueprints...and I'm like, this isn't hard. And then it kind of came together.

The Experienced. Reed, an operator for five years, talks about experienced operators as being able to identify a problem and the causes of problems, when he says, "...an experienced operator is going to know exactly what that is right away and what the problem is." In this particular problem incident, Reed does not define himself as an experienced operator. Experienced operators are discussed throughout the transcripts by others who do not view themselves as such. Experienced operators are "better problem solvers" and they "always know what to do".

Experienced operators and those who are training others on a specific operation, shared the learning they experience from the newcomers and novices. Todd, for example, ran into a problem while training another operator. Apparently, as he was attending to something else nearby, the newer operator attempted to realign the tooling, causing the machine to halt. In trying to help her resolve the problem, Todd joked with her, saying, "I never seen this before...and I told her, you're the first one. You're going to make this a difficult training process, aren't you?" He then goes on to explain to me, "Well, actually it's made it a learning process for me...". An experience which Casey, a 20 year operator, encountered changed his perspective on experience level, "I've learned to open my mind up more in the last seven years- where I don't care if this guy has three months down here or 45 years experience...if someone can help me and make my life easier, I'm willing to listen." Operators also seem aware that, despite years of experience, different people have different strengths and weaknesses such as in the case of a novice and experienced operator, "I need help over here so he (the experienced operator) always is the one to help me fix it.. And a lot of times I have to help him...because I remember the things about the different numbers and so I help him and he helps me on things that I don't know.

For machine operators in this study, the strategies for resolving a problem seem to depend on the experience level of the operator. Most interesting, when cross referencing experience level with help from others, those operators with 0-1 years experience (newcomers), 2-3 years experience (novice operators), 4-7 years experience (competent) and those with more than 8 years experience (expert operators) followed different patterns of seeking assistance when faced with a problem. Newcomers relied heavily upon their operator trainer when faced with a problem. Novice operators first sought help from a supervisor. If the supervisor was not readily available, the novice operator would contact another more experienced operator to assist them, followed by any co-worker that was present during the incident. The last resort when faced with a problem was to try and figure it out for themselves. For example, Taylor, an operator with 1.5 years experience, explains this tendency.

> Supervisors over there are pretty smart when it comes to things like that…they're all easy to talk to…If you have any problems, go to them for help. They'll explain it. A lot of times they go with you and show you. They've been through all this already. If not I ask another Bolter (experienced operator) or you figure it out for yourself.

The expert operators, on the other hand, handle problem solving in the reverse order, beginning with themselves. Casey, a 30 year machinist, remembered a problem he was having with a tool. When asked how he resolved that problem, he said, "I went out and had an illegal smoke- I just sat there and I thought about it and I said, OK- you've got chatter. It's got to be the tool- how can I dull that thing down? I never tried that before but it worked. Operators that are neither novice or expert, as can be expected, seem to toggle between getting help from another more experienced operator or handling the problem themselves. Judy, with 6 years experience as a machine operator explains.

> …the length of the part was changing and the end of the part was getting chewed up. I was starting to throw away more parts than keeping. But I was getting very frustrated. The man that I work with has been here forever, because they are years and I thought—first I thought should I ask him? What would you advise that I do? And then I would think no, I'm going to try and solve this myself. I said I've learned enough, I can solve this. So then you go do your tooling. You watch it and you watch the machine after each tool to try and figure out which tool needs to be replaced and is causing the problem. It seemed to be the drill and I looked, the shavings were balling up at the end of the part, which was probably the end that gets all nasty.

As mentioned in an earlier section, supervisors are also sought to assist in resolving a problem, especially by less experienced operators who perceive them to be knowledgeable. In one case, I asked one of the NICO, Inc. operators if he perceived a difference between the knowledge gained from a supervisor versus another operator. He said, "Maybe the way in which they do it. Maybe there's a little bit of difference, but it all comes out the same." Looking back, I should have inquired more about these differences. Clearly, for this operator, he viewed the supervisor and operator as having the ability to assist him, though he recognized that they assisted in different ways, possibly offering different kinds of knowledge.

Clearly, problem solving and learning are part of an ongoing process of becoming a machine operator. This has been illustrated using the words of newcomers to machine operation, novice machine operators and experienced operators.

What Machine Operators Come to Know

Through the problem solving process, machine operators come to know things about themselves, their work task, their machine, their organization, and learning in general. The types of knowledge they gain happens as a result of the process of attempting to resolve a problem and is directly related to the trigger event. I will first illustrate this relationship using several critical incidents from Reed's story as a machinist at Emmer Corp. I then outline the several kinds of knowledge associated with the learning processes across all machine operators and organizations. That is, what they come to know as a result of resolving problems.

Connection to the Trigger Event. Reed has been a machinist for 5 years. I chose Reed's critical incidents because of the wide variety of types of consequences illuminated by the incidents. In critical incident #15, Reed explains that, "...the parts started falling out of his shoot with the drill wandering out the side of the part- when it happened, we both knew what it was. And once it starts to wander, you see that. He later states,

> At some point when you are a machinist you know those little realizations come through and you say wow that's cool. You know (that) if you don't catch this now it can be a real problem and okay, next time I'm going to make sure that that's not going to happen again. We want to go back and see well just what caused this? What changed in this set-up?

Not only is Reed planning for future behavior based upon the trigger event, but he is also attempting to learn about the causes of the problem.

In critical incident #16, Reed remembers a recent time when, as a union representative, he is trying to solve a member's problem, "…you think you've got it nailed down and you think you've got something that everybody can agree on and then all of a sudden it raises its ugly head again and it's like, damn…" The trigger event is the reoccurrence of the problem and the consequence to that reoccurrence was that Reed learned something about himself. "And I guess what I went through with the union being a representative, it's not my forte? I am more hands-on as far as machining problems, I just love those. You know that's my nature."

In critical incident #17, Reed describes a proud moment he encountered but only after he was presented with a 'nightmare job'. "And I walked down there and he said guess what you get to do and I said what's that. And he said, you get to set up this little nightmare of a job and he handed me the print." The consequence related to this trigger event was that Reed learned more about his capabilities as a machinist.

> I really—I just finessed that thing to no end and I'll never forget when I got done, he ran it and it was a long running job… I don't remember if it was that day or the next day the job was still running…Bob says, what can I say, it's running like a dream. And I said, yes, I nailed it! So there's a lot of pride.

In critical incident #18, Reed and his co-workers are attending a focus group meeting lead by a corporate facilitator/trainer. The facilitator is asking the machinists for production improvement ideas. Reed explains that one of the ideas concerned the working relationship between the CNC programmers and the CNC machine operators. Apparently, from their point of view, the programmers would send parts back to the operators without addressing their concerns. "The instructor said well then why don't you refuse to do it." The instructor's comment was unacceptable to the machinists. Reed explains, "…we are problem solvers. You bring it back down here and if it ain't fixed we know that it needs to run, so we'll solve it again. We'll make it run." The consequence to Reed of this trigger event was an increased understanding of the Emmer Corporation.

> I learned that the instructor had no clue. I mean he was just as befuddled as us that we couldn't get it resolved and I thought wow, it's no wonder this place doesn't go under because you know now they're even saying they don't have a clue either. It's like nobody is doing the job. Nobody is steering the ship. And I've learned that…because his bottom line was, well then just don't set that job up, but that's not an option.

In critical incident #19, Reed remembers the day he went from operating the automatic screw machines to the CNC machines, "Going from the automatics to the MC's I think there was a little bit of apprehension, whether I can pick up on the programming part of it." The consequence related to the trigger event of moving from one machine to another seemed quite meaningful to him.

> I know that if you ever get out of the process of learning, it's hard to learn. You know you get out of school and then you go and you do your thing and then all of a sudden your asked to learn something new again, it's hard to get back into that rhythm of learning. And fortunately around here, we've learned a lot. I mean we're learning all the time. They are always throwing something new at us. I doubt if the majority of people here appreciate that, but I do. It's kept me on top of the game....And I since then have talked to other people and my eyes were open to that's not a new or uncommon thing. That's life.

The 70 critical incidents produced a description of 81 learning events.Further analysis of these events uncovered types of knowledge gained from their experiences solving a problem. Following is a description of each, followed by examples from the one-on-one interviews with machine operators. The number in the parenthesis appearing after the subheading is the number of times that type of knowledge appeared in the transcripts.

Automatic Knowledge (4). Though this type of knowledge is defined as knowledge that is not known, the very idea that it exists is clearly articulated by operators within my study. For example, one experienced operator commented,

> I try training somebody and I can't tell them because half the time I don't know what I'm doing, but my hands you know-my hands just go ahead and do it. I mean there's—I've done it for so long, I can be thinking about something else and go right ahead and do something else. I mean I can be thinking about what am I going to do next? What's my next job going to be? And I can still be working on the first job and my hands are doing you know I might be burning parts or things like that, something simple. But I try to—I've been on two NG training teams, okay. And I've talked to some of the people, some of the older people that are here and ask them, do you ever pay attention to what you actually do? I said, you know you go step by step, by step? Do you ever pay attention to what you actually do and realize that you're doing things that you don't know that you're doing? Because I do, I mean it's just so automatic that I don't even have to think about it.

Another example of this is when a focus group participant said, "...when you're on a job long enough and you get comfortable with it, you can almost do it in your sleep..."

Knowledge about the Organization (8). Machine operators also learn about their organization as a whole as well as the organizational structure they work within. For example, Todd told me,

> I guess basically I've learned that-I would think that we would work together a lot more than we have to try to make things run more smoothly... I don't think we actually work together as a team to try and make this a better company... I think we could produce a lot better product and...people would be happier because if we all get along it makes things a lot smoother. But that is a big surprise to me how big of a difference there is between the two (labor and management).

Hank was involved in a process improvement group, with the purpose of reducing set-up time. He said, "And what we learned was that you can operate as a large team...it was the intercommunication between the start-up process to the end process that made this thing go." For some operators, what they learned from having to adjust to a problem as a result of non-action by the representatives of the organization (management) only served to reinforce their earlier opinions. Denny commented, "I don't think I learned anything new...it just seemed to add to the list to me that around here we seem to have a very hard time ever listening to the people actually doing the work."

Operational knowledge (28). Understanding more about the operational process and the product itself was one of the major learning events through solving operational problems. "What I learned through the whole thing was how to reset it all because I've never had to reset the arms and all that and I've never had them stop in the middle of them. So just resetting it..." Others learned how to get around the 'system', " Well I've certainly learned how to get around a lot of those problems that we had with them, different ways of doing things-of our process that you have to take a different way than what is normal protocol to be able to keep the flourmill running." Certainly operators, as in Taylor's case, shared that they had learned more about causes of certain problems they encountered, "You've got to go over there and unchoke it, find whatever caused it and make sure that the proper setting goes back..."

Knowledge about Learning (15). Machine operators talked a lot about learning. Operators learned about the role of problems in learning, the importance of learning to the production process and how an operator learns best.

> I know that if you ever get out of the process of learning, it's hard to learn. You know you get out of school and then you go and you do your thing and then all of a sudden you're asked to learn something new again, it's hard to get back into that rhythm of learning. And fortunately around here, we've learned a lot. I mean we're learning all the time. They are always throwing something new at us. I doubt if the majority of people here appreciate that, but I do. It's kept me on top of the game.

Interestingly, one of the experienced machine operators shared with me his story about a teaching problem he encountered and what he learned from the experience,

> From that I learned, yeah, you can't do it with just books and tapes. You know they had some books and some videotapes that I was showing the guys when they first come in...I thought at the time they needed to see the movement of the machines that I wasn't prepared to show them out there (on the actual machine). Well I could see that wasn't working, eventually the feeling that I got was what in the hell are we looking at? And so then I had to backtrack and say I need to set one of these things up, so they could see it for real.

Other operators suggested that, for them, the knowledge they obtained from a problem incident was helpful for future incidents.

> And you know I learn something different every week, something happens that I haven't seen before and then I try to put it back in my mind so that the next time it happens I remember what to do or what caused that problem.

Casey told me that he solved a problem by remembering a similar situation he had run into and used that knowledge toward resolving the current problem situation.

> I thought about it and I said, okay, you've got chatter. Can't get rid of it. It's got to be the tool is too sharp. How can I dull that thing down? I knew if I took a hone and tried to hone it by hand, I'm going to screw up the insert...Because you've got too much on one side or not enough. Here is another thing that come across my mind. When we used to use taps on the old Index machines, a lot of times you use a tap…

<u>Knowledge about Oneself (25)</u>. As with operational knowledge, self-knowledge was a major learning event. There does seem to exist a continuum of what they learned about themselves, from the informational to the transformational. For example, Patty learned more about what she wanted to learn, "I want to learn more. I want to learn more machines." One operator formed a belief about teaming, "I'm a firm believer in teaming because well it's just like the problems I had on my machine, it was something that was kind of beyond me, but somebody saw it. And I'm open, you know, for change." Taylor made a decision for looking at current and future problems, "I should start looking for the problem sooner and looking for the solution sooner, not take for granted that it will go away." Other operators learned about themselves and others based upon an experience he had moving from one machine to another more complex machine,

> I learned to open my mind up where I don't care if this guy has three months experience down here or 45 years of experience down here, if somebody can help me and make my life easier, I'm willing to listen. I don't care if I'm training somebody and he comes up and says hey, what about—I'll listen.

Deeper learning about the self is reflected in Judy's story about her struggle she encountered becoming a machine operator,

> Well I learned that if you put your mind to something you can do anything, you can do it. And I've learned that because you know there is no way I would have never done this type of job. This was just put in front of my face and I took the opportunity. And my brother still to this day can't believe that I'm doing it…
> that's probably the biggest thing that I learned. That a person can do anything they want basically, I mean there are some things that you can't, but something like this, if you put your mind to it and really try, try so hard you know go home and 24 hours, 24/7, so I learned it until I got it. And I want to be the best that I can be. And there are people out there a lot better than I am, but I want to be the best that I can be. And you always strive—she learns. I learn something every day if I can, you know learn something new out there that will help me be even better. And not be so dependent on someone else for their knowledge, but have the knowledge to share with others that are come along and maybe I can turn to them.

Machine operators not only learned about themselves, some even expressed that they learned more about their co-workers or supervisors, as in, "I learned that my foreman knew more than I did."

Emotion

As with the trigger event, emotion seems to be associated with the significant learning event. Comments made during the focus group session not only confirmed that consequences occur as a result of trigger events, but that emotion is connected. For example, upon understanding that operators at Emmer Corporation solve problems themselves, or among their co-workers, Corey, a Gant employee, felt envious.

When asked to describe the most important outcome from learning that they've gained through problem solving, the following comment was made by focus group participants, "It makes me feel great.";

> The satisfaction of correcting a problem that you might have been having for some time and being able to feel that you were a part of the company instead of only the lower level. They are using your idea or suggestions and they are actually going to listen to you and say okay, maybe you are right.

Corey explains that, "...if everything is running real good, everybody is patting themselves, management is patting themselves on the back." He continues by telling the focus group participants that if things are not running well, the mood effects management's willingness to work with employees regarding personal time off, making vacation arrangements and cooperation on the job itself. Judy responds by describing her physical condition before and after feeling comfortable with her job,

> "On my way to work before I had any experience, my stomach would be in my throat. Every single day on my way to work, I'd be a nervous wreck. I was what am I going to come across today? What problems? What's going to happen? Now I go to work and my stomach stays where it is supposed to be...I don't have that fear now.

One of the least experienced operators mentioned that, "I have more confidence. Before it was like oh, I don't know what I'm going to do, what's today going to bring? It would scare me to death. But now I don't and that's a good feeling. Being comfortable with my job, even though I still come across things. I can stay there now." Following this confession, one of the focus group members offered, "We all get that feeling, especially if you know you're going on a job where there are a lot of problems on that job. My stomach is nervous because I don't want to mess up. So we still get it to this day." Another spoke up and said, "It's (being able to solve problems) helped my self-confidence…" The most experienced operator in the focus group agreed.

> And it's a scary feeling to have to come in there and run a machine that you don't know how to run really that well and plus by me learning it, I can help other people out that need help. It's just a feeling that knowing that they can't throw something at you that you're going to be lost and not know how to fix. It's like getting into a brand new car, where's the lights at? Where is the blinker?

Cognizant that one focus group participant spoke for all the participants when he said, "We all get that feeling…", John Dirkx, co-facilitator of the focus group then asked, "How important is that to the rest of you, feeling self-confident? Responses from three different group members were, "It's important to me", "Very important", and "It's our signature. That's my name."

Summary

"It's our signature. That's my name." This last phrase is illustrative of the strong connection between the self and the ability to problem solve on the job. I began this chapter talking about the event that triggered the actions related to resolving a problem and ended the chapter with findings which describe the types of things machine operators learned as a result of the problem solving process. Whereas the majority of problems were operational in nature, over half of the learning events as a consequence of the problem solving incident were related to the Self. Learning and the Self seem to be closely related within the context of problem solving. The main findings of this study reflect this relationship. First, learning is perceived by machine operators to be intimately bound up with problem solving. Second, the problem solving process is triggered by an incident which leaves them frustrated, confused and uncomfortable. The process of regaining equilibrium or certainty is inherently social in nature and is guided by personal strategies to achieve balance. Third, problem solving and learning are part of an ongoing process of becoming a machine operator, with three definable phases. Fourth, the consequences of the learning process results in several kinds of knowledge.

CHAPTER SIX

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

"Production work is more than merely the performance of tasks by isolated individuals, and learning involves much more than gaining the ability to perform required tasks." (Darrah, 1996, p.47).

Introduction

The purpose of this study is to explore the nature of learning associated with the problem solving activity of machine operators in industry. In Chapter five, four findings revealed themselves upon completion of the individual and focus group interviews and the analysis of the interview data. First, learning is perceived by machine operators to be intimately bound up with problem solving. Second, the problem solving process is triggered by an event which leaves them frustrated, confused and uncomfortable. The process of regaining equilibrium or certainty is inherently social in nature and is guided by personal strategies to achieve balance. Third, problem solving and learning are part of an ongoing process of becoming a machine operator, with three definable phases. Fourth, the consequences of the learning process results in several kinds of knowledge. It is through the lens of both the constructivist and situated cognition approaches to learning that I interpret my findings. In brief, the findings suggest that learning is characterized by a dialogic relationship between the machine operator, the task and the machine. Furthermore, this dialogical process occurs within a community of practice. As Norman (1993) suggests, "One cannot look at just the situation, or just the environment, or just the person: to do so is to destroy the very phenomenon of interest" (p.4), in this case, the phenomenon of learning.

Chapter Overview

The chapter begins with a discussion about the learning which occurs in the dialogic relationship that exists between the machine operators who participated in this study, the context or task within which this study was situated and the machine as mediator between the machine operator and the task. I then suggest that this does not completely describe the entire learning process by offering a discussion on the nature of learning within a community of machine operators. The remaining sections include the theoretical and practical implications, and the recommendations for future research.

The Dialogic Relationship Between the Worker, the Task and the Machine

The relationship that exists between the machine operators, their task and their machine can best be described as dialogic. The Merriam-Webster dictionary defines dialogic as, "..of relating to, or characterized by dialogue." Dialogue is then defined as, "…3: the conversational element…4: a musical composition for two or more parts suggestive of a conversation…" (p.319). Likewise, a dialogic relationship between the worker, the task and the machine is "suggestive of a conversation" and the images that that produces- images of closeness, understanding, communication and intimacy. To an outsider, this dialogic relationship is implicit and conceptual in nature. In fact, the actual work of the machine operator is, for the most part, invisible to all others. Recall the following story from a previous chapter:

> ...we have people come down from upstairs and take a tour and one guy came down and he had a group of people and he was our personnel director. And he stopped at the automatics and he said now the bars go in those tubes back there and the parts come out here. And then he walked away. And it's like wow, that's what they see and it was a real revelation there that they have no clue what it takes for the bars to go in there and then come out here and look all nice and pretty. Have no clue.

Orr (1996), in his study of photocopier technicians, refers to the current trend which renders work invisible. This, he believes, reflects the fact that it has become an abstraction, a generalized input into a production function. To the machine operators in my study, however, their work is anything but an abstraction. In fact, the relationship between themselves, the task and the machine is explicit and personal. The learning that occurs within this dialogical relationship is informal, contextual, situated, and constructive. Furthermore, the learning develops through a form of knowledge which comes from a sense of holistic patterns and relationships. Each of these characteristics of learning will be discussed in more detail.

<u>Learning is Informal</u>

The learning associated with the problem solving activity of machine operators is informal. Marsick and Watkins (1992) describe informal learning as experience-based, situated within non-routine activities and involving both tacit and explicit knowledge. The majority of informal learning in the workplace occurs in the course of social and individual work activities through which employees interact, share ideas, resources, and perform their work (Leslie, 1998). Recall what Aaron, an experienced operator, said about how he learns, "I learn how to solve problems through past experience, other operators, and job training… Most of it is just from working." Aaron's comment is typical of other operators' comments.

Learning is Contextual

The learning associate with the problem solving activity of machine operators is contextual. That is, it occurs within the lived experiences of the machine operator's relationship with the task and the machine. The machine operator has a familiarity with the machine much like individuals have with those they are close to. This familiarity is sensory and is noticeable by the way in which operators talk about them. Carla commented, "And you know, you've got to learn that machine, its little quirks…they say the machines are the same, but they are each a little different." Patty **watches** her machine, "…the part would come down and then I watch what each tool did. I still do that…to make sure the tool is working the way it is supposed to." Doug **listens** to his machine, "It comes over and grabs this part. But it's very quiet about it. It doesn't go choooo, it doesn't make that air release or anything like this you know. It's sneaky about it." When Patty was new to being an operator she describes how unfamiliar she was with operating, "If your drill starts to get dull, they'll whine…when I first came down here, I wouldn't have given it a second thought of why…I've gotten a whole different ear now to listening to sounds." Hank, an experienced operator, says, "I always try to make sure that when I change it, to make sure I run my finger on the back of it to make sure I can't **feel** that screw...you really have to be conscious of your tooling." Others report the unique ways the machine **smells** while running certain parts and products. Sight, sound, touch, smellthese are the senses used to define and describe operators' relationship with their machine. I believe that Hank summed it up best when he told me that, "Everybody has what they call their own feel…" Craftspeople have long been valued for their ability to render skilled performances based on an intuitive feel for materials and techniques (Orr, 1997). This is the essence of their explicit, personal relationship operators have between the task they are performing, the machine they use to perform the task and themselves as the operator.

Learning is Situated

Learning is not only contextual, but it is also characterized by the situation within which the learning occurs- it is situated. As one operator said, "Well I guess it depends on the problem and where it occurs." The situation within which this dialogic relationship is taking place is the resolution of operational problems, the majority of problems encountered by the machine operators who participated in this study. The nature of many problems which make up the 70 critical incidents within this study include a mixture of problems that vary in degree of structure and routine. Jonassen (1997) suggests that many of the problems encountered in the workplace are ill-structured. Foshay and Kirkley (1998) describe everyday problems as falling on a continuum from well-structured, through moderately structured, to ill-structured. Sinnott (1989) describes problem solving within manufacturing as unsystematic and rather 'messy'.

Within my study, problems are described as unpredictable, complex and variable, many times calling for 'creative' solutions. Taylor reminds me, "Well, you're doing something new each day. I mean it's the same things, don't get me wrong..like taking samples from one tank, taking this and that…(but) there are so many things that could happen out there...there are so many things you run into." Bob commented on the complexity of his work, "Whenever you have 110 robots, you're going to have things pop up. That's just the way it is. It's incredibly complex…" Reed more specifically talks about the variability inherent with the equipment, the tooling, the material, the weather- all which can have an effect on the work. He says, "If you could measure everything right down to where it needs to be measured, it would be almost an exact science." He goes on to explain that operating a machine is not an exact science and that the variability is what causes problems to occur. Resolution of problems is not an exact science either. Recall in Chapter Five the strategies operators use to "fix" problems through adjusting their usual practice. Blake knows "what to do to get around the errors in the program". Casey knows that the programmers don't like it when operators touch their programs but when not getting a response from them to fix it, he "would go into the program and I'd change it myself." Corey remembers how they adjusted the side molding when management ignored their problem, "The chrome piece would not sit flush and so we ended up using popsicle sticks as shims."

<u>Learning is Constructive</u>

Within the context of problem solving, machine operators reflect upon their experience, they draw from prior knowledge to make sense of their current situation and they gain new knowledge as a result of resolving the problems they face. In other words, they construct the meaning of the context and the situation in which the problems arise. This involves thinking about and reflecting on the problems they encounter, and relying on and making use of prior experience and past knowledge.

The dialogic relationship is illuminated by the intensity with which machine operators think about their work while resolving a problem. Reed makes this clear in his explanation of how he worked to resolve a problem, "I have to go back and find out…there are certain things that cause that." He continues to provide a litany of causes and consequences in a situation where "tools are burning up".

When machine operators run into a problem with either their product or their machine, it is often accompanied by a pause to check or think about what has happened. Doug commented, "So at times it's very important to stop the machine because you want to check the dimension of the part, you have to say, okay, where's that other program at? What's it going to do when I start it back up?" And if someone else was helping to fix the problem, Doug said, "I would have to stop him and say wait a minute, wait a minute, what did you do and why did you do it? Casey remembers,

> We tried everything. To be honest with you I went out and had a smoke illegally and—but I went out and I just sat there and I thought about it and I said, okay, you've got chatter. Can't get rid of it. It's got to be the tool is too sharp. How can I dull that thing down?

Sometimes machine operators cannot stop to think about what has happened when faced with a problem as in Jill's case, "You get no planning time because there is no time to do the rest of it as you get around the corner, because there's a load right around the corner." In other cases, the problem happens so quickly that the reaction time is brief. Reed mentioned,

> But there are times when something like that occurs say in the middle of a run, all of a sudden you start getting run out. Whoa, stop, what's going on here? Why is that? What's the variable? What happened? And you know you start walking it back through…"

These are but a few examples of how the dialogic relationship is made visible. When attempting to resolve problems, machine operators think intensely and intently about their work and their machine.

Boud and Walker (1996) would suggest that this "thinking through" is required for learning to occur and is referred to throughout the adult learning literature as reflection. Reflection, according to Dewey (1916) is the "discernment of the relation between what we try to do and what happens in consequence." (p.169). For example, experienced operators told of newcomer operators trying a variety of ways to solve a problem to no avail. They used the method of trial and error. Trial and error is described as "...simply doing something and when it fails, we do something else, and keep on trying till we hit on something that works..." (p. 169). The significance of this method for learning from the experience is the degree to which one reflects upon or connects the event with the consequence. Operators in my study were clearly reflective when thinking about causes of problems and how to resolve a problem.

Within the personal strategies machine operators use to resolve problems, there is a sense of reflection. Merriam and Clark (1991) write that an "experience must do more than gain an individual's attention; for learning to occur, a person must reflect on that experience" (p. 202). Reflection is an activity in which people recapture their experience, think about it, mull it over and evaluate it. Boud, Keough and Walker (1985) suggest that reflection, for adult learners, arises out of the normal occurrences of everyday life, occurrences at home, work, and community. Events that precipitate reflection can be fraught with the experience of inner discomfort or as Dewey (in Boud, Keough and Walker, 1985, p.19) writes, "A state of doubt, hesitation, perplexity, mental difficulty in which (reflective) thinking originates, and…an act of searching, hunting, inquiry, to find material that will resolve the doubt, settle and dispose of the perplexity." The problems encountered by machine operators, as previously explored, certainly have caused them discomforts of this sort.

As individuals, we seek to make sense of the world and attempt to overcome confusion in what we experience. Equilibrium is a goal that requires the integration of new information with prior knowledge. The analogy is one of balance: individuals strive to maintain balance when faced with changes that attempt to throw them off balance. Therefore, in seeking equilibrium, there is an attempt to balance what the individual already knows with what they are experiencing (Piaget, 1966). While attempting to resolve problems, a situation which often throws an individual 'off balance', machine operators in this study used prior knowledge gained mostly from on-the-job experience to gain a sense of equilibrium.

<u>Holistic Patterns and Relationships through Prior Knowledge and Experience</u>

Learning develops through a form of knowledge which comes from a sense of holistic patterns and relationships. These holistic patterns and relationships are derived through prior knowledge and experience. The dialogic relationship between the worker, the task and the machine creates new knowledge through bridging prior knowledge and the current situation within a particular context such as problem solving. Machine operators "come to know" how to solve operational problems through this dialogic relationship. In this study, it became apparent that the more experienced the operator, the more they relied first upon themselves to resolve the problem. They 'come to know' by seeking themselves. This makes sense, in that the dialogic relationship between the worker, the task and the machine is strong. Newcomers, on the other hand, do not yet have that dialogic relationship with the work and the machine and therefore must search for the "dialogue" from someone who does. The knowledge inherent within the dialogic relationship is contextual. It resides in a practitioner's ability to find and interpret subtle visual, aural and tactile cues where newcomers see no information.

The differences which exist between newcomers, novices and experienced practitioners is captured within the 'expert-novice' literature. Woll (2002) suggests that, for the most part, the 'expert-novice' research has not dealt with 'everyday knowledge', nor with the kinds of ill-defined or ill-structured problems that are characteristic of everyday situations. He argues that, "...attempts to take everyday skills out of their everyday context or to study isolated components or simulations of them is to alter the skill entirely. " (p.286). Nevertheless, within the problem solving literature, researchers have found substantial differences between how novices solve problems and how experts solve problems. Foshay and Kirkley (1998) summarize these differences. First, experts have deeper understandings and representations of a domain or context. Second, experts synthesize their rich declarative knowledge to generate a mental model of the problem solving space for solving a particular class of problems. Third, experts have an attitude and confidence that problems can be solved through persistent analysis. Woll (2002) further adds to this list by providing a comprehensive summary of novice-expert differences. First, experts show better memory, both short term and long term, for content in their domain of expertise. Second, experts are faster at solving problems and performing their skills, in part because expert's skill is more automatic. Third, experts spend more time during the initial stages of the problem solution in analyzing the problem on a qualitative level. Fourth, experts represent a problem at a deeper level, whereas novices represent the same problem more superficially. Lastly, experts are better at monitoring their progress in solving problems.

Within the situated learning literature, Lave and Wenger (1991) describe in detail the process of becoming an 'expert' within five studies of apprenticeship. One of many conclusions they draw from these studies is that access to practice is a critical resource for learning. Billett (2001) uses the data from these studies to inform his development of Guided Learning, a form of instruction encompassing direct interactions with experts and collaborative problem solving to help develop the robust knowledge required for vocational expertise. In summary, substantial differences do exist between how novices solve problems and how experts solve problems.

Due to the different levels of experience among the machine operators in this study, problem solving strategies may vary. Problem solving is a multiple step process where the problem solver must find relationships between past experiences and the problem at hand (Mayer, 1983). Though strategic differences may occur, all machine operators in this study used prior knowledge gained from past experience to resolve problems that they face every day. Some of the prior knowledge could be explained verbally, while other prior knowledge could not. For example, Patty, while telling about a problem she was having with her tooling, draws upon prior knowledge about tooling, "You can have one tool go out and if you're not paying attention, it will wipe out four or five others. It is just amazing. There are certain metals that are harder to run, you know…" Blake, on the other hand, recalls, "I just get a feeling from maybe some past experience here that it might not be exactly the same thing we're dealing with but maybe that it is close." He can't explain that feeling, only that it exists.

Prior knowledge that can be explained verbally, as in Patty's case, is referred to in the literature as explicit or declarative (Billett, 2001). On the other hand, prior knowledge that cannot be explained verbally, as in Blake's case, is referred to in the literature as tacit or procedural (Raelin, 2000; Billett, 2001). Explicit knowledge is recognized and labeled as knowledge and can be tested. Tacit knowledge refers to "…knowledge that is not easily articulated…and not typically reportable since it is deeply rooted in action and involvement in a specific context." (Raelin, 2000, p.53). Though tacit knowledge may not be able to be expressed while performing a task, it may be made explicit upon reflecting on the experience after the fact (Wenger, 1998). Schon (1983) describes this activity as reflection-on-experience.

Machine operators construct new knowledge as a result of resolving the problems they face. They discovered their own tacit knowledge; they learned about their organization; they gained technical expertise they hadn't had before; they learned about the role of problems in learning; and they learned new things about themselves. For example, while teaching a machining class at the nearby community college, Reed, a machine operator told me that he learned a valuable lesson about teaching machining. He said, " I learned you can't do it with just books and tapes." Blake, a machine operator at NICO, Inc. mentioned, "I've learned how to get around a lot of problems- different ways of doing things."

It has also been shown that though prior knowledge and experience is necessary for learning to occur, it can engender incomplete, naïve, and inaccurate theories that interfere with rather than support learning. (Land and Hannafin, 2000). Hank, for example, admits to not always being as thorough as he could be when identifying causes to problems because he is so familiar with the operation.

Nevertheless, the learning that does occur within this dialogical relationship is informal, contextual, situated, and constructive. Furthermore, the learning develops through a form of knowledge which comes from a sense of holistic patterns and relationships, based on prior knowledge and past experience. However, this does not tell the whole story about the nature of learning. The next section of this chapter will discuss learning as emerging through a community of practice.

Machine Operators Practice in Community

The processes and characteristics of the learning which occurs in the dialogic relationship previously discussed is embedded in and inseparable from the broader community of machine operators. The addition of other operators, with their own dialogic relationships, adds a new dimension to the activity of problem resolution. Lana makes this point when she says, "When things go wrong, you've just got more people who are more knowledgeable...now the whole team is taking responsibility for all of the operations, not just one guy or one woman taking responsibility for their one job. I mean *people feel more connected through their work.*" Here Lana is suggesting that, in her experience, people are feeling more connected through their work as communication between and amongst other operators begins to occur. This implies that "learning is a process that takes place in a participation framework, not in an individual mind." (Lave and Wenger, 1991, p.15). This means, among other things, that learning is mediated by the differences of perspective among co-participants (Lave and Wenger, 1991). Orr's work on the knowledge required by photocopier repairers in practice, for instance, disproves any notion either that repairers operate as isolated individuals, or that they do so on the basis of the knowledge supplied by the company's documentation (Matthews and Candy, 1999). To put it simply, learning is created by the *interaction* between the individual, the content and the context. Lave and Wenger (1991) have proposed, for example, a concept of communities of practice, wherein people learn as they participate and become involved with a community or culture of learning. Individuals interact with the community and learn to understand and participate in its history, assumptions, and cultural values and rules.

This notion of a community of practice is characterized by a sense of learning and meaning making that is inherently social. It involves varying levels of participation and a clear definition of the "other". This learning in community is emotionally dynamic and involves an emerging sense of identity defined through and in relation to the community. Further, it transcends particular roles, contexts and situations. The following discussion will touch upon each of these characteristics of learning in a community of practice.

Learning is Inherently Social

In Chapter Five, I presented findings suggesting that problems are not resolved alone. The vast majority of the seventy critical incidents in this study support the idea that problem solving is a social activity. It became quite clear to me that this social activity specifically includes those who are perceived as experienced operators or supervisors who are deemed to have knowledge and skill with respect to the problem at hand. In addition, machine operators work with other machine operators to think about or reflect on the problems they are facing. In Hank's case, "...another operator and I got together and we looked the situation all over and we made a picture in the machine so we could run these parts....the operator and I, we kind of brainstormed and figured out what we had to do..." Lana describes another situation that happened in her work area when faced with a problem, "They were having scratches along the midline of the hood. And they were wondering where is this coming from? They had their team meeting and they talked about it..." Reflection is an inherent activity that occurs during the problem solving process and can occur with oneself or with other machine operators.

Though individuals themselves are meaning makers, Billett (1998) suggests that we must extend meaning making as a social activity as the characteristics of the different and overlapping social practices in which they participate influence what meaning is constructed, what experiences they engage in, and what provisions of guidance and support is available. For example, returning to the story of the tour, it is very possible that the personnel manager is unaware of the complexity of running a CNC machine, hence, his explanation to the tourists that steel rods go in one end and finished parts comes out the other end. It is also very possible that the personnel manager designs and administers the training and development program for the facility. If the personnel manager perceives that the operation of a CNC machine is more simple than complex, he or she may design and administer a training program that aligns with this perception. In this case, the individual meaning making that occurs is influenced by other social practices. As machine operators turn to others who, like themselves, have dialogic relationships with their own task and machine, we begin to see the makings of a community of machine operators. It is this very community in which operators come to know their craft.

The Community is Defined by the "Other"

Machine operators' identities are strengthened over time as they become full members of the community of practice and as they interact with and between the dialogic relationships within which other operators find themselves. We can observe learning taking place as newcomers become novices who then become experienced operators. Workers themselves refer to the demarcations of knowledge and skills made visible when they discuss other operators as new and experienced. Smith and Berg (1997) provide a detailed account of how our 'self' is defined through 'other'. They write, "For any entity to be able to think about itself, it must be able to...make the distinction between what it is and what it is not." (p.53). Mead (1934) argues that the self is socially emergent, that we are the product of social interaction. In this sense, understanding and situating others inside and outside the community is really an attempt to understand and situate ourselves.

For example, those in the community of machine operators who profess to 'know it all' and refuse to participate as a learner, are threatened with disqualification from the community by either management or the community itself. Recall the case of "Crash", an operator who thought he knew everything about running his machine.

> If you make that remark out there, "...well I know—I don't need any help, I know how to do that.", they're not going to help you. The word gets around that you made that remark and you think you're a know it all. There was this one guy and he's on 3rd (shift), his nickname ended up being crash because he crashed every night. He wouldn't listen. So they just said okay, there you go.

Here the community of operator practitioners may allow this operator to fail and to possibly disqualify himself, by way of management, from the community altogether. Smith and Berg (1997) might analyze this behavior as the community protecting their strong identity as a community of learners.

Clearly the machine operators in this study communicate and relate to other 'communities' within their organization. One such 'community' is referred to as management. To machine operators, management includes all individuals who are not paid on an hourly rate. All of the machine operators in my study had things to say about management- some more than others, some positive, some negative. One reason why this is such a strong 'community' within all three organizations is the fact that they are all unionized. The union/management dichotomy is historically and politically entrenched within any unionized organization.

One way operators talked about management centered around the issue of control and ownership. At one point, Hank's employer decided to include the machine operators in testing new machinery. Hank explained, "They gave us control...when that machine came in the guy said, 'Hank, that's your machine'...we were given ownership. Just like the machine belonged to us. And that made a big difference...because we didn't want to do anything to hurt the machine." Judy talked about why she likes her job, "I like it because I can push myself as fast as I want. It's up to me how many parts I get." It is important to know that her job is non-incentive based. Others comment about control and ownership of the problem solving process itself. Corey, for example, spoke of management formalizing the problem solving process which only served to remove it from the time and place where it should be solved- with the operator experiencing the problem.

Operators and non-operators have a very different relationship with the machine and the work, as operators have a certain amount of personal identity invested in their machines. Yet, it is the non-operators (management) that "own" the machines. The operator's machines are in the hands of others who don't 'know' the machine. The issue of control and ownership present in the workplace can create immense tension between the communities that make up the workplace. Billett (1998) reminds us that social relations among the various communities of practice, such as in workplaces, are based on unequal relationships (Billett, 1998). The issues and tensions in the workplace shape what kind of person we can be in our workspaces, what kind of relationships we can establish and maintain, and with whom, at what cost, what kinds of communities we can build and what kinds of knowledge we can make.

Transcends Roles

It should be clear at this point that the learning associated with the problem solving activity of machine operators occurs in a dialogic relationship which is embedded in and inseparable from the broader community of machine operators.

Taken further, however, the identity of being a machine operator transcends particular roles, contexts and situations. Darrah (1996) observed in his ethnographic work with computer technicians that,

> "Work is conducted within a community of fellow practitioners, and becoming an effective worker means becoming part of that community. The community of practitioners has an internal organization built out of the division of labor on the production floor and the informal networks among workers, and it extends *beyond the boundaries of the production floor…*" (p.47, italics added)

His observation that a sense of community extended beyond the production floor was apparent during the focus group session with machine operators..

Immediately following the focus group session, Dr. John Dirkx and I discussed both the process and the content of the session itself. In brief, John observed that the majority of responses to our questions were given in the form of stories and, in addition, he noticed a comfort level among the participants who had just met for the first time. I, on the other hand, became aware quite early in the focus group session that responses to our questions were quickly directed from either John or I to the other machine operators. Typically, participants within a focus group session will attend to the facilitators of the focus group as they are the ones asking the questions, especially in the case where participants do not know each other. John and I concluded that this atypical behavior was due in part to the strong common bond that the work of machine operator holds for the participants. As in the professions, machine operators, too, form communities of practice in and out of the work environment. At the same time communities are evolving, so too are individuals evolving their sense of self.

Sense of Self Through the Community

Carl Rogers (in Merriam and Clark, 1991, p.196) worked extensively to connect the process of learning to the self. To Rogers, experiential learning, such as problem solving at work, is equivalent to personal growth and change. Likewise, Jarvis (1998) contends that, "Experiential Learning is the process through which we become ourselves." (p.47). Kegan (1982) argues that the concept of person is more verb than noun, and that we must understand "human being as an activity" (1982, p.8). Activity is one of rendering experience coherent or meaningful, and it is central to the psychological concept of the ego or the self. Meaning making is what humans do; and that activity is the way the self is given form.

Barab and Duffy (2000) suggest that individuals develop a sense of self in relation to a community of practice. They write, "When individuals become legitimate members of the community, they inherit a common heritage, which becomes intertwined with their identities as community members. *This is a central component in the development of the self.*" (p.37). Nowhere is this more apparent than in the knowledge gained by the machine operators in this study from their attempt to resolve operational problems. Of the 80 learning events as described toward the end of Chapter Five, 25 of them constituted 'Knowledge about Oneself'. For example, Reed learned about his capabilities, "I'll take your nightmare of a job and see what I can do with it…I just finessed that thing to no end…Bob says it's running like a dream. And I said, yes, I nailed it!" Hank commented, "I'm a firm believer in teaming because well it's just like the problem I had on my machine, it was something that was kind of beyond me, but somebody saw it. And I'm open you know, for change." Larry says of his situation with the truck overflow, " I was embarrassed. I was mad at myself. It's one of things you learn when you are operating. You figure sooner or later you're going to mess up..." Judy learns to trust her instincts, "I learned trusting in yourself and your judgment. I learned that from Matt because from now on I set it, every time I take a break, I come back and set it." Most of the significant learning events resulting from the resolution of a problem were directed toward the self and toward learning events other than operational enlightenment.

In addition, individuals described their emotional experiences which accompanied the trigger and learning events. Emotion can be a highly individual experience and plays a critical role in our sense of self and in the process of adult learning (Dirkx, 2001). Though we most often attribute emotional dynamics to individuals within a learning situation, emotion is also connected to the learning process within a community of practitioners. Learning within a community of practice is emotionally dynamic. Dewey (1916) contends that,

> the social environment...is truly educative in the effects in the degree in which an individual shares or participates in some conjoint activity. By doing his share in the associated activity, the individual...becomes familiar with its methods and subject matters, acquires needed skills, and is saturated with its **emotional spirit.** (p.26)

Participation is a complex process that involves our whole person, including our bodies, our minds, **emotions** and social relations (Wenger, 1998). Recall when Corey told us how he felt when he corrected a problem, "It makes me feel great...the satisfaction of correcting a problem...being able to feel you are a part of the company instead of only the lower level." As the sense of self evolves, a sense of identity within the community emerges.

Learning as participation is a process of "being active participants in the practices of social communities and constructing identities in relation to these communities." (Wenger, 1998, p.4). Recall the machine operator from Emmer Corporation who pulled me aside, saying, "I will not volunteer to be interviewed because I was offended by your calling me a machine operator." In his view, a machinist is a more highly skilled operator and he refused to be put into the machine operator classification. "Through his telling and retelling, individuals...contribute to the construction of their own identity in relationship to the community of practice and, reciprocally, to the construction and development of the community of which they are a part." (Barab and Duffy, 2000, p.37). For example, one machine operator told me a story about another operator's attempt at drilling a straight hole.

> Well like I said, once it started blowing out the side of a part, we went back—or I shouldn't say we went back-I watched him. And he went back through his production and you could just see where the problem started... and an experienced operator is going to know exactly what that is right away, what the problem is.... if you'd done something pretty great on a machine or what we thought was great, you know we'd let the other one know about it. You know toot our own horn a little bit...You are going to learn how I define myself for a long time because I always considered we had some of the best people that I ever met working on screw machines here at one time, and some of them are still here. So I always considered myself one of the best. It's an ego thing.

This particular machinist explicitly defines himself in relation to how others perceive him within the activity field of working through a problem. He talks about 'tooting his own horn' if he knew or thought he knew he performed well on a machine. The feedback he receives helps him to define himself- in this case, as one of the best machinists.

Fused with the identity of being a machine operator is the attached role of problem solver. Machine operators across all three organizations referred to themselves and other machine operators as problem solvers. There is an immense amount of pride in solving operational problems. One of the operators summed it up in one sentence, "We are problem solvers- that machinist no matter from first getting the job to 20 years- we're all problem solvers and we love it." Others shared this very thought. Even further, they define solving problems as their expertise. For example, Reed commented, "I wouldn't be able to work at a help desk I don't think, because the first idiotic question that I got I think they would take me down the road...but with machines, in terms of problem solving, that's your expertise."

An Apparent Contradiction?

I have, up to this point, talked about learning as being characterized by a dialogic relationship between the worker, the task and the machine **as well as** occurring within a community of practice. Though this may seem contradictory or over inclusive, interpretation of my data overwhelmingly supports the notion that learning is both individual **and** social. How machine operators experience their job, what they understand about what they do, what they know, and what they don't want to know are not simply individual choices nor are they just the result of assignment to the "machine operator" classification. The meanings that machine operators attribute to their experiences and hence, the construction of new knowledge, is shaped by belonging to a community, but with a unique identity.

The concept of individual identity serves as a pivot between the social and the individual (Wenger, 1998). Lave and Wenger (1991) argue that the process of learning occurs as newcomers move toward full participation in the practices of the community. They discuss newcomers to a community as legitimate peripheral participants, acknowledging that newcomers and novices master skill and knowledge by gradually increasing their participation in the socially organized practices of the community. Mastery is not simply a matter of task performance, nor is it based upon internalization of knowledge but rather upon becoming a full participant in a diverse community of co-practitioners. "A person's intentions to learn are engaged and the meaning of learning is configured through the process of becoming a full participant in a sociocultural practice." (p.29). For example, the very act of approaching a more experienced operator for assistance, with feedback from the experienced operator of a willingness to assist, is itself an engagement toward learning. The act of engagement performed over time is the very process that Lave and Wenger describe.

Learning is bound up in the identity of being a machine operator. This notion becomes quite clear throughout the transcripts. For example, Judy, a machine operator at Emmer Corporation, is determined to learn more about her machine. She says, "I learn something every day if I can, you know, learn something new out there that will help me be even better…to have the knowledge to share with others that are coming along." This statement also suggests that she believes others will join the "community of practice" and take her place as a novice operator- a continuous stream of differing identities within a community of practice. A quick analysis of this statement made by Judy leaves me with the sense that the individual and the social are so tightly woven that to dissect them would ruin a holistic view of the phenomenon of study. In this case, learning.

Summary of Discussion

Problem solving, by virtue of its action orientation, provides the opportunity for creating experiences that lead to informal learning (Walker and Marsick, 2001). Even within the classroom, problem solving scenarios are most often used by educators to create opportunities for student learning (Roth,1997) because it is believed that learning occurs through problem solving (Anderson, 1993). Robinson (1999) suggests that adult learning is problem-centered and that,

> Purposeful learning occurs when individuals experience a problem or recognize a gap between where they are and where they want to be, and then institute a self-inquiry in which the learner draws on whatever resources are available to acquire the learning deemed necessary to close the gap (p. 1).

The literature clearly links learning with problem solving, though the size of overlap between the two varies among scholars. In the everyday work world, however, it is believed that the overlap between learning and problem solving is quite large. Zuboff (1988) writes,

> Learning is no longer a separate activity that occurs either before one enters the workplace or in remote classroom settings. The behaviors that define learning and the activities that define being productive are one and the same. Learning is not something that requires time out from productive activity: learning is the heart of productive activity. (p.395)

One of the findings of this study suggested that machine operators viewed learning and problem solving as intimately bound together. Both the definitions from the literature as well as the findings of this study define learning as occurring within the context of problem solving. In other words, individuals enter situations and construct experiences. But the experience they construct is one that either they themselves or others create on their behalf. The situation itself, therefore, is only the context within which the experience occurs, not the experience itself (Jarvis, 1998). The problem solving process, then, really describes a learning process in the context of resolving a problem.

Barab and Duffy (2000) argue that the key proposal from both the constructivist and situative perspectives is that knowledge is situated through experience. The situated learning approach of Billett offers the best attempt to date at reconciling the cognitive and sociocultural perspectives (Tennant, 1999). For Billett (2001) learning is the process of constructing new knowledge and the means by which the new knowledge is constructed is through goal-directed problem solving. The interpretation of my findings support Billett's definition. Though we observe that problem solving begins and ends with the self (cognitive), it is between the beginning and the end that meaning is made within a community of practitioners (sociocultural), not as solitary process of knowledge reception. The previous sections illustrate this.

I began with the dialogic relationship between the individual worker, their task and their machine. I then progressed to the community level within which their experience and resulting knowledge were enriched. I ended the interpretation of findings section with a discussion about the development of self in relation to the community. The main conclusion of this study is that the nature of learning is embedded in the interrelationship between cognitive and social aspects of learning and knowing.

Implications for Theory

Working through the analysis of my findings, several implications for theory came to light. This section will highlight three implications which I believe will add new insight to current theories about learning and knowledge.

Reflection and Action

The practice of reflecting, or reflective practice, is most often associated with professional practice (Merriam and Cafarella, 1999) and holds three major assumptions. Briefly, the first assumption is that those involved in reflective practice are committed to both problem finding and problem solving. The second assumption is that individuals are making judgments about what actions will be taken in a particular situation. The third assumption holds that reflective practice results in some form of action. Clearly, the machine operators who participated in this study not only reflected upon their experience in order to communicate with me, but, more importantly, they reflected upon their reflection regarding the problems they were facing.

Many scholars have focused upon the reflective actions of professionals. Schon (1983), whose work in describing the reflection-in-action and the reflection-on-action of professionals in practice, has received notable recognition for furthering the study of reflection. Orr (1997), who studied the everyday problem solving of copier repair technicians, states that one drawback of the definition of technical work is that it "provides no clear criteria for distinguishing between traditional blue-collar workers who *simply operate complex machinery* and those whose function has been fundamentally transformed." (p.11, italics added). Likewise, Patel, Arocha and Kaufman (1999) in their study of implicit knowledge in the professions comment that, "Probably nowhere is the study of implicit knowledge more important than in the professions, where a large part of learning occurs in practice." (p.77). Though the study of the professions provides a place to investigate learning and knowledge, it is to our own demise if researchers continue to ignore an entire group of individuals who are learning and reflecting in practice every day.

Communities of Practice

Constructivism and situated cognition are two theories I have used to explain or interpret my findings. Taken together, these theories capture the essence of the development of identity through participation in a community. Social interactions are important to the development of identity, learning and thought. It is through others and everyday activity that we come to know ourselves. Too often, however, the social and the cognitive are dichotomized. Wenger (1998) writes,

> Traditional dichotomies are useful distinctions when they are used to highlight an aspect of a process that has not received enough attention. But when it comes to issues like meaning, knowing or learning, dichotomies cannot provide clean classificatory categories because they focus on surface features rather than on fundamental processes. Instead a more meaning framework would be to analyze the various way in which they are always both at once (p.68).

Therefore, Wenger (1998) has used 'identity' as the pivot between the social and the individual. He argues that, "Building an identity consists of negotiating the meanings of our experience of membership in social communities." (p.145). This research confirms this 'identity as pivot' by highlighting the various ways machine operators define themselves in relation to other machine operators in terms of levels of expertise. In addition to the levels of expertise, however, participants in my study have offered a glimpse into another identity shared by all machine operators- the identity of machine operator as problem solver. The idea of 'shared identity' is another way of describing identity as a pivot between the individual and social realms.

The Role of Emotionality in Learning

The intersection between learning and emotion in the literature is scant, even though it is recognized that emotion is central to learning and development (Dirkx, 2001; Chodorow, 1999; Wenger, 1998; Kegan, 1982). Further, the practice of teaching and learning reveals a "..tradition of marginalizing emotions and elevating rational, cognitive processes, and understand emotions as either impediments to or motivators of learning." (Dirkx, 2001, p.67). This study places emotion firmly within the realm of learning throughout the problem solving process of machine operators. The findings of this study clearly show emotion as an integral part of learning which spans from the initial trigger event of a learning incident through the creation of new knowledge. Participants were able to clearly identify and articulate their feelings and how these feelings interacted with their learning experience.

Learning as Non-Sequential

Researchers criticize in-use experiential learning models for: insufficient attention to the process of reflection (Boud, 1983); little account of different cultural experiences/conditions (Dewey, 1933); weak empirical support for the model (Jarvis, 1987; Tennant, 1997); and the realm of isolation in which the model is set (Beard and Wilson, 2002). Further, the most popular experiential learning models used as the foundation for most formal education progress sequentially through cycles or flowcharts.

However, Sinnott (1989) recognized in her study on problem solving processes of individuals of various ages, using the think-aloud method, that respondents' thoughts sometimes worked forward and sometimes worked backward,

> He worked out the essence of the problem, the goals, the criteria for selection of goals and solutions, the solutions, and ways around difficult emotional and cognitive points. Many of his statements dealt with emotions, his past cognitive or emotional history, or his present roles in life; all these factors became part of the decisions about problem parameters or strategies for proceeding in the task." (p.80)

Likewise, this study suggests that workers do not learn from experience in a sequential, cyclical way. This provides evidence that learning from experience seems more a process of negotiation in which thinking, reflecting, experiencing and action are different aspects of the same process. It is negotiation with oneself and in collaboration with others that may actually form the basis of learning.

Implications for Practice

Theories tend to "fall apart" the closer they get to practice. For example, the full application of constructivist and situational approaches to learning within practice may be translated into a total banishment of "teaching by telling", an imperative to make "cooperative learning" mandatory and a complete nullification of instruction that is not "problem-based" or not situated in a real-life context. In practice, however, theoretical stances are balanced by those who interpret both the theory itself and the world within which they work. For workers to learn the hazards of cleaning certain types of machinery, for example, they would not be put in an 'authentic' unsafe situation. Most likely, they would 'learn by being told'. Good design of learning environments should be informed by theory, not a slave to it (Wilson and Meyers, 2000) in that the needs of a situation rise above the dictates of rules, models or even standard values. Despite the difficulties and barriers which exist in our attempts to bridge theory and practice, it is critical that we continue to make the attempt. Attempting to understand the way people learn through participation at work is important for deciding how to best structure workplace learning experiences. The more this learning process is understood, the more focused our efforts to develop vocational expertise in the workplace can be (Billett, 2001).

Implications for Workplace Learning

This research holds several implications for practice. It holds implications for problem solving training within the workplace, the role of managers and supervisors in relation to the development of expertise, the role of the Human Resource professional as adult educator, and the role of adult educators in general.

Today's problem solving training designed for and administered to frontline employees continues to be strongly influenced by the industrial training model, a model developed from the scientific management approach (Taylor, 1911). The majority of manufacturing organizations continue to operate, in whole or in part, according to this approach. In addition, the language of the industrial training model has been adopted by practitioners of workplace learning programs- " a language of technical rationality for framing their work and 'scientific' strategies for planning learning experiences and assessing their effectiveness." (Dirkx, 1996, p.43). The curriculum used in problem solving skills training in industry uses the scientific method of formulating or describing the problem clearly, generating several response alternatives, selecting the best solution, and verifying the effectiveness of the selected solution (D'Zurilla and Goldfried, 1971; Klein, 2001). Though other methods may have more or less steps, they follow the same "rational" method of solving problems. With the scientific management foundation as its guide, the industrial training model, like any model or approach, sits upon a range of assumptions about the workers as learners, their prior knowledge relative to problem solving, and how they acquire expertise in this important area of working knowledge. With the increased need for workers to solve operational and organizational problems, it is critical that researchers question the underlying assumptions of the current training model through a deeper understanding of the realities of worker's knowledge, skill and ability; the realities of their work environment; and the strong theoretical base within the adult learning literature about adult learners, of which workers are a part. This study provides a detailed picture of these current realities.

Though the industrial training model continues to be the most recognized form of problem solving skills training for workers in manufacturing, there does appear to be some change in progress. Rothwell (1999), the leading author of the ASTD report on models for workplace learning, suggests that, because of the new environment of fierce competition and new technologies, human resource development practitioners are shifting their focus away from formal training events and toward various types of learning experience. Coupled with this is the current dissatisfaction voiced by workers themselves. Workers are increasingly dissatisfied with the formal education they receive at work and increasingly dissatisfied with how well employers use their knowledge, skills and abilities (NCR, 1999; Freeman, 1999). Further, frontline workers repeatedly state that formal training and other in-house training systems are less effective than the contributions provided through undertaking everyday work activities (Billett, 2001; NCR, 1999). Observing and listening; other workers; everyday activities; and direct instruction, are consistently supported as effective in developing work-related knowledge.

Training for effective problem solving in the workplace requires a recognition and integration of the experience and practical knowledge workers already possess with regard to problem solving skills and the socio-cultural contexts of their practice with the working knowledge required by their employers. Such a model of problem solving training resembles the integrated theme-based approach to teaching adults (Dirkx, 1997), which grounds the development of academic skills, life skills, and the processes of problem solving, learning-to-learn and critical thinking within the context of particular thematic issues of importance to the learner. This approach uses the *learners themselves as points of departure*. Similarly, the model also reflects the words of Joseph Hart (as cited in Adams, 1975), "If teaching was to have any real share in education, it must learn, somehow, to work inside the experiences of those being taught and not forever hang around on the periphery of experience, piously hoping that something might happen inside" (p. 45), as well as Myles Horton's belief that education "happens" when the educator "starts where the learners are." (p. 213).

This study also holds implications for the way in which managers and supervisors manage, as well as the ways in which organizations structure frontline or shop floor work. By capturing and utilizing a breadth and depth of knowledge and skills not previously recognized by the organization, managers may see increased gains in productivity, a main objective of manufacturing organizations. The challenge for managers is to figure out how to encourage informal learning without taking away its unique individual, social, spontaneous and idiosyncratic aspects (Rossett, 2001). One way is for managers and supervisors to foster an atmosphere in which informed trial is encouraged and error is accepted and used as a learning experience. Adults learn through experience, but to learn is to risk failure. One trend within organizations over the past decade is to recreate the role of manager and supervisor as learning coaches (Marsick and Watkins, 1999), a role of support and encouragement as opposed to the role of rule by a 'two-by-four'.

Frontline workers should be recognized and acknowledged for the complexities involved in producing a product and for the informal learning and knowledge required for successful machine operation through increased control over *how they learn* to perform their work. Moreover, this study holds implications for how work is actually performed. Already we see a shift as High Performance Work Systems replace the traditional work systems. Though I would argue that the motivation behind this shift is not at all related to an increased value in learning, it does serve to increase workers control over their learning and work in general. Managers and supervisors must see workers as purposeful beings who flourish under the requirements for work, and workplaces must be developed which not only meet the requirements for productive activity, but which develop opportunities for continuous learning. They must provide for autonomy, meaningful work, mutual respect and support for creating desirable futures. It would be wise for workplaces to be structured and managed in such a way that individuals and groups can act as research and development partners, and can generate knowledge as well as apply it.

One of the most currently compelling challenges for adult educators in workplaces will increasingly be to help people and organizations to co-ordinate and negotiate the working knowledge, working relationships and work practices of the workplace. Adult educators may use the results of the study to further inform their practice and educational delivery methods. The assumption of most adult education is that if the instructor communicates to learners what they know, then learners will know it like the instructor (Jonassen, 2000). Teaching a classroom of machine operators how to run and troubleshoot a machine through studying the machining manual is similar to the traditional instructional approach. However, what we learn from my study is that that is not how machine operators learn to operate and troubleshoot a machine. Instead of learning from the "outside-in", or the instructional approach, they learn from the "inside-outside-in", through the community of machine operator practitioners.

A minority of adult education researchers and practitioners have created alternative approaches to learning in the workplace which are "strengthening the driving forces" toward change. Some focus on creating principles for workplace learning, while others focus on creating curriculums and programs for the workplace. For example, Foshay (1998) suggests several principles which must be foundational for any problem solving learning to occur: problem solving must be taught in the context in which it will be used and learners should be encouraged to ask questions and make suggestions about problem solving strategies they use. Billett (2001), on the other hand, has focused on creating a workplace curriculum called Guided Learning. In this curriculum, co-workers learn from each other. Other examples included Resource-Based Learning (Jung and Leem, 1999); Cognitive Apprenticeship Models (Berryman, 1992); Action Learning (Rothwell,1999); Work-Based Learning (Raelin,2000); and Anchored Instruction (Merriam and Cafarella, 1999). These are only a few examples of "curriculum" which strive to link adult learning theory and the realities of worker capabilities and workplace learning into practice.

It is recognized that classical training methods can successfully be allied with work-based training methods (Raelin, 2000; Darmon, et al, 1998). The process of transferring new learning from adult training into practice is influenced by multiple factors. These include characteristics of the learner, the context of application, as well as the characteristics of the training program. For example, Daley (1998) found that novices and experts in her study of practicing nurses use different learning processes. Programs that address multiple influences and prepare learners to cope effectively with obstacles are more likely to produce results than programs that treat application as a simple process of transferring knowledge, skill and attitudes from the training to the targeted workplace. (Jones and Bowler, 1997). Pratt (cited in Merriam and Cafarella, 1999) provides a comprehensive framework for combining instructor-directed and learner-directed ways of designing learning activities. Merriam and Cafarella (1999) argue that this framework "...can be helpful for both instructors and planners in formal and nonformal work settings and for individuals and groups of learners who want to plan their own learning activities." (p.37).

Implications for Higher Education

Billett (2001) argues that learning experiences in the workplace are seen as inherently less valuable than those in educational institutions, as opposed to just being of a different kind,

> Workplace experiences are viewed by key advocates (the trades, professions and educators) principally as a means to apply and refine what has been learnt in educational institutions or as "fallback" settings when these institutions lack the expertise or infrastructure to provide appropriate learning experience. (p.3).

The workplace and its contextual situations and ill-structured problems can be used to inform both content and method of teaching and learning within higher education. At the heart of instruction are the cases that include the contextualized problems that learners must solve. So, the designer must develop cases that represent probable real-world problems in an authentic domain (Jonassen, 1997). Senge (1994) in his discussion of the development of learning organizations, referred to the creation of practice fields as a primary approach to training. Practice fields are separate from the real field, but they are contexts in which learners, as opposed to legitimate participants, can practice the kinds of activities they will encounter in the field.

For example, the engagement of workers in discussing their problem solving experiences and the learning inherent in the process can inform higher education's current conversation about Practice-Oriented-Education. Practice-oriented-education formally attempts to integrate work experience with classroom study. (Center for Work and Learning, 2004). Richard Freeland, Northern University President stated,

> The premise of practice-oriented-education is that each of the three traditional forms of learning—liberal arts education, professional education and practical experience—can contribute to the others. It is animated by the belief that

> learning should expand our understand, widen our experience, increase our skill, and elevate our spirits. (p.1)

It is important to present learners with interesting, relevant and engaging problems to solve. Problems should be ill-structured, so that some aspects of it are emergent. Unless some components of the problem can be defined by the students, they will have no ownership of it and will be less motivated to solve it. (Jonassen, 2000).

Recommendations for Future Research

As themes began to emerge from the interview transcripts and the findings started taking shape, I felt encouraged and comfortable, feeling as though closure was near. However, as I dove back into the sea of literature while writing my last chapter, I quickly lost that feeling of closure. In fact, it seemed as though I was as far away from my initial research question as I had been when I started thinking about my dissertation over two years ago. During the past couple of months, so many new understanding and questions have started to take shape. For example, the link (or lack thereof) between theory and practice and all of the questions that arise from that relationship; the term "knowledge" and what that means individually, institutionally and politically; the overlap between disciplines and the need to read beyond one's own discipline; the influence of social relations on our identities and how we shape and are shaped by those relations; the list is endless. This leaves me both frustrated and intrigued.

So to write about recommendations for future research is a difficult task as I am sure to leave several recommendations behind. With that in mind, I can offer a few recommendations which I believe are worthy of following. In fact, they are suggestions which I myself have added to my research agenda.

Generally speaking, since the apparent divide between worker and management no longer captures what people do at work, major issues for future research should consist of adapting practices which rely on this divide or other outmoded images of work (NCR, 1999). Changing the images of work and going beyond abstract arguments about learning, knowledge and skill requires detailed and rich description and data reported from direct experiences of workers. Workers on the "front line" have experienced an unprecedented change in the way they work. Though it is important to continue to conduct research on the managerial/professional level, we must also pay an equal amount of attention to those who are "closest" to work; the frontline worker.

Related to this recommendation is the influence of both the work structure and the role of supervision on workplace learning. In Chapter Four, I briefly discussed my observation that the work structure seemed to affect the strategies machine operators used for solving problems. In addition, the role of supervision within each organization seemed to have an affect on how machine operators solved problems as well as their willingness to explicitly communicate those problems. In turn, the work structure and the role of supervision may have a similar affect on the learning associated with the solving of problems. I only touch upon this concern briefly as my research question does not encompass work structure and supervision as primary paths to investigate. However, I would recommend that this path be further developed.

When I first began thinking about my research question and the methods I would use to "answer" the question, I was most intrigued by the think-aloud method. Though I did not use this method for my current study, I continue to believe that it would be worthwhile to study the problem solving process of machine operators *while they are in the process of solving a problem*, otherwise known as reflection-in-action (Schon, 1983). This method of research would most likely capture a richer sense of the nature of learning and the learning process. We may then paint a more detailed account of learning and the interaction between the individual and the community.

Machine operators learn through experience while working and solving problems on the job. Current training programs do not align with the reality of how workers learn their craft. Therefore, experiential teaching methods must be studied and evaluated. The current concept of experiential learning and teaching explores the cyclical pattern of all learning from experience through reflection, and conceptualization to action, and then again to further experience. However, it is unclear as to whether experiential learning is cyclical. As mentioned previously, this study questions whether experiential learning is a cyclical process. This study provides evidence that learning from experience seems more a process of negotiation in which thinking, reflecting, experiencing and action are different aspects of the same process. It is negotiation with oneself and in collaboration with others that may actually form the basis of learning. In addition, the training experiences need to go beyond developing the requirements for routine workplace activities. They also need to develop the attributes required to respond to the non-routine tasks likely to be encountered in the workplace.

Research in this area must also work to accommodate multiple levels of scale within a situated framework. As Wilson and Meyers (2000) suggest,

> We see no inherent incommensurability between the situated cognition framework and many neural and information processing concepts of individual cognition. This is an area where we would like to see further development and discussion; we are optimistic that a greater level of integration can take place between theories that are seen, at present, as competitors. (p.75).

From a cognitive point of view we use dichotomous language to define boundaries of meaning. Dichotomy produces images and it is through these images that we make meaning for ourselves and others. "Scholars characterize each others projects in terms of a variety of well known binary oppositions; materialistic versus idealism, applied versus academic; biological reductionist versus naive humanist; science versus art." (DiGiacoma, 1992, p.114) On the one hand, dichotomization of perspectives allows us to gain organized understanding. On the other hand, it shuts off any possibility of perspective integration. In fact, the worldview of dichotomy sees the "other", not just as different, but as enemy. In the resultant struggle, one part will eventually survive by subordinating, and appropriating the "other" (Mies, 1993). Therefore, it is difficult to see how *one* can *be* with the other. However, the complexity of learning requires that we de-dichotomize and allow for multiple perspectives to live in harmony. Wenger (1998) illustrates this well when he says,

> Our experiences and our world shape each other...that goes to the very essence of who we are. The world as we shape it, and our experiences as the world shapes it, are like a mountain and a river. They shape each other, but they have their own shape. They are reflections of each other, but they have their own existence, in their own realms. They fit around each other, but they

> remain distinct from each other. They cannot be transformed into each other, yet they transform each other. The river only carves and the mountain only guides, yet in their interaction, the carving becomes the guiding and the guiding becomes the carving. (p.71)

By accommodating multiple levels of scale within a situated framework, a more holistic picture will emerge which may shed light on the dynamics and process of learning at work.

Conclusion

I have explored the nature of learning associated with the problem solving activity of twenty machine operators across three manufacturing organizations. We must be cautious in drawing lessons from such a limited sample. Nevertheless, this study has firmly confirmed my own view that the workplace is a community within which adults learn. By ignoring this fundamental lesson, organizational decision makers will not realize the capabilities that individuals bring to the workplace, nor will they see the workplace as a context for learning. Furthermore, the nature of this learning is shaped by the dialogic relationship between the worker, the task and the machine, within a broader community of practice. These findings have served to enhance the understanding of the informal learning associated with the problem solving process of machine operators within the context of their everyday work. This conclusion implies that more attention must be given to the way in which frontline employees learn and create knowledge during their everyday activities on the job. To do this, we need rich descriptive data on what people do and how they do it, not only because such data will improve our theories and our decisions but because only with such information can we develop an appreciation of and respect for the contributions that people make each day to the society and economy in which we live.

APPENDICES

APPENDIX A

INFORMED CONSENT FORM FOR INDIVIDUAL INTERVIEWS

Informed Consent Letter
Individual Interviews
The Informal Learning of Machine Operators

The purpose of this study is to explore the informal learning associated with the problem solving process of machine operators within their work context. I am interested in understanding the types of job-related problems you encounter during your work, how you attempt to solve those problems and the learning associated with each step of the way.

Your signature on this form indicates that you have agreed to be interviewed for one hour. This form outlines your rights as an interview participant. **Your privacy will be protected to the maximum extent allowable by law.**

Participation includes the following:

- You will be voluntarily participating in a doctoral dissertation research project that will explore the informal learning of machine operators.
- You can withdraw participation from this interview at any time. You can also refuse to answer a question. If you withdraw your participation during the interview, the audiotape will be immediately destroyed.
- You can ask questions of the interviewer at any time during the interview process.
- Your identity will be confidential. Pseudonyms will be used in all written papers; both published and unpublished, in order to protect individual identification.
- You know that this interview will be audiotaped. All tapes will be destroyed or erased after the transcription is complete. The researcher will retain the transcript of the audiotape and will delete any reference which may identify you as an individual or an employer. If you would prefer not to be audiotaped, the interviewer will take extensive notes during the interview.
- You consent to the publication of parts of the transcript and accept that any information will be anonymous in order to prevent any identification.
- You will be invited to a focus group session at a later date for which you may or may not choose to participate. If you do choose to participate, you can

withdraw at any time during the session. Your name and address will be taken at this time for the purpose of sending you a personal invitation to attend the focus group session.

- If you have any questions about this study, please contact the investigator, Dr. John Dirkx, College of Education, 408 Erickson Hall, Michigan State University, E. Lansing, MI 48823, (517) 353-6393. You may also contact the researcher, Julie Brockman, 16050 Center Rd., E. Lansing, Michigan 48823, (517) 339-9529, brockma4@msu.edu. If you have any questions or concerns regarding your rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact, anonymously, if you wish, **Dr. Ashir Kumar, PhD, Chair, University Committee on Research Involving Human Subjects, by phone:(517) 355-2180, fax: (517)432-4503, e-mail: ucrihs@msu.edu, or regular mail: 202 Olds Hall, E. Lansing, MI 48824.**

You voluntarily agree to participate in this study.
____You agree to have the interview audiotaped.
____You agree to have the primary investigator observe the interview.

Signature of
Participant____Date_________

Signature of Interviewer____
Date_________

APPENDIX B

INFORMED CONSENT FORM FOR FOCUS GROUP SESSION

Informed Consent Letter
Focus Group Session
The Informal Learning of Machine Operators

The purpose of this study is to explore the informal learning associated with the problem solving process of machine operators within their work context. I am interested in understanding the barriers and enablers to learning in the workplace as well as confirmation or disconfirmation of my interpretation and analysis of informal learning in the workplace based upon my initial analysis of interviews (in the aggregate).

Your signature on this form indicates that you have agreed to participate in this two hour focus group session. This form outlines your rights as a focus group participant. **Your privacy will be protected to the maximum extent allowable by law.**

Participation includes the following:

- You will be voluntarily participating in a doctoral dissertation research project that will explore the informal learning of machine operators.
- You can withdraw participation from this session at any time, without penalty. You can also refuse to answer a question.
- You can ask questions of the interviewer at any time during the session.
- Your identity will be confidential. Pseudonyms will be used in all written papers; both published and unpublished, in order to protect individual identification.
- You know that this session will be audiotaped. All tapes will be destroyed or erased after the transcription is complete. The researcher will retain the transcript of the audiotape and will delete any reference which may identify you as an individual or the name of an employer. If you would prefer not to be audiotaped, the observer will take extensive notes during the interview.
- You will receive $100 upon arrival for participating in the focus group session.
- You consent to the publication of parts of the transcript and accept that any information will be anonymous in order to prevent any identification.

- If you have any questions about this study, please contact the investigator, Dr. John Dirkx, College of Education, 408 Erickson Hall, Michigan State University, E. Lansing, MI 48823, (517) 353-6393. You may also contact the researcher, Julie Brockman, 16050 Center Rd., E. Lansing, Michigan 48823, (517) 339-9529, brockma4@msu.edu. If you have any questions or concerns regarding your rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact, anonymously, if you wish, **Dr. Ashir Kumar, PhD, Chair, University Committee on Research Involving Human Subjects, by phone:(517) 355-2180, fax: (517)432-4503, e-mail: ucrihs@msu.edu, or regular mail: 202 Olds Hall, E. Lansing, MI 48824.**

You voluntarily agree to participate in this study.
____You agree to have the interview audiotaped.
____You agree to have the primary investigator observe the session.

Signature of
Participant______________________________________Date________

Signature of Interviewer______________________________________
Date________

APPENDIX C

INTRODUCTION PROTOCOL

1. My name is Julie Brockman. I am a graduate student at Michigan State University in the College of Education. I am interested in workplace education and adult learning. I am doing research on the way machine operators learn while solving problems at work. The reason I am studying this is to better understand what machine operators learn while they are solving problems since, today, there seems to be a trend in which machine operators and other frontline workers are taking on a lot more shop floor problems themselves. Often times we learn from new experiences such as when problems occur and that helps us to deal with future experiences. Studying how workers learn from their experiences- in this case, problem solving- will help managers and employees prepare for letting go of and taking on the responsibilities of increased problem resolution and also to recognize employees for what they already know and understand about shop floor problems." Do you have any questions about what I am doing or the purpose of our meeting?

2. As a researcher, I have a responsibility to keep whatever you tell me confidential. That means that your name will not appear on any transcript- I will code this meeting as a # only. I have an obligation to destroy all tape recordings after transcribing them. This is in no way related to your employer, though for purposes of research, I was required by MSU to get permission to talk with you. I spoke with _________ and they gave me the approval to be here. I was not hired by your employer and am receiving no pay for doing this research. I am a lone researcher interested in gaining some information from a number of machine operators across several manufacturing sites. This interview will last about one (1) hour. (discuss and complete the "Informed Consent" form, though I understand that there is a possibility that the participant will not consent). Do you have any questions or concerns?

3. Fill out Demographics sheet (see Appendix B)

4. I would like to ask you a few questions throughout the interview. I'll ask you to think about a couple of recent problems you encountered while performing your job and how you attempted to resolve those problems.

5. Do you have any questions before we begin?

APPENDIX D

DEMOGRAPHIC DATA SHEET

Demographic Data Sheet

Personal

Name____

Address______________________________________

Phone_______________________

E-mail_______________________

Age______

Race______

Job

What is your job?_____________________________________

How long have you been working that job?_________________

How long have you been a machine operator?_______________

Workplace

How long have been working for this company?__________

What product do they make?__________________________________

APPENDIX E

INDIVIDUAL INTERVIEW PROTOCOL

Effective Incident Report Form

- Would you please describe your job and what you do on a daily basis?
- Can you think of a couple of technical or non-technical problems you were involved in while you were working- ones which you believed you resolved effectively?
- What triggered the problem?
- What were the events which lead up to the problem?
- How did you attempt to resolve the problem?
- Why did you choose to resolve it the way you did?
- Who else was involved in the problem resolution?
- What, if anything, did you learn from others who were involved?
- What was the outcome of the resolution?
- What happened/changed as a result of the outcome (behaviors, tasks, practices, procedures)?
- What did you learn from the outcome?
- Taken as a whole, what did you learn from this problem solving experience?
- (Repeat questions for another specific problem)

Ineffective Incident Report Form

- Can you think of a couple of technical or non-technical problems you were involved in while you were working- ones which you believed you did not resolve well?
- What triggered the problem?
- What were the events which lead up to the problem?
- How did you attempt to resolve the problem?
- Why did you choose to resolve it the way you did?
- Who else was involved in the problem resolution?
- What, if anything, did you learn from others who were involved?
- What was the outcome of the resolution?
- What happened/changed as a result of the outcome (behaviors, tasks, practices, procedures)?
- What did you learn from the outcome?
- In what ways was the problem resolution ineffective? In what ways was it unsuccessful?
- Taken as a whole, what did you learn from this problem solving experience?
- (Repeat questions for another specific problem)
- From your perspective, are you handling more and/or different kinds of problems than you handled previously, say, in the past couple of years?
- Have you ever attended a problem solving training session offered by your employer or any other organization?

APPENDIX F

FOCUS GROUP INVITATION

Julie L. Brockman
16050 Center Rd.
E. Lansing, MI 48823

Name of Participant
Participant's Address
City, State, Zip Code

January 19, 2004

Dear (Name of Participant)

I would again like to thank you for participating in my research study last Fall. I have now completed all of my interviews with machinists/machine operators. Therefore, I am in the process of planning for the focus group sessions which I briefly mentioned to you during our interview.

Therefore, I invite you to attend a focus group session which will be conducted on **Saturday, February 14, 2004 at the (name of location) in Jackson, Michigan**. I chose this location because it is conveniently located (close to I-94) and central to the individuals I interviewed. I will be holding two focus group sessions to accommodate participants work schedules. The two sessions will be from **11am-1pm** and from **6pm-8pm**. You may attend either one of those sessions. Enclosed is a map and driving directions to the Comfort Inn. Refreshments will be served.

The purpose of the focus group is to bring all those I interviewed together in one place to talk more about learning and problem solving in your everyday work. Those who attend a focus group session **will each receive $100** as a gesture of my appreciation for attending as well as to defray any travel costs. Please note that you are under no obligation to attend.

Please let me know if you will or will not be attending a focus group session by tearing off the bottom portion of this letter, checking the appropriate box and returning it to me in the enclosed self-addresses, stamped envelope.

If you have any questions, please feel free to contact me at home in the evening at (517) 339-9529 or on my cell phone during the day at (517) 285-8670.

I hope to see you on Saturday, February 14th at the Comfort Inn.

Sincerely,
Julie L. Brockman
PhD Candidate
Michigan State University

- -

☐ I **will** attend the focus group session. Please circle below the time you plan to attend:

11am-1pm 6pm-8pm

☐ I **will not** be attending the focus group session.

Name____

APPENDIX G

FOCUS GROUP INTERVIEW PROTOCOL

- What types of problems do you encounter when performing your job?
- When do you know that a problem has occurred?
- What does it feel like when you have discovered there's a problem?
- When you think about a specific problem you have encountered, who is usually involved in that problem resolution? Are there specific people you seek out?
- How do you get the information you need to resolve a problem? What kind of information do you use?
- What do you learn, or what do you gain, or what do you understand from resolving problems that you have on your job?
- What kinds of things you do you continue to learn on your job?
- What does the word 'experience' mean to you?
- What would you consider to be the most important outcomes you get from solving problems on the job?
- Is there anything that we haven't asked you that you want to say or you want us to think about?

APPENDIX H

PARTICIPANT SUMMARIES

The twenty individuals who participated in this study are all machine operators as broadly defined in Chapter Three. Below are summary biographies of each individual machine operator in order of the number of years in their current position, beginning with the individual with the least number of years. In addition to the short biography, I have added a small piece of information from their transcript which stood out as a general theme throughout the individual interview:

- Patty is a 42 year old white female. She has been a machine operator for only 8 months total. When Patty switched recently to a bigger machine, she was overwhelmed, "When I opened that door, I was like good lord, these things are big. I felt like Alice in Wonderland...and then when I go back to them (the machines) I started out on...I feel like...Andrea the Giant against these machines because...the turrets are so much smaller. The machines are just unreal."

- Corey is a 44 year old Hispanic male. He has been in his current position for one year though he has operated machines for ten years total. Corey has worked as far back as he can remember. "Through my previous years of growing up...dealing with work is basically what I have been doing. So I just kind of enjoy working, hitting the metal and banging it and forming it and seeing how it all comes out. And how one little piece starts from the beginning and the next thing you know you've got something. And it's awesome. It's just wild."

- Taylor is a 42 year old white male. He has been a machine operator for only 1.5 years. Previous to that, he loaded things on pallets. In re-reading his transcript, one can't help but catch the feel of his enthusiasm for his new job. "This is a new experience for me. I like it a lot. It's neat. It gives you a little bit of responsibility, you know? Knowing that you've got the power to put that (product) wherever it's supposed to be going."

- Lana is a 33 year old African American female. Of the eight years as a machine operator, she has been in her current position for only two years. Lana was quite articulate in her explanations and seemed to think deeply about what and how she performed her work. "I find it best to learn in segments of the job, so they might show me one element, I get that. The second element, I get that. And the third element and now I've got the whole job down. So I guess what I'm saying is that a visual observation is what teaches you a job versus all those documents.

- Denny is a 47 year old white male. He has been a machine operator for two years, though he has worked in the facility for many more performing jobs that have taken him across many of the production departments from raw material to finished goods. Daryll was talked quite a bit about the importance of gaining a broad knowledge of the facility and how helpful that has been in solving problems. As a machine operator he works closely with supervision and appreciates the relationship he has with them, "…we're human so there is a mistake made here and there, but since we've changed over to this open door policy where there's no write-up because we made a mistake- things have been a thousand percent better."

- Terry is a 32 year old white male. He has been a machine operator for three years. Terry's position requires him to fill in for other operators during breaks, absences, and/or vacation. He also assists other operators with problems they encounter while operating machines. Terry is involved with the union as a shift committeeperson. Terry's work as a "liaison" between the union and management has led him to question his vision of what might be possible in forging a collaborative relationship.

- Blake is a 48 year old white male. He has been a machine operator for four years. Blake was articulate and detailed in his description of problem incidents he encountered, "(I knew how to fix it) from having trouble when I first got the job…I guess I learned from getting into trouble and trying several different ways of taking care of something that worked. And so now it sticks in my mind that I kind of had it in my head when I went over already what the problem was going to be and what to do about it." Having worked in the facility for several years prior to becoming a machine operator, Blake has experience with the "system". He spoke candidly about unresolved issues which have necessitated adjustments to his practice- adjustments which go against normal protocol for the purpose of keeping the mill running.

- Carla is a 51 year old white female. She has been a machine operator for five years. Carla was most verbal when the discussion turned to other machinists role in her problem solving efforts. One particular machinist is her "go to guy". Though Carla tries to solve problems by herself, she gets easily frustrated, "…you get so frustrated because you've run another part and it still isn't right…you move it this way and that way and you go back and forth and after awhile, you just say, I've got to get Charlie."

- Reed is a 43 year old white male. Though he has been a machine operator for 25 years, Reed has held his current operator position for only 5 years. Reed spoke a lot about his work as art. "Like the story about the sculpture and how does a sculpturer make a horse? Well, he just removes everything that is not a horse. And that's true. But where does all that stuff go? That's the challenge. And you know I couldn't make a horse out of a block of stone. But I could do it out of metal."

- Doug is a 56 year old white male. Though he has been a machine operator for 30 years, Doug has held his current operator position for only 6 years. Prior to becoming a machine operator, Doug had planned to be a teacher and had already completed two and a half years of college toward that end. His plans were interrupted and he found himself operating a machine for the rest of his career. Interestingly, Doug, throughout the interview, spoke a lot about learning, "What you're drawing from is the other person's experience and maybe a different point of view...because everybody has a different thought process they go through...approaching a problem."

- Judy is a 49 year old white female. She has been a machine operator for six years. A theme which ran throughout the interview was pride in accomplishment. When she first began her job as a machine operator she felt that she already had many strikes against her and she was bound and determined to be successful. She commented, "I want to prove to them that I'm smart- that's my own personal goal."

- Bob is a 45 year old white male. Bob has been operating machinery in his current position for 6 years, though he has over 20 years of operator experience. A theme that ran throughout my interview with Bob was the importance of communication. "I am in constant communication with the electricians, absolutely. Just like with everything else, communication is such an important aspect. And as you talk with folks, you learn more what you're doing..."

- Daryll is a 58 year old white male. Though he has been a machine operator for 35 years, Daryll has held his current operator position for only 7 years. He mentions that his transition to his current position was made easier by "all those years operating other machines."

- Jill is a 49 year old white female. Though she has been a machine operator for 20 years, Jill has 10 years experience in her current position. Jill was careful to explain the problem solving process at her organization which is more formal than at the other organizations. "They didn't want to do it...but some bought it and they did it and they actually like it. Now, not all of them, some of them I guess if they get the opportunity they won't do it. But for the most part, they say it's not all that bad."

- Larry is a 60 year old white male. Though he has been a machine operator for 36 years, Reed has held his current operator position for 13 years. At first, Larry was very reluctant to talk with me, however, as he began to talk about his job and the facility it was difficult to get a question in edge-wise. He enjoyed talking about his past experience and all of the mistakes he made over the years, "...but it's one of those things that you learn when you're operating. You figure sooner or later you're going to mess up, I don't care how good you are, you're going to mess up..."

- Mel is a 46 year old white male. He has been a machine operator for 17 years. Mel was hesitant to talk with me but had agreed to 'give me 30 minutes' out of respect for the HR manager who was arranging the interviews. However, he did agree to draw me a diagram of his work area and the product flow. From that, he could explain a couple of problems he encountered on the job. He became quite verbal 25 minutes into the interview and actually stayed longer than he had planned.

- Aaron is a 53 year old white male. Though he has been a machine operator for 34 years, Aaron has held his current operator position for 18 years. Aaron spoke a lot about his years as a machine operator and the benefit of having worked on machines in the past for moving to other machines. "Because an experienced machinist learns it a lot faster because you already understand the basics of the machine...the more you experience the better you are."

- Casey is a 49 year old white male. He has been a machine operator for 20 of the 22 years he has worked. Casey felt that at one time, machine operators had a lot more control over their workspace, machinery and tools than they do now. He was and still is bothered by the company's tool policy which disallows any personal tools in the shop. Casey commented several times that machining is a challenge and he enjoys his job, "It's like I said, I don't have to work for a living, you do."

- Hank is a 58 year old white male. Though he has been a machine operator for 37 years, Hank has held his current operator position for 23 years. Hank reflects quite a bit on his tacit knowledge which seems to get in the way of his ability to train someone new. He says, "I think sometimes it can go against you, but most of the stuff we do by rote are little things. You know they're not major things but they're important to what we do, see?"

- Laura is a 46 year old white female. She has been a machine operator for 26 years. Laura has experience working in several different jobs throughout the plant and has therefore experienced several different work structures. She is a proponent of working on teams that rotate, "We've got small teams now and it helps a lot better. And you can call and say, hey, I missed the rivet and they call, okay, I've got it! I've got it!"

REFERENCES

REFERENCES

Adams, F. (1975). Unearthing seeds of fire: The idea of Highlander. Winston-Salem, NC: John F. Blair.

AFL-CIO Working for America Institute. (1999). Worker-centered learning: A union guide to basic skills. Washington, D.C.: AFL-CIO Human Resource Development Institute.

Anderson, J.R. (1993). Problem solving and learning. American Psychologist, 48(1), 35-44.

Andrew, M. (1998). The dilemmas of experiential teaching: Toward and interpretive approach. The Journal of Continuing Education in Nursing, 29(2), 73-78.

Applebaum, E., Bailey, T., Berg, P., Kalleberg, A.L. (2000). Manufacturing advantage: Why high performance work systems pay off. Ithaca: Cornell University Press.

Argote, L., Guenfeld, D. and Naquin, C. (2001) Group learning in organizations. In M.E Turner (Ed.) Groups at work (pp. 369-411). Mahwah, NJ: Lawrence Erlbaum and Associates.

Argyris, C. and Schon, D. (1974). Theory in practice: Increasing professional effectiveness. San Francisco, CA: Jossey-Bass Publishers.

Argyris, C. (1982). Reasoning, learning and action. SanFrancisco, CA: Jossey-Bass.

Baldwin, T. and Ford, J. K. and Naquin, S. (2000). Managing transfer before learning begins: Enhancing the motivation to improve work through learning. In E. Holton, T. Baldwin and S. Naquin (Eds.), Advances in developing human resources (pp. 23-35). Baton Rouge, LA: The Academy for Human Resource Development.

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall.

Barab, S. and Duffy, T. (2000). From practice fields to communities of practice. In D.H. Jonassen and S.M. Land (Eds.), Theoretical foundations of learning environments (pp 25-49). Mahaw, NJ: Lawrence Erlbaum and Associates.

Barley, S.R. and Orr, J.E. (1997). Between craft and science. Ithaca, NY: Cornell University Press.

Bassi, L.J., Gallagher, A.L., Shroer. E. (1996). The ASTD training data book. Alexandria,VA: American Society for Training and Development.

Beard, C. and Wilson, J. (2002). The power of experiential learning. London, Kogan Page.

Beckett D. and Hager, P. (2002). Life, work, and learning: Practice in postmodernity, London: Routledge.

Berg, C.A. and Klazynski, P.A. (1996). Practical intelligence and problem solving: Searching for perspectives. In F. Blanchard-Fields and T.M. Hess (Eds.), Perspectives on cognitive change in adulthood and aging (pp.323-357). New York, NY: McGraw-Hill.

Berryman, S.E. (1992). Designing effective learning environments: Cognitive apprenticeship models. Retrieved March 26, 2003 from http://www.ilt.columbia.edu/publications/papers/berry1.html.

Billett, S. (1993). What's in a setting? Learning in the workplace. Austalian Journal of Adult and Community Education, 33(1), 4-14.

Billett, S. (2001). Learning in the workplace. Crows Nest, Australia: Allen and Unwin.

Billett, S. (1998). Ontogeny and participation in communities of practice: a socio-cognitive view of adult development. Studies in the Education of Adults, 30(1), 21-34.

Blanch, M. and Kelly, K. (1999). Interpretive methods. In M.Blanche and K.Durrheim (Eds.), Research in practice (pp. 123-146). Capetown, South Africa: University of Capetown Press.

Boud, D., Cohen, R. and Walker, D. (1985). Reflection: Turning experience into learning. London: Kogan Page.

Boud, D., Cohen, R. and Walker, D. (1996). Using experience for learning. Bristol, PA: Open University Press.

Boud, D. and Miller, N. (1996). Working with experience: Animating learning. New York, NY: Routledge.

Boud, D. and Garrick, J. (1999). Understanding learning at work. New York, NY: Routledge.

Brehmer, B., and Dorner, D. (1993). Experiments with computer simulated microworlds: Escaping both the narrow traits of the laboratory and the deep blue sea of the field study. Computers in Human Behavior, 9, 171-184.

Brightman, H.J. (1978). Differences in ill-structured problem solving along the organizational hierarchy. Decision Sciences, 9, 1-17.

Broad, M. (1997). Overview of transfer of training: From learning to performance. Performance Improvement Quarterly, 10 (2), 7-21.

Broad, M. (2000). Managing the organizational learning transfer system: A model and case study. Managing and changing learning transfer systems. In E. Holton, T. Baldwin and S. Naquin (Eds.), Advances in developing human resources (pp. 23-35). Baton Rouge, LA: The Academy for Human Resource Development.

Brookfield, S. (1981). The adult education learning iceberg. Adult Education (UK), 54(2), 110-118.

Brookfield, S. (1995). Becoming a critically reflective teacher. SanFrancisco, CA: Jossey-Bass Publishers.

Brown, A.L. (1978). Knowing when, where and how to remember: A problem of metacognition. In R. Glaser, Advances in Instructional Psychology. (pp.79-165). New Jersey: Lawrence Earlbaum.

Brown, J.S., Collins, A. and Duguid, P. (1989). Situated cognition and the culture of learning. Educational Researcher, 18, 32-42.

Bruner, J. (1990). Acts of meaning. Cambridge, Mass.: Harvard University Press.

Cannon-Bowers. (2000). The transfer of team training: Propositions and preliminary guidance. Managing and changing learning transfer systems. In E. Holton, T. Baldwin and S. Naquin (Eds.), Advances in developing human resources (pp. 23-35). Baton Rouge, LA: The Academy for Human Resource Development.

Carnevale, A.P. and Fry, R.A. (2001). The economic and demographic roots of education and training. Paper commissioned by the Center for Workforce Success of The Manufacturing Institute, National Association of Manufacturers, Nov. 19, 22 pages.

Casey, C. (1999). The changing contexts of work. In D. Boud and J. Garrick (Eds.), Understanding learning at work. New York, NY: Routledge.

Center for the Study of Practice-Oriented Education. (2003). Current projects and research. Retrieved April 23, 2003 from http://www.poe.neu.edu.

Center for Work and Learning. (2004). Practice-oriented-education. Retrieved on 3/29/04 from http://www.poe.neu.edu/

Chell, E. (1998). Critical incident technique. In G. Symon and C. Cassell (Eds.), Qualitative methods and analysis in organizational research. Thousand Oaks, CA: Sage Publications.

Chodorow, N. (1999). The power of feelings. New Haven, Conn.: Yale University Press.

Clagett, C.A. (1997). Workforce skills needed by today's employers. Market Analysis MA98-5. Largo, MD: Prince George's Community College, Office of Institutional Research and Analysis. (ERIC Document Reproduction Service No. ED413949)

Clark, A. (1998). Born of incidents but thematic in nature: Knowledge construction in practicum settings. Canadian Journal of Education, 23(1), 47-62.

Colley, H., Hodkinson, P., and Malcolm, J. (1999). Non-formal learning: Mapping the conceptual terrain. Retrieved on April 23, 2003, from www.infed.org.

Coyle, H. and Ellinger, A. (2001). Learning beliefs and strategies of female entrepreneurs: The importance of relational context in informal and incidental learning. Symposium conducted at the 27th AHRD Conference in Tulsa, OK.

Creswell, J.W. (1994). Research design: Qualitative and quantitative approaches. Thousand Oaks, CA: Sage.

Daley, B. (1998). Novice and expert learning: Impact on training. In V. Kosky (Ed.), Individual differences in learning. Conference proceedings of the Academy of Human Resource Development. (March 4-8, 1998, Oakbrook, Illinois).

Daley, B. (1999). Novice to expert: An exploration of how professionals learn. Adult Education Quarterly, 49(4), 133-147.

Darrah, C.N. (1996). Learning and work: An exploration in industrial ethnography. New York, NY: Garland Publishing, Inc.

Darmon, I., Hajivassiliou, K., Sommerlad, E., Stern, E. and Turbin, J. (1998). Continuing vocational training: Key issues. In F. Scoffield (Ed.), Learning at Work (pp. 23-36). Bristol, UK: The Policy Press.

Day, N. (1998). Informal learning gets results. Workforce, 77, 30-36.

Dewey, J. (1916). Democracy and education: An introduction into the philosophy of education. New York, NY: McMillan.

DiGiacomo, S.M. (1992). Metaphor as illness: Post modern dilemmas in the representation of body, mind, and disorder. Medical Anthropology, 14, 109-137.

Dirkx, J.M. (1996). Human resource development as adult education: Fostering the educative workplace. In R.W. Rowden (Ed.), Workplace learning: Debating five critical questions of theory and practice (pp. 41-47). San Fransisco, CA: Jossey-Bass. (New Directions for Adult and Continuing Education, No. 72)

Dirkx, J.M. (2001). The power of feelings: Emotion, imagination, and the construction of meaning in adult learning. In S. Merriam (Ed.), The new update on adult learning theory (pp. 63-72). San Fransisco, CA: Jossey-Bass. (New Directions for Adult and Continuing Education, No.89)

Driskell, J.E., Johnston, J. and Salas, E. (2001). Does stress training generalize to novel settings? Human Factors, 43(1), 99-110.

D'Zurilla, T.J. and Goldfried, M.R. (1971). Problem solving and behavior modification. Journal of Abnormal Psychology, 78, 107-126.

Educational Development Center. (1998). The teaching firm: Where productive work and learning converge. Newton, MA: The Center for Workforce Development.

Eraut, M., Alderton, J., Cole, G., and Senker, P. (1998). Learning from other people at work. In F. Coffield (Ed.), Learning at work. Bristol, UK: The Policy Press.

Eraut, M. (2000). Non-formal learning, implicit learning and tacit knowledge in professional work. In F. Coffield (Ed.), The necessity of informal learning. (pp. 12-31). Bristol, UK: The Policy Press.

Erickson, F. (1985). Qualitative methods in research on teaching. In. M. Wittrock (Ed.), Handbook on research on teaching (3rd ed) (pp. 119-161). New York, NY: Basic.

Fenwick, T. (2001). Tides of change: New themes and questions in workplace learning. In T. Fenwick (Ed.), Sociological perspectives on learning through work (pp.3-18). San Fransisco, CA: Jossey-Bass. (New Directions for Adult and Continuing Education, No.92)

Fincher, C. (1985). Learning theory and research. In J.C. Smart (Ed.), Higher education handbook of theory and research, 1, 57-80: Agathon Press.

Foley, G. (1999). Learning in social action: A contribution to understanding informal education. London: Zed Books.

Foley, G. (1998). What about the workers? Informal learning in workplace change. In J. McIntyre and M. Barrett (Eds.), VET research: Influencing policy and practice. Proceedings of the National Conference of the Australian VocEd and Training Research Association (1st, Sydney, Australia).

Foshay, R. and Kirkley, J. (1998). Principles for teaching problem solving (Technical Paper No. 4). Edina, MN: TRO Learning.

Ford, J.K. (1997). Transfer of training: An updated review and analysis. Performance Improvement Quarterly, 10(2), 7-21.

Foxx, R.M. and Faw, G.D. (2000). The pursuit of actual problem solving behavior: An opportunity for behavior analysis. Behavior and Social Issues, 10, 71-81.

Freeland, R. (1999). Practice-oriented education: A new model of undergraduate learning. Retrieved on 3/29/04 from http://www.numag.neu.edu/9905/freeland.html.

Freeman, R.B. and Rogers, J. (1999). What workers want. Ithaca, NY: Cornell University Press.

Gagne, G. (1980). The conditions of learning. New York, NY: Holt, Rhinehart and Winston.

Garrick, J. (1998). Informal learning in the workplace. New York, NY: Routledge.

Gowen, S.G. (1992). The politics of workplace literacy: A case study. NY, NY: Teachers College Press.

Hager, (1998). Recognition of informal learning. In J. McIntyre and M. Barrett (Eds.), VET research: Influencing policy and practice. Proceedings of the National Conference of the Australian VocEd and Training Research Association (1st, Sydney, Australia).

Haskell, Robert E. (2001). Transfer of Learning: Cognition, instruction and reasoning. San Diego: Academic Press.

Hein, G.E. (1991). Constructivist learning theory. Paper presented at the CECA Conference, Jerusalem, Israel, October 15-22, 1991.

Hill, N. (2004). "Coalition for the Future of Manufacturing". Retrieved February 10, 2004 from Economy.com.

Holton, E. (2000). Making transfer happen. Managing and changing learning transfer systems. In E. Holton, T. Baldwin and S. Naquin (Eds.) Advances in developing human resources (pp. 23-35). Baton Rouge, LA: The Academy for Human Resource Development.

Holton, E. (2000). What's really wrong?: Diagnosis for learning transfer system change. Managing and changing learning transfer systems. In E. Holton, T. Baldwin and S. Naquin (Eds.) Advances in developing human resources (pp. 23-35). Baton Rouge, LA: The Academy for Human Resource Development.

Hull, G. (1993). Hearing other voices: A critical assessment of popular views on literacy and work. Harvard Educational Review, 63(1), 20-49.

Hycner, R.H. (1985). Some guidelines for the phenomenological analysis of interview data. In A. Bryman and R.G. Burgess (Eds.), Qualitative research (V.3). Thousand Oaks, CA: Sage.

Imel, Susan. (1999). Workforce education: Beyond technical skills (Trends and Issues Alert No. 1). Columbus, Ohio: ERIC Clearinghouse on Adult, Career and Vocational Education. (ERIC Document Reproduction Service No. ED426295).

Imel, Susan. (1995). New ways of learning in the workplace (ERIC Digest No. 161). Columbus, Ohio: ERIC Clearinghouse on Adult, Career and Vocational Education.

Jannings and Armitage (2001). Informal education: A hidden element of clinical nurse consultant practice. Journal of Continuing Education in Nursing, 32(2), 54-59.

Jarvis, P. (1997) Learning and reflective practice in an organization. Staff and Educational Development International, 1(1), 12-17.

Jonassen, D.H. (2000). Toward a design theory of problem solving. Educational Technology Research and Development, 48(4), 63-85.

Jones, D. and Bowler, S. (1997). The link between a participant's perceptions of training and subsequent levels of application. Journal of Alcohol and Drug Education, 42, 53-68.

Jung, I. and Leem, J. (1999). Designing strategies for developing web-based training courses in a Korean context. Retrieved March 26, 2003 from http://www.ouhk.edu.hk/cridet/gdenet/Teaching/Design/EATL11C. html.

Kahney, H. (1993). Problem solving: Current issues. Philadelphia: Open University Press.

Kegan, R. (1982). The evolving self: Problem and process in human development. Cambridge, Mass: Harvard University Press.

Kitchner, K.S. (1983). Cognition, metacognition and epistemic cognition: A three-level model of cognitive processing. Human Development, 26, 222-232.

Klein, G. (2001). Sources of power: How people make decisions. Cambridge: MIT Press.

Knowles, M. (1950). Informal adult education. New York, NY: Associated Press.

Knowles, M. (1970). The modern practice of adult education: Androgeny vs. pedagogy. New York, NY: Cambridge Books.

Kolb, D. (1984). Experiential Learning. New Jersey: Prentice Hall.

Land, S. and Hannafin, M. (2001). Student centered learning environments. In D.H. Jonassen and S.M. Land (Eds.), Theoretical foundations of learning environments. Mahaw, NJ: Lawrence Erlbaum and Associates.

Lauffer, E.A. and Glick, J. (1996). Expert and novice differences in cognitive activity: A practical work activity. In Y. Engestrom and D. Middleton (Eds.), Cognition and communication at work. New York, NY: Cambridge University Press.

Lave, J. (1988). Cognition in practice: Mind, mathematics and culture in everyday life. Cambridge, England: Cambridge University Press.

Lave, J. and Wenger, E. (1991) Situated learning: Legitimate peripheral participation. New York, NY: Cambridge University Press.

Lave, J., Murtaugh, M., and de la Rocha, O. (1984) The dialectic of arithmetic in grocery shopping. In B. Rogoff and J. Lave (Eds.), Everyday cognition: Its development in social context (pp.67-94). Cambridge, Mass.: Harvard University Press.

Lee, D. (1989). Everyday problem solving: Implications for education. In J.D. Sinnott (Ed.), Everyday problem solving: Theory and applications. New York, NY: Praeger.

Leslie, B., Aring, M., Brand, B. (1998). Informal learning: The new frontier of employee and organizational development. Economic Development Review, 15(4), 12-18.

Livingstone, D.W. (2001). Basic patterns of work and learning in Canada: Findings of the 1998 NALL survey of informal learning and related statistics Canada survey (NALL Working Paper). Toronto, Ontario: OISE.

Llorente, J. (1996). Problem solving and constitution of knowledge at work. Research Bulletin 92: Finland.

Marshall, R. (1994). Organizations and learning systems for a high-wage economy. In C. Kerr (Ed.), Labor Economics: Industrial Relations (pp. 601-645). Cambridge: Harvard University Press.

Marshall, C., and Rossman, G., (1995) Designing qualitative research (2nd edition) Thousand Oaks, CA: Sage Publications, Inc.

Marsick, V.J. (1987). Learning in the workplace. London: Croom-Helm.

Marsick, V.J and Watkins, K.E. (1990). Informal and incidental learning in the workplace. London: Routledge.

Marsick, V.J and Watkins, K.E. (2001). Informal and incidental learning. In S.B. Merriam (Ed.), The new update on adult learning theory (pp. 25-34). San Fransisco, CA: Jossey-Bass. (New Directions for Adult and Continuing Education, No.89)

Martinez, M.E. (1998). What is problem solving? Phi Delta Kappan, 79(8), 605-609.

Mayer, R. (1983). Thinking, problem solving and cognition. New York, NY: W.H. Freeman and Co.

McGivney, V. (1999). Informal learning in the community. Wales: National Institute of Adult Continuing Education.

Mead, G.H. (1934). Mind, self and society: From the standpoint of a social behaviorist. Chicago, Ill.: University of Chicago Press.

Merriam, S.B. (2001). Andragogy and self-directed learning: Pillars of adult learning theory. In S.B Merriam (Ed.), The new update on adult learning theory (pp. 3-11). San Fransisco, CA: Jossey-Bass. (New Directions for Adult and Continuing Education, No.89)

Merriam, S.B. and Caffarella,R.S. (1999). Learning in adulthood (2nd edition). San Francisco: Jossey-Bass Publishers.

Merriam, S. and Clark, M.C. (1991). Lifelines: Patterns of work, love, and learning in adulthood. SanFrancisco: Jossey-Bass.

Merriam-Webster Collegiate Dictionary. (1993). Springfield, Mass: Merriam-Webster, Incorporated.

Mies, M. and Shiva, V. (1993). Ecofeminism. London: Zed Books.

Moore, Beverly. (1998). Situated cognition versus traditional cognitive theories of learning. Education, 119(1), 161-171.

Nardi, B. (1996). Context and consciousness: Activity theory and human computer interaction. Cambridge, MA: MIT Press.

National Research Council. (1999). The changing nature of work: Implications for occupational analysis. Washington, D.C.: National Academy Press.

Norman, D.A. (1993). Cognition in the head and in the world: An introduction to the special issue on situated action. Cognitive Science, 17(1), 1-6.

Ottoson, J. (1997). Beyond transfer of training: Using multiple lenses to assess community education programs, In A.D. Rose and M.A. Leahy (Eds.), Assessing adult learning in diverse settings: Current issues and approaches (pp. 88-96). San Fransisco, CA: Jossey-Bass. (New Directions for Adult and Continuing Education, No. 75).

Orr, J.E. (1996). Talking about machines. Ithaca, NY: Cornell University Press.

Patel, V., Arocha, J., and Kaufman, D.R. (1999). Expertise and tacit knowledge in medicine. In R.J. Sternberg and J.A Horvath (Eds.), Tacit Knowledge in Professional Practice (pp. 75-100). Mahwah, NJ: Lawrence Erlbaum and Associates..

Payne, J. (2000). Local perspectives on globalization and learning: A case study of the printing and packaging industry in South West England. In C. Symes (Ed.), Working knowledge productive learning at work. Proceedings of the International Conference held in Sydney, Australia.

Perlow, R. (2001). Training and development in organizations: A review of the organizational behavior management literature. In C. Merle Johnson, William Redmon and Thomas Mawhinny (Eds.), Handbook of organizational performance. New York, NY: The Haworth Press.

Piaget, J. (1966). Psychology of intelligence. Totowa, NJ: Littlefield, Adam and Co.

Polkinghorne, D.E. (1991). Two conflicting calls for methodological reform. Counseling Psychology, 19, 103-114.

Quarter, J. and Midha, H. (2001). Informal learning processes in a worker cooperative. (NALL Working Paper). Toronto, Ontario: OISE.

Raelin, J.A. (2000). Workbased learning: The new frontier of management design. NJ: Prentice-Hall.

Revans, R.W. (1982) The origins and growth of action learning. Bickley, Kent: Chartwell- Bratt and Lund.

Robinson, R.D. (1999). Helping adults learn and change. Milwaukee, WI: Omnibook Co.

Rogoff, B. and Lave, J. (1984). Everyday cognition. New York, NY: Replica Books.

Rossett, A. (2001). Beyond the podium: Delivering training and performance to a digital world. SanFrancisco, CA: John Wiley and Sons.

Roth, W. (1997). Toward a new perspective on problem solving. Canadian Journal of Education, 22, 18-32.

Rowden, R.W. (1996) Current realities and future challenges. In R.W. Rowden (Ed.), Workplace learning: Debating five critical questions of theory and practice (pp. 3-12). San Fransisco, CA: Jossey-Bass. (New Directions for Adult and Continuing Education, No. 72)

Rudestram, K.E. and Newton, R.R. (1992). Surviving your dissertation. Newbury Park, CA: Sage.

Schoenfeld, A.H. (1987). What's all the fuss about metacognition? In A.H. Shoenfeld (Ed.), Cognitive science and mathematics education. (pp.189-215). New Jersey: Lawrence Erlbaum.

Schon, Donald. (1983). The reflective practitioner. New York, NY: Basic Books, Inc.

Schroth, M.L. (2000). The effect of type and amount of pretraining on transfer in concept formation. The Journal of General Psychology, 127(3), 261-269.

Schmidt, H. (2000). The future of labor-management relations, training and labor market institutions. In Peter Berg (Ed.), Creating competitive capacity. Berlin: Ed. Sigma.

Schwandt, T.A. (2000). Three epistemological stances for qualitative inquiry. In N.K. Denzin and Y. Lincoln (Eds.), Handbook of qualitative research (pp.189-213). Thousand Oaks, CA: Sage.

Scoffield, F. (2000). The Structure Below the Surface: Reassessing the significance of informal learning. In F. Scoffield (Ed.), The necessity of informal learning (pp. 1-12). Bristol: Policy Press.

Scribner, S. (1997). Thinking in action: Some characteristics pf practical thought. In E. Tobach, R. Falamagne, M. Parlee, L. Martin, and A. Kapelman (Eds.), Mind and social practice (pp. 319-337). Melbourne: Cambridge University Press.

Scribner, S. and Cole, M. (1973). Cognitive consequences of formal and informal education. Science, 182, 553-59.

Senge, P. (1994). The fifth discipline fieldbook: Strategies and tools for building a learning organization. New York, NY: Doubleday.

Senge, P. (1990. The fifth discipline: The art and practice of the learning organization. New York, NY: Doubleday.

Sierbert, K.W. (1999). Reflection-in-action: Tools for cultivating on-the-job learning conditions. Organizational Dynamics, 27(3), 54-65.

Vogt, W.P. (1999). Dictionary of statistics and methodology: A non-technical guide for the social sciences (2nd ed). Thousand Oaks, CA: Sage.
Vygotski, L.S. (1978). Mind in society. Cambridge, MA: Harvard University Press.

Walker, A.R. and Marsick, V.J. (2001). A study of informal learning in the context of decision making. Symposium conducted at the 27th AHRD Conference in Tulsa, OK.

Walter, S., Morgan, L and Walker, L. (1999). Formal vs. nonformal education. Retrieved April 23, 2003 from http://www.sil.org.

Webb, M.W. (2003). A definitive critique of experiential learning theory. Retrieved on April 23, 2003 from http://cc.ysu.edu/~mnwebb/critique.

Wenger, E. (1998). Communities of practice. Cambridge: Cambridge University Press.

Wilson, B. and Meyers, K. (2000). Situated cognition in theoretical and practical context. In D. Jonassen and S. Land (Eds.) Theoretical foundations of learning environments. NJ: Lawrence Erlbaum Associates.

Woll, S. (2002). Everyday thinking. Mahwah, NJ: Lawrence Erlbaum and Associates.

Wood, P. (1983). Inquiring systems and problem structures: Implications for Cognitive Development. Human Development, 26, 249-265.

Yacci, M. (1999) The knowledge warehouse: reusing knowledge components. Performance Improvement Quarterly , 12(3), 132- 140.

Yelon, S. (1997). Medical fellows tell stories of application: a grounded theory on the dynamics of transfer. Performance Improvement Quarterly,10(2), 134-155.

Yelon, S. and Ford, J.K. (1999). Pursuing a multidimensional view of transfer. Performance Improvement Quarterly, 12(3), 58-78.

Zimmerman, M. (1999). Dictionary Information. Retrieved April 23, 2003 from *http://www.selfknowledge.com*.

Zuboff, S. (1984). In the age of the smart machine: The future of work and power. New York, NY: Basic Books.

Sinnott, J.D. (1989). Everyday problem solving: Theory and applications. NY, NY: Praeger.

Skiba, M. (2000). A naturalistic inquiry of the relationship between organizational change and informal learning in the workplace. Dissertation Abstracts, 60(7-A):2581.

Smith, K. and Berg, D. (1997). Paradoxes of group life. SanFrancisco, CA: Jossey-Bass.

Spitzer, Q. (1997). New problems in problem-solving. Across the Board, 34, 36-40.

Stebbins, R.A. (2001). Exploratory research in the social sciences. Thousand Oaks, CA: Sage Publications.

Sternberg, R and Wagner, R. (1986). Practical intelligence: Nature and origin of competence in the everyday world. Cambridge: Cambridge University Press.

Stolovich, H. (1997). Introduction to the special issue on transfer of training-transfer of learning. Performance Improvement Quarterly,10(2), 5-6.

Stolovich, H. (1997). Use of case study method to increase near and far transfer of learning. Performance Improvement Quarterly,10(2), 64-82.

Strauss, A. and Corbin, J. (1999). Grounded theory methodology: An overview. In A. Bryman and R.G. Burgess (Eds.), Qualitative research (Vol. 3), Thousand Oaks, CA: Sage.

Suzaki, K. (1993). The new shop floor management. New York, NY: The Free Press.

Taylor, E. (1911). The principles of scientific management. New York, NY: Harper and Row.

Tennant, M. (1999). Is learning transferable? In D. Boud and J. Garrick (Eds.) Understanding learning at work. New York, NY: Routledge.

Tobach, E., Falmagne, R.J., Parlee, M.B., Martin, L.M. and Kapelman, A.S. (1997). Mind and social practice: Selected writings of Sylvia Scribner. New York, NY: Cambridge University Press.

Thomas, C.A. (2002). Get your hands dirty. Time, May 6, p.43.

US Bureau of Labor Statistics. (2001). Demographic Characteristics. Retrieved April 23, 2003 from BLS website www.bls.org.

Verespej, M.A. (1998). Formal training: 'Secondary' education? Industry Week, 247, 42-44.