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Practical work activity in the industrial fastener industry: A study of expert/novice differences in cognition and activity

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PRACTICAL WORK ACTIVITY IN THE INDUSTRIAL FASTENER INDUSTRY: A STUDY OF EXPERT/NOVICE DIFFERENCES IN COGNITION AND ACTIVITY

by

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A dissertation submitted to the Graduate Faculty in Psychology in partial fufillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

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Abstract

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by

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Adviser: Professor Sylvia Scribner

The present study examines how socio-cultural activity theory and information processing theory can be employed as complementary perspectives for the investigation of novice/expert differences in practical work activity. Observations of work activity within the offices of five industrial fastener sites and interviews with all levels of office workers form the basis of this research. Based on these observations, two experimental tasks were devised, using natural stimulus material consisting of bolts, nuts,

screws, and washers, one sorting task and one quasi-naturalistic order processing task. Empirical data from the performance of twenty-four telephone office workers, using this multi-method approach, were examined.

The major finding of this study was that when traditional methods of explanation, employing 'ideal' standards borrowed from information processing theories, were applied to the knowledge domain of the fastener business, they lost their predictive power. For example, experts exhibited less stability of organization in the sorting task than did novices and experts generally worked backwards in the order processing task whereas novices worked forward.

Findings suggested that knowledge and knowledge organization of product items, although necessary, were not the sole measure of expertise. Their large data base liberated the experienced sales person and facilitated the development of expertise through the acquisition of social and cultural knowledge, effecting an integration of technical and social skills.

An activity approach was shown to be more useful in examining the social and material aspects of the office world and novice/expert differences in content and structure of telephone sales work. The analytic scheme, in this study, included activity components from all levels.

From this approach, findings suggest that the shift from novice to expert resulted in:

1) A reorganization of goal-motives and greater differentiation between meaning and sense.

2) A transformation of surface to complex, multi-layered social relations.

3) A change in the forms of mediation, from external to internal means, accompanied by a shift in the locus of knowledge and the level of various activity components.

By employing an activity perspective, it was found that aspects of work activity were made visible which are usually not examined when more traditional information processing theories are employed.

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I am deeply grateful to the five companies which allowed me to do this study in their offices, for their generosity and openness.

This dissertation is dedicated to my husband, Jack. His love, his encouragement, and faith in me helped make this dissertation possible.

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INTRODUCTION

"You can't be too nice if you want to survive in the jungle. The business world is a jungle and you have to be on guard every second." These were the parting words of the owner of the New World Industrial Bolt Company, the first site of my investigation[1] and for me the beginning of a uniquely exciting adventure that eventually developed into the present dissertation.

This dissertation is about ordinary people, their work, how they interact with others and what makes them expert in what they do. My aim was to examine a work activity that could not be studied by experimental tasks alone away from the natural setting, but had to be embedded in the everyday detail of the work world. For this reason much of this research focused upon the texture of people's work experiences, what they said, felt and did in their every day life. As my study progressed, I realized that I might be witnessing social and ideological aspects of business not unique to one industry. The firms I studied, I believe, were a microcosm of the corporate world at large and replicated much of

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1. The names and identifying characteristics of the corporations and people dicussed in this investigation have been changed.

the everyday rules-in-use that people play by when there is thought to be no fixed or objective standard.

I gained access to five industrial fastener companies through personal contacts after being refused by many others. Most refusals were based on the rationale that workers were too busy to "take time off" or that the timing was inappropriate because of "transitions" in the particular department I wanted to study (i.e., change from manual to computer systems, etc.). I later found out that these refusals were based on concern for letting "outsiders" in, so as not to reveal so called "private" or "inside" information.

Getting into five industrial fastener companies presented me with descriptive data, the significance of which I only realized in retrospect. When I approached this project I certainly had no firm grasp, for example, of the subtle, ambiguous process of communication between 'insiders' of these companies and 'outsiders' of the business world. I studied the activity of twenty four telephone sales clerks in these five sites, how they communicated with others outside and inside their company, and the tasks required to accomplish their work. In most cases, these workers were extraordinarily cooperative and only too willing to share, with me, the knowledge of their work, their everyday experiences, and even their feelings toward the job.

Central to this dissertation was their interaction with other people and their use of socially provided tools or

external resources. After spending time in several companies, I realized that such an investigation required diverse research strategies and a more unorthodox theoretical perspective than usually employed with research solely focused on experimental tasks. Thus, the aim of my research evolved into examining work activity from two perspectives: a) from an information processing perspective which emphasizes the role of knowledge in respect to novice/expert problem solving, and b) from an activity theory perspective which focuses attention on the process of work activity.

Information processing theories have contributed significantly to expert/novice differences. Extensions of this framework, however, to the study of everyday activity in natural settings have been particularly problematic. Computer-based information processing approaches to knowledge conceive of the mind as an information processor divorced from the world. This is a justifiable position but not without some caveats. It is a truncated view which I believe I will demonstrate with this study, and runs the risk of producing static models which have difficulty explaining growth and change. Working within an activity framework, observational methods become an essential part of the research strategy. The present investigation began with observations of ongoing activity of adults working in the office of one of the five chosen sites. Observations included descriptions of the office setting, the psychological

content of various activities and the knowledge-domain of fasteners. On the basis of my observations, the occupation of telephone sales clerk was selected for closer analysis. Structured naturalistic observations of self- and other-initiated interactions for the performance of various work tasks of telephone sales clerks were analyzed. Central to this occupation was the task of filling a customer order. A quasi-naturalistic simulation of an order-filling task was designed after many hours of observation and interviews in the sites that I studied. This task allows for the analysis of moment-to-moment problem solving in the natural context of the office.

The knowledge domain of fasteners lends itself to many analyses. Even though there are thousands of items, it is a bounded domain. These product items can be related in many different ways and fully specified. In recent years there has been a shift within the information processing perspective, especially in memory and problem solving research, to the study of domain-specific knowledge. The functional role of domain-specific knowledge has also been emphasized by investigators who ventured out of the laboratory and studied the practical experiences of active individuals in real world settings (Lave, Murtaugh, de la Rocha, 1984; Scribner, 1984b).

An activity perspective focuses on many issues which information processing theory fails to address. It takes as

its starting point categories of practical activities such as work or play which have cultural and social meaning and are embedded in the real world (Leontyev, 1979). In fact, the central thesis of Leontyev's activity theory is that mind and behavior cannot be studied in isolation. Recently, Scribner (1984a, 1984b), and Engestrom and Engestrom (1986a, 1986b) applied and extended the activity framework to practical work. With this dissertation I hope to extend and operationalize the theory even further.

In sum, my research seeks to examine how socio-cultural activity theory and information processing theory can be employed as complementary perspectives for the investigation of practical work activity.

In the following chapter I will present a general overview of the literature from both perspectives. This will be followed by a chapter on the research design and hypotheses of this dissertation. In order to provide a context for this dissertation and in keeping with the methodological dictates of activity theory, chapter three will endeavor to give an account of the cultural-historical aspects of telephone sales activity. The fourth chapter will present observations and descriptions of the work activity and setting which directly contributed to the generation and the rationale for each of the experimental tasks. Chapter five and six present and discuss the research methods and data analyses for these tasks. Chapter seven presents and discusses data

collected after the completion of these tasks. The final three chapters bring the different strands of the dissertation together: chapter eight offers an alternate interpretation of the sorting data; chapter nine seeks to operationalize various activity constructs; and finally, chapter ten points out some similarities between Scribner's findings among dairy workers and that of telephone sales workers and explains how her model of practical thinking at work (Scribner, 1984b) has been extended by this dissertation.

CHAPTER 1

LITERATURE REVIEW

There were few guidelines for this dissertation and the design and analysis of the quasi-naturalistic task central to this investigation. Therefore the literature review that follows will include several lines of research which I believe are germane to this study.

The literature involved with problem solving and reasoning will be reviewed first. Then in order to provide a more specific context for the present study, I will discuss research that relates to practical activity. I will conclude by briefly discussing certain aspects of activity theory and other lines of work which I believe are relevant to this investigation.

Information Processing Approaches

Domain- Specific Knowledge. With increasing emphasis on ecologically valid investigations, cognitive scientists have recently focused their attention on domains requiring a rich knowledge base because gaining expertise in the real world requires the acquisition of large bodies of domain-specific knowledge.

Therefore, in recent years information processing studies of problem solving have shifted from tasks requiring little prior knowledge (i.e., pure problem solving

techniques to guide a search; simulations of problem solving performance at different stages of learning (Newell & Simon, 1972), to tasks requiring a rich structure of domain-specific knowledge in technical or scientific professions (e.g., in electronics, Rasmussen & Jensen, 1974; Egan & Schwartz, 1979; and in physics, Larkin, McDermott, Simon & Simon, 1980; Chi, Glaser & Rees, 1982).

Advocates of a knowledge-based view assert that experts differ from novices primarily in the amount, quality, and organization of knowledge that can be brought to bear on a given problem, rather than the underlying cognitive processes. Therefore, studies on problem-solving expertise have emphasized this new focus by describing contrasts between the performance of novices and experts. Although there is no one theory concerning the way in which knowledge develops from novice to expert, these studies have shown strong interaction between structures of knowledge and cognitive processes (Chi, Feltovich & Glaser, 1981; Chi, Glaser & Rees, 1982; Chi, 1985). Results from many empirical studies have helped to emphasize the importance of examining the development of expertise in terms of the interplay between knowledge structure and cognitive processing.

The research reported by Siegler and Richards (1982), for example, illustrates the importance of content knowledge in acquiring sophisticated problem-solving abilities in children. Results from their rule assessment studies point

to the importance of knowledge as a basis "underlying other changes previously attributed to the growth of capacity and strategies"(p. 930). This knowledge, however, cannot be generalized to other domains. For example, Chi (1978) found that a child expert in chess cannot access competencies in other domains.

Cognitive psychological research in problem solving expertise has also followed a tradition of comparing expertise with skilled performance (Glaser, 1976). In this view , expertise has been defined as the "possession of a large body of knowledge and procedural skill" (Chi et al., 1982) and is the result of a learning process whereby behavior changes from being initially conscious, discrete, and inaccurate to eventually automatic, fast, continuous and precise (Glaser, 1976).

What are the critical differences between individuals who share high and low levels of competence in a particular domain of knowledge? Data from expert/novice problem- solving and developmental literature show that one of the major components of expertise may reside in the possession of rapid access to, and efficient utilization of very organized local or domain- specific knowledge (Brown, 1982; Brown, Bransford, Ferrara & Champione, 1983).

Often it is assumed that even though relevant knowledge is there, it is somehow difficult to access. That is, it is assumed that the knowledge of younger children and novices

is "welded or tightly wired" to constrained domains, (Rozin, cited in Brown, 1982, p.107) whereas the knowledge of older children and experts can be accessed within multiple contexts. Chi interpreted this to mean the same thing as saying that a child's knowledge is not represented in a way that makes it accessible. Viewed in this way, an access interpretation becomes one concerned with knowledge representation and reorganization (Chi & Rees, 1983).

Glick and Holyak (1980), found that information that is in the knowledge base is not always effectively used by adults. Much depends on prior knowledge and how that knowledge representation captures the essential relations relevant to the solution of a new problem. If a current situation can be related to prior knowledge, then the situation has the potential to be subsequently related to a new analog. According to Chi et al. (1981), experts tend to encode at a relatively abstract level, therefore it is possible that knowledge of experts can transfer to a new domain (Glick and Holyoak, 1983).

Problem Representation. A problem representation has been described as a coherent organization of knowledge that represents the elements and relations contained in a problem (Simon and Simon, 1978). A problem solver develops a problem representation in order to understand or interpret information in the original problem situation. In real- life problem solving or in ill- structured problems, on constructing

a problem representation, a solver will usually need to augment the information contained in a problem with knowledge he already has. If that knowledge is not represented or properly organized in memory, then it is unlikely that the solver will be able to construct a problem representation to accurately solve a problem.

A consistent finding in the problem solving literature of adult experts and novices shows that relations between the structure of a knowledge base and problem- solving processes are very much mediated through how well the problem is first represented.

Simon & Simon (1978) termed this 'physical intuition' and Chi et al. (1982) called it 'qualitative analysis'. Furthermore expertise according to these researchers can be attributed to "practice effects"(Simon & Simon, 1978, p.346). The problem representation is constructed on the basis of the available domain- specific knowledge and how this knowledge is organized for a particular type of problem. Recent efforts to understand problem solving in physics Chi et al.(1982) and Larkin et al.(1980) pointed out the importance of this representation.

> The quality of a problem representation is determined not only by the knowledge that is available to the solver but by the particular way the knowledge is organized. The quality of the problem representation then influences the subsequent problem solving behavior (Chi, et al., 1982, p.30).

Thus, expert problem representations allow the solver to recall solution methods associated with an appropriate set of physics equations for solving problems. Novice problem- representations, being more fragmentary and incomplete, do not provide the solver with knowledge of solution methods. (Chi et al., 1981; Larkin et al., 1980; Simon & Simon, 1978).

For example, when presented with a particular problem in elementary mechanics, Larkin (1985) argued that:

> The solver must convert the string of words with which he is presented into some internal mental representation that can be manipulated in efforts to solve the problem. Understanding the problem then means constructing for it one of these internal mental representations. A useful and powerful representation corresponds to a good understanding, whereas a fragmented or limited representation corresponds to a poor understanding" (p.142).

The differences in domain-specific knowledge also contributed to differences in problem representation and solution. Larkin et al. (1980) distinguished between "naive" representations composed of entities related to familiar situations and scientific representations "composed of entities that have special powerful meanings in science" and scientific ways of thinking about problem situation (Larkin, 1985, p.158).

Problem solving, according to Chi et al.(1981), begins with a brief analysis of the problem. A representation is formed based problems differently. These categories facilitate knowledge structures (schemas) which include potential solution methods. Experts perceive more in a problem statement than novices. They have tacit knowledge that can be used to make inferences and derivations from the situation described by the problem statement" (Chi et al., 1981, p,149). Novices, on the other hand, because they have different criteria for categorizing problems, deal with literal problem components. Thus, experts establish a relationship between the problem category and methods of solution. Novices on the other hand are unable to readily formulate solution methods.

This research suggests that acquiring knowledge and expertise requires not only adding new content but also restructuring knowledge. Chi et al. (1982) have conceptualized this restructuring as involving a change in relations among concepts and a shift of level at which concepts are at the basic level. As Chi and her associates have conceptualized the problem: "What is basic level for the novice is subordinate level for the expert. For example, novices' representations are organized around the literal object and events given explicitly in a problem statement. Experts knowledge, on the other hand, are organized around inferences about principles and abstractions. These principles

are not obvious in the statement or surface reading of the problem" (1982, p.48). Chi et al. (1981) found, from their protocol analysis, that experts solve their problems working from their problem-representation whereas novices change and construct their representation in the course of solving a problem; experts use what they know and novices look for the unknown to search out the solution.

An Empirical Study. For example Chi et al. (1982) designed a simple experiment contrasting the way in which introductory physics students and experts group similarity among physics problems involving pulleys and inclined planes. Each group arrived at very different categorization schemes. Beginning physics students used surface characteristics of the problem to form a similarity class. (e.g., all the problems about pulleys are similar; all the problems about inclined planes are similar). Advanced physics students grouped the problems by the underlying equations and concepts that would have to be used to solve them.

Some of the problems relating to planes and pulleys might both call upon the same basic equations and solutions according to the experts. The authors interpreted this to mean that for novices the basic level of concept is pulleys and inclined planes; for experts this level of concept becomes the subordinate level. The basic level thus becomes whatever the set of equations are. So that according to Chi and her associates, in this experiment, restructuring

involved some shift on the level of the concept and different relations among concepts.

Simon & Simon (1978) found that expert physicists used 'working forward' strategy to generate successive equations solvable from given information. On the other hand, novices attempted to evoke an equation that contained an unknown variable. This was a 'working backward' strategy since if the equation contained another unknown variable, the novice attempted to evoke another equation containing the new unknown variable. Larkin et al. also suggested that experts use a process of forward reasoning based on a highly elaborated representation of the problem. In contrast, novices tended to use processes such as means-ends analyses and generate-and-test methods that involved backward reasoning.

Schoenfeld & Herrmann, (1982) tested students' perception of the structure of mathematics problems before and after a month of intensive courses on math problem solving. Experimental results demonstrated that experienced students in mathematics penetrated the "surface structure" of the problem. They also perceived "deep structure" similarities and thus approached the problem accordingly. Schoenfeld & Herrmann concluded from the results of their study, that 'schemata' change with experience.

Expert Knowledge Organization. The development of expertise depends upon changes in the representation and organization pertinent to a specific problem domain. One

important change involves the organization of domain- specific knowledge into units or "chunks." Several problem-solving studies have shown that experts develop a knowledge base containing a large number of chunks for the information of a specific domain (Egan & Schwartz, 1979; Chi et al., 1981 ; Chi et al., 1982). For example, Egan and Schwartz found that experienced electronic technicians accurately reconstructed circuit diagrams by recognizing meaningful and functional patterns of elements symbolized in the diagram. Expert computer programmers remember program commands by recalling well known algorithms containing individual commands (McKeithen, Reitman, Reuter, & Hirtle, 1981). Expert recall of domain-specific chunks of information has also been found in physics (Chi et al., 1981; Simon & Simon, 1978).

In sum, the differences between experts and novices indicated that experts in diverse fields are better able to remember facts, features and patterns in their area of expertise than novices. Experts and novices apparently perceive information differently (Schoenfeld & Herrman, 1982), remember information differently, and use different criteria to judge the utility of the information that they perceive and remember.

Reasoning Processes in Medical Problem- Solving

Another line of research consists of studies of diagnostic reasoning and medical problem- solving. Diagnostic

reasoning is assumed to reveal characteristics of how a physician has represented and organized domain-specific knowledge. The physicians think- aloud protocols provide a directly identifiable component of a problem formulation. Diagnosis is in the form of a problem solving activity because it interprets information in order to identify the disease process causing a patient's illness. Studies of medical problem- solving reveal that physicians use a general "hypothetico deductive " reasoning method to generate and evaluate diagnostic hypotheses when examining a patient's case data. This general problem- solving method is, however, shared by both experienced and inexperienced physicians and is found across medical specializations (Elstein, Shulman & Sprafka, 1978). The use of this method is not necessarily a reliable indicator of diagnostic expertise or the quality of diagnostic reasoning nor the correctness of the diagnosis (Elstein et al., 1978). Elstein et al. (1978) also found that hypotheses are consistently generated early in the taking of a history of a patient when only a limited amount of information is available. The hypotheses serve to transform an open medical problem (What is the patient's illness?) into a set of closed problems (Is it X or Y ?) that are then much easier to solve.

The content of an individual's medical knowledge base and the use of that knowledge with respect to the data structure of a patient's case are the best indicators of

diagnostic expertise (Johson, et al., 1981; Neufeld, Norman, Feightner & Barrows, 1981). The methods of diagnostic reasoning depend on the level of detail of a physician's representation and organization of domain- specific medical knowledge. Johnson et al. (1981) suggested that medical experts have "a hierarchy of disease knowledge that is well organized and extensively differentiated into a number of disease variants," (p.41) whereas novices' knowledge of diseases is relatively shallow. Similar to Chi's findings, on the basis of this theory, experts and novices differ mainly in having more lower level concepts rather than structural differences in the concepts they share. Novices and experts are also found to vary considerably in their diagnostic effectiveness, depending on the nature of the problem.

Elstein et al. (1978) and Johnson et al. (1981) worked within the hypothetico-deductive framework emphasizing that experts differed from novices only in the nature of the knowledge base they utilized. This is not entirely consistent with results concerning expert performance in other domains of knowledge. The controversial question becomes: What is the nature of the problem-solving process of expert physicians? One of the problems seems to be that much of this work has been based on the Newell-Simon methodology (Newell and Simon, 1972) which is less applicable in verbally complex situations that depend on a rich knowledge

base.

Recently, Patil and Groen (1986), using a propositional analysis technique, found that all experts with accurate medical diagnoses used bottom-up forward reasoning whereas the experts with inaccurate diagnoses used at least some top-down backward reasoning. They argue that "it is compelling to interpret this latter kind of reasoning as involving some kind of process of generating a hypothesis and testing it in the light of whatever the subject has recalled about the facts of the case. It is wrong to conclude, however, that a subject's inaccurate diagnosis is due to the use of a hypothesis testing strategy" (p.107). The content and patterning of problem formulation will vary with expertise since there are individual differences in the differentiation of medical knowledge represented. The line of reasoning used by expert physicians can contain representations of medical problem- solving knowledge at several levels including patient data, cue interpretation, disease states, etc. (Patil & Groen, 1986). For example, an expert may discriminate among several diseases whereas a novice will focus on only one disease. Thus novice's medical reasoning is characterized by more specific solution activity such as evaluation of a single disease hypothesis with respect to a limited set of patient findings. This novice use of reasoning corresponds to novice problem representation reviewed

earlier for other problem-solving domains.

Corcoran (in press) in studying approaches to planning, used by hospice nurses, found that expert nurses used broad initial approaches to planning in simple cases while no general pattern was evident for novices. Experts, however, varied their overall approaches across more complex cases. This is consistent with Payne's (1976) finding that information processing in decision-making is highly contingent upon the demands of the task. Experts used opportunistic overall approaches in more complex cases, a procedure which is consistent with the model of planning proposed by Hayes-Roth and Hayes-Roth (1979). Corcoran concludes that most novices used opportunistic overall approaches across all cases, because all cases appeared complex to them.

Contrary to these findings, Lesgold et al.(1981) found that experts involved in X-ray and medical diagnosis were generally "opportunistic planners" even for simple diagnoses. Novices were less flexible. Experts did not necessarily know what they know. For example, expert radiologists often had difficulty informing novices of diagnostic errors. An expert could accurately identify a large white blotch on an X-ray photograph as a collapsed lung, whereas novices (medical residents) diagnosed the same stimulus as a large tumor. Furthermore, experts reported that they did not consciously entertain the idea that the blotch was a tumor when making the correct diagnosis, although, on being

questioned, they did readily point out in rule form the visual difference between a tumor and a collapsed lung on an X-ray. The expert radiologist, however, reported having no understanding of what led the novice radiologist to the mistaken diagnosis. Lesgold et al.(1981) suggested therefore that the expert radiologist's visual diagnostic skills might have become a kind of automatic perception.

Summary. Although much of this literature is confusing, the notion of expert/novice differences rests heavily on the assumption that there is a cognitive shift. Based on Chi et al. (1981); Larkin et al. (1980) and Lesgold et al. (1981) it appears that the progression from novice to expert is relative irreversible and domain specific. However, whether or not a shift is identified as qualitative, depends on the dimensional criteria for measuring and specifying the stage-related components of noviceness and expertness. Evidence for a qualitative change depends on what and how many measures show a changed interrelationship among variables. One difficulty is that the differences between experts and novices may be qualitative, but the transition may involve only small incremental, quantitative change along several dimensions.

Results from these studies generally indicate that novices are less flexible than experts. The latter also show faster access around multiple interpretations of a given problem and the use of higher level concepts compared to

novices. Interestingly, all the studies in diagnostic reasoning and medical problem-solving employed verbal reports as data to infer mental processes and knowledge structures. Most of these investigations were individual case studies employing only two or three subjects.

In sum several main points emerge from this confusing picture in reviewing the literature on problem- solving and diagnostic reasoning within an information processing perspective (Glaser, 1986):

1) Expertise in problem-solving continues to develop as experience in a field accumulates and can be attributed largely to the organization and size of the knowledge base.

2) The knowledge of experts is domain- specific. Expertise in one domain does not generally spread to other knowledge domains.

3) In solving problems, experts tend to work forward based on a highly elaborate representation, whereas novices tend to work backwards.

4) Experts know how to apply their domain-specific knowledge whereas novices have difficulty applying their knowledge.

5) The problem representations of experts are qualitatively different from those of novices. In the course of developing expertise, problem representations change from surface representation to deeper categorizations.

6) The 'qualitative analysis' early in the solution process of experts is the result of their knowledge which is

organized around certain fundamental principles. In contrast the novice's representation is organized around dominant objects mentioned in the problem statement which change during the solution process and make it less complete and coherent.

7) The perception of the problem for novices is more literal and qualitatively different than that for experts.

Studies in Practical Activity.

The importance of knowledge has also been emphasized by investigators who have ventured out of the laboratory and studied practical activity in real world settings (Lave, Murtaugh, de la Rocha, 1984; Scribner, 1984b). These studies deal with active individuals in the real world and seek to investigate the functional role of knowledge.

An Early Empirical Study. In a study on the psychological structure of the work process Lewin & Rupp (1928), investigated the moment-to-moment interplay of textile workers with the spinning machine. This was one of the earliest studies which examined the course of concrete work activity within a natural setting and viewed the machine, the worker, and their specific interaction, as a dynamic unit. Lewin and Rupp analyzed the individual actions of novice and expert factory workers, operating a spinning machine, without ever losing sight of the total work-process. They found that inexperienced workers had more and longer unknotted broken threads on the spools of the reels

they operated and that they spent much of their time placing new threads on these spools that were not operational. In other word spools accumulated because novice workers did not find time to knot the threads as they broke.

Expert workers, on the other hand, organized and adjusted their work actions to the machine and thereby had " more freedom of action", and more "free time for relaxed preparation" by knotting threads as they broke. Lewin and Rupp explained that:

> [1]...when an empty reel is covered with a new strand, the expert worker experiences that the knotting of the thread and the setting into action of the spool directly follows the placing of the strand on the machine. The novice worker, on the other hand, when putting or placing a strand on the machine, does not usually allow the knotting of this thread to occur, but first attends to the other reels, mainly to place new strands on them. Consequently, in contrast to the expert, the novice places, in fact, the strand on the reel, but the reel is not in operation, because the thread has not yet been knotted. (p.22)

He concluded that novices made poor use of the machines because they lacked the proper organization of actions, producing a conflict situation. Expert workers organized their actions so that they had, "more free time for relaxed

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1. Unpublished translation by the present author (Laufer,1989).

preparation and because of their good performance and the good work situation they did not have to exert themselves as much" (p.13). Lewin and Rupp's comments on the work process are interesting in the light of activity theory:

> The main purpose of researching this task performance in the textile factory was as it related to the psychological study and penetration of dynamic factors into the work process. This not only served to ascertain why certain types of actions occurred during the work process and how frequently and how long each type usually lasted; it mainly served to find out how each individual action played a role in the whole process (p.39).

More importantly and relevant to the present study, Lewin and Rupp examined the goal of the work action and the 'goal-motive' of the whole work activity:

> For the woman who has been working for a long time, the situation is completely different...She does not approach the machine as a neutral observer (like the novice), but with certain goals which she wants to achieve, namely to achieve as much work as possible and earn a lot of money. Thus, the significance of the individual objects and events on the machine is essentially determined by the events which affect the increase or limitations of earning, i.e., the continuation or standstill of the work effect (p.15).

Current Investigations

Studies have shown that complex knowledge is required for even the most unskilled jobs (Kusterer,1978; Singleton,1978; Scribner, 1984a). Recently investigations of

various work tasks or "goal-directed actions" such as bartending (Beach 1985), waitressing (Stevens,1985), house-cleaning (Engestrom and Engestrom, 1986a) and dairy product assembly (Scribner, 1984b) have been examined. These investigators all employed: 1) observational and experimental methods; 2) actual work tasks; 3) examined goal- directed actions; 4) analysis of the reciprocity between mental operations and the external environment.

Beach (1985), for example, examined the role of external memory cues in learning to become a bartender. Stevens (1985), systematically observed experienced waitresses filling orders and the effect of the physical environment of the restaurant setting and the changing customer demands on the organization of information in their working memory.

There is a paucity of studies on expert and novice problem-solving as part of a practical, everyday activity. Most studies derive from an information processing framework. Chi et al. (1981) and Larkin et al. (1980). Scribner's (1984b) investigation of a product assembly problem- solving task performed by novice and expert dairy plant workers is a novel departure from a long standing tradition of research on work skills and problem- solving.

Scribner (1984b), found that dairy workers used array configurations as a way of organizing mental operations for determining single case numbers. Scribner designed a model of practical thinking based on problem-solving in the dairy

which she characterized as "having flexibility, economy of procedures, effective utilization of knowledge and fine tuning to the environment" (p.40) and most importantly a shift from mastery of the general to mastery of the concrete. (For a more detailed discussion of this model turn to chapter 10). Scribner presented her research from a Vygotskian approach and within an activity framework.

Everyday knowledge and problem solving has recently been studied in other than work activity. Lave et al. (1984) examined mathematical problem solving in a supermarket by observing shoppers doing arithmetic for items on a shopping list. Shoppers selected 'best buys' often without exact numerical solutions and made their decision on some other basis.

Ceci and Liker (1986) recently demonstrated that adults who performed poorly on IQ tests and had only a few years of schooling, were nevertheless capable of very complex thinking and reasoning in a specific knowledge domain. These subjects were very familiar with racing facts and selecting winners at the race track; knowledge, however, that they could not transfer to other domains. In studying various problem tasks performed in a dairy Scribner (1984b) summarizes practical activity more generally:

> The picture that emerges is of a dynamic, interactive cognitive system that departs in significant respects from the models of problem solving proposed

> by information - processing theorists. In these models, problem solving is linear and one way, proceeding from a defined problem through a sequence of steps to a solution. In the dynamic system of problem-solving observed in the dairy, the movement of thought is two-way. In addition to going from problem to solution, thinking proceeds from 'anticipated solution' to 'construction of the problem.' Steps to the solution are variable and modified in kind and in order by fine tuning to the environment; they do not invariably follow fixed or 'one best' sequence for a given class of problems (p.40).

Sahlins' Model of Exchange Processes.

Because of the nature of my dissertation, Sahlins' (1972) model of exchange processes among 'primitive cultures' ("primitive" here referring to "cultures lacking a political state") described in his chapter "On the Sociology of Primitive Exchange," (1972, pp. 188 - 275) is also applicable to my dissertation. Sahlins does not separate economic activity from other social relations but instead argues that "the material flow underwrites or initiates social relations " (1972, p.186) and "the material flow is sustained by prevailing social relations" (p.195). While according to Sahlins, exchange processes among primitive people in non-market economies are qualitatively different from those in modern complex societies, my data reveal many similarities. In both, exchange can be seen as containing the components of the formal agreement, which must be honored, and the informal favor, which must be returned and

which results in the blurring of the distinction between social and economic types of transactions. Although further discussion of Sahlin's model and classification of types of exchange processes is beyond the subject of this dissertation, it is important however to note that my data revealed how critical the kind of exchange is for the functioning of the sales clerks and the whole fastener industry, and that often these distinctions are difficult to make.

The Classification of Domain-Specific Knowledge. Results of an earlier study by Laufer (1985a) suggested that experience was the best predictor of high recall performance regardless of age and education, and education was best predictor for stable sorting patterns. Using fastening items as stimulus material, which can be related in many different ways, subjects were asked to sort 48 high frequency and 48 low frequency items until they achieved two successive identical sorts. Laufer found that for the high frequency items, subjects: 1) more readily achieved stable sorts than for the low frequency items. Findings also suggested that the subject's sorts of high frequency items was based on 2) more criteria (features) which resulted in 3) more groups and therefore a more differentiated (exhaustive or deeper) sorting pattern.

The subjects' performance varied significantly with respect to the experience they had with the item. For example, results from that study indicated that 43% of the

subjects were not able to reach a criterion of two identical sorts for rarely used fastener items as compared to only 5% for the more frequently used items. Sortings were also significantly more idiosyncratic and shallow for low frequency items compared to high frequency ones. Sorting was based on the relationship among a total of 240 different attributes for a set of 48 frequently used items and a set of 48 rarely used product items and a set of 48 rarely used product items.

Similarly, Chi (1981) demonstrated that children's classification of familiar dinosaurs was based on greater interconnectedness and a more structured knowledge base than that for less familiar dinosaurs. Gobbo & Chi (1986), for example, studied the structure of dinosaur knowledge among 7 year old novices and experts. They hypothesized that the " knowledge base becomes increasingly organized around salient attributes...through learning, the child notices the correlated features of each attribute. By noticing the constituent pattern of interrelationships, the child's knowledge base becomes restructured in a more cohesive way" (p.222). Results from the sorting task indicated that novices: a) were not consistent amongst themselves on the criteria they used for judging class membership; b) left a residual group because they could not sort exhaustively; and drew on more explicit features thus sorting on a more basic level. Experts on the other hand: a) sorted consistently and exhaus-

tively; and based their sorting upon more abstract features. Gobbo and Chi interpreted these findings to mean that novices are not able to find distinctive features as a basis for classification. Experts, however, made exhaustive sorts by being able to use a small set of features to contrast classes.

Classification is essentially a mental representation. There is a body of research to demonstrate cultural and developmental differences in the use of categorization (Nelson, 1973; Nelson, 1977; Cole, Gay, Glick & Sharp, 1971). Categories that are salient to a particular group may not necessarily coincide with those categories considered taxonomically or hierarchically ordered, in a traditional sorting and task. Chi (1985) for example, found that there are developmental differences in a child's knowledge of classmates. The preferred mode of representation was not taxonomical. Similar Scribner (1984b) in her study of dairy workers, found that occupational variations influenced the particular product attributes selected as grouping principles. In speaking of consumers and wholesale dairy drivers she states: "occupational variations appear to reflect, not only differences in 'what is known,' but differential salience of product attributes as organizing criteria (p.31)." Nelson (1973) found strong evidence that even very young children rely on the function of objects as a primary basis

for categorization rather than solely perceptual features (p.37).

Results from a recent study (Bolster, in press) with adults, employing naturalistic sorting materials, indicated that experts based their sorts on functional criteria more characteristic of the sorting pattern of young children. Bolster found that expert fishermen relied on their sorting criteria for both similarity of form and function of fish. Contrary to expectation, novice fishermen classified fish according to their morphological characteristics only.

Lesgold et al. (1986, p. 65) examined the classification of jet engine components by skilled and unskilled jet engine mechanic subjects. The task consisted of classifying components into fuel, oil, electrical and mechanical systems. "Forty-nine components were selected for a task in which subjects assigned each component to one of these categories." No significant difference in sorting criteria was found between skill groups.

These studies suggest that when naturalistic materials were employed experts departed from the usual results found in traditional sorting studies employing experimental materials.

From interviews from my earlier study (Laufer, 1986), it was evident that there were numerous ways in which relevant knowledge was organized by sales clerks in an industrial fastening company.

My findings revealed that standard sorting instructions often resulted in responses such as: "Sort for what?" or "What for?" Without a particular goal as the basis for sorting, sales workers often relied on very general or idiosyncratic principles of sorting. For example, previous post-test interview data revealed that some sorting criteria by subjects was based on the number of dimensions of an item rather than the type of attribute. Participants claimed that " the items are easier to remember if they are a washer or a nut, for example, because they have fewer size dimensions than a screw or bolt." Cole et al. (1971) in their study of the sorting patterns among the Kpelle people in Liberia, and Dougherty & Keller (1985) in analysis of the sorting patterns of blacksmiths in England found that participants based their criteria on personal goals and understandings rather than taxonomical requirements. Subjects often were not responding to the questions that the experimenter thought he was posing and some sort of goal direction was necessary for these sortings to be meaningful.

Activity Theory as a Framework for Psychological Analysis. The studies that were discussed have made valuable contributions to the understanding of the structure of knowledge and knowledge representation. Their main focus, however, was on the individual knower acting alone in the world. Information processing theories and models are not sufficient for the investigation of practical real life

tasks and their underlying mental processes. These models do not address the issue of how and where knowledge is acquired and most importantly they fail to address the significance of the role of social interaction and motivation.

To understand how knowledge is used in the world an additional approach is needed which sheds light on the substance of the activity of a cognizing subject embedded in a cultural and social milieu. In applying this framework, methodologies and research questions as well as terms common to many western psychological theories must be reconceptualized.

Even though this theory does not represent a unified framework, the focus in the present investigation will be on Vygotsky and Leontyev's work and on the relationship between the organization of social activity and the organization of psychological processes. For example, Vygotsky emphasized symbolic tools and social interaction whereas Leontyev emphasized practical activity.

Activity theory involves a specific concrete activity which is directed toward particular objects and properties. It also deals with particular sequences of activity components directed around specific physical and psychological objects. Leontyev proposed a distinction among three levels of activity. In order of decreasing level of abstraction these were: a) activity and associated motives, b) actions

and associated goals, and c) operations and associated conditions.

The level of 'activity' pertains to conscious and unconscious motives. It is also the level of personality. Cognitive processes and personality are not separate processes; nor can personality be understood without the social aspects of the individual (Busse & Lampe, 1987). Motives are socially and culturally defined and directed toward object(s) in the world. Motivation does not spring from inside the person but comes about through the participation in socially constructed activity (i.e. motivation for doing something). According to Leontiev[1], motivation has both social meaning and personal sense.

Theories of motivation have been the focus of much attention in the past. For example a classic example is the studies of McClelland, Atkinson, and their associates (1953), who studied extensively the need for achievement, the need for affiliation (the desire to establish and maintain positive ties with other people), and the need for power or to control others. Although hampered by low reliability techniques, especially 'projective' ones, for measuring motives, it is still, to this day, the subject of many investigations. Maslow (1954) spoke of a need

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1. The name Leontyev and Leontiev are employed interchangeably in this dissertation.

hierarchy by which all individuals are first compelled to satisfy basic needs, such as hunger and thirst, physical security, and protection from the elements. When these needs are satisfied, the individual can then seek satisfaction in growth needs and approach the state of self-actualization. Leontiev's concept, in contrast to these theories, conceptualized motivation not as an abstract "need" for achievement or self-actualization within the individual but more concretely as a need that must find its tangible object.

The second level, that of 'actions', refers to behavior aimed at conscious goals. Actions are goal-directed units and are defined by their goals. All goals are temporal and as such can also be thought of as outcomes.

The third level, 'operations', are the means or conditions by which actions are carried out on a task.

In adopting culturally organized activity as his unit of analysis, Leontyev was able to overcome the dualism between mental and behavioral processes because 'activity' encompasses both intra and extra psychological action. The work of Zinchenko (1981) on involuntary memory and Istomina (1975) on voluntary memory represents some of the earlier studies using the structure of activity to account

for what people remember. More recently, investigators in the United States and abroad have shown great interest in activity theory and its constructs (Hacker, 1978; Zinchenko & Gordon, 1981; Scribner, 1984a; Wertsch & Stone, 1985; Engestrom & Engstrom, 1987). It is these two theoretical perspectives based on information processing theories and activity theory that provide the framework for my dissertation.

CHAPTER 2

RESEARCH AIMS AND METHODOLOGICAL APPROACH

Following two different lines of investigations, that of Scribner (1984) and that of Chi (1983), the present research seeks to investigate how knowledge is structured and represented and how it functions in practical, everyday activity. Observations of telephone sales clerks' daily work activity within the offices of two industrial fastener sites and interviews with all levels of office workers, formed the basis of much of the descriptive data of this investigation. Based on these observations, two experimental tasks were devised using natural stimulus material, one experimental sorting task and one semi- naturalistic order filling task.

The semi-naturalistic task is based on the concrete work activity of telephone sales workers in this industry. It was developed in order to examine the process of filling an order. The task involves the asking of goal-oriented sequences of questions and permits comparing different methods for achieving the same goal. The method was developed to generate empirical data to:

a. understand better the problem solving processes or cognitive mechanisms of practical problem-solving at work;
b. understand the structure of the underlying knowledge base and how it is used; and finally
c. compare performances between subjects with differ ent knowledge bases.

The sorting task is based on a long line of experimental research in classification. It serves here to determine how knowledge of fasteners is organized by expert and novice workers and how that knowledge interacts with the order filling task.

Aims and Hypotheses

The aim of this investigation is:

1. To examine the nature of the expert /novice shift along several lines. Based on earlier observations, it is hypothesized that experts would differ from novices along the following:

   a. Expert- problem solving is expected to be characterized by linear or sequential steps toward a solution. In contrast, novice problem-solving is expected to jump back and forth between different steps of the process (Chi, Glaser & Rees, 1982).

   b. Expert subjects are expected to choose certain principles. Once a principle is applied (eg. " Is this item standard or is it special?") it narrows the range of possible solutions. Novice subjects are expected to proceed by stringing together the checking of miscellaneous external knowledge sources only loosely connected with the problem at hand.

   c. Expert subjects are expected to use more and different external physical aids than novice subjects to solve problems. Novice subjects are expected ask the help of other people more often than experts.

   d. Experts would be more accurate at judging the difficulty of a problem compared to novices.

2. To examine how the structure of knowledge changes with becoming more expert in a particular occupa

tion. It is expected that the knowledge base would be more hierarchically organized into knowledge categories and subcategories, more elaborately represented, and with a more stable organization.

3. To examine the relations between experimental task performances. It is expected that:

   a. A more stable, hierarchical and elaborately organized knowledge base would facilitate more efficient access of information i.e. more key questions.

   b. The number and type of classifying dimensions used in the classification task would be positively related to the number of questions and key questions asked because subjects drew on a similar knowledge domain for the perform ance of both tasks.

4. To present an activity approach of the work task; to examine how constructs borrowed from a Soviet activity approach can be employed for the objects of this investigation. Information processing theories have their limitations and do not "locate" activity in time- space or in their natural setting. Nor do they take the goal of the activity into consideration. It is expected that these limitations can be overcome within a broader framework.

Multi-Method Design

The multi-method design employed in this study is patterned after Scribner's (1984) investigation of practical work activities in a dairy plant. In order to understand any

work activity within working corporate environments, researchers must observe 'work in progress'. This will allow for the observation of the interactive processes that lead up to, for example, 'the filling of an order.' This may be as important as, perhaps more important than, the more quantifiable cognitive information analyzed in an experimental task.

A significant portion of the day for many of the workers that I observed is spent in casual interaction and negotiation with suppliers and customers. Much of the information gathered in this dissertation is spontaneous and quite revealing, in other words, information which might not be made apparent in a more traditional laboratory setting. Thus, the "richness" of my observations and interviews in this study is as important as the more "rigorous" data obtained from my more experimental type tasks. Each serves to complement and substantiate the other.

This investigation has several phases (Scribner, 1984b) and each phase contributed to the whole picture. The first phase of this research involved three years of interviews and observations of workers in five fastener companies (i.e., manufacturers and suppliers of metal and plastic parts). The second phase consisted of an experimental sorting task devised to examine how workers organize their knowledge of industrial fasteners, and how this knowledge is utilized.

The third phase consisted of a quasi-naturalistic task generated by observations and interviews with staff. This task was designed to explore a "real life" work activity under semi-natural conditions.The experimental tasks were administered in two sessions with alternating subjects from each group receiving one or the other task first to control for practice effects. The final phase consisted of additional observations of work activity and a series of one hour sessions with management and experts where questions were raised and responses noted. As Scribner (1984b) has stated, far from being separate parts, however, "ideally, seeing and describing in the work-place and seeing and analyzing in the laboratory were activities that informed each other" (1984b, p.4).

This multi-method approach is reflected in the organization of my dissertation. In other words, the findings are presented as they relate to aspects of work activity. This is in part a descriptive study with quantitative components to it, and it is reported as such. The onus is more on the richness of the qualitative data. The experimental tasks are presented together with interview and observational data to describe fully the nature of the particular work activity embedded in the situation in which it occurs. For the experimental tasks, and for the purpose of group comparisons, there are twelve subjects in each group. This enabled me to apply descriptive statistics but limited the inferential

statistics that could be employed on the quantitative data without violating a number of critical assumptions. [1] Correlations, Chi squares for categorical data and T-tests for continuous or interval data are employed wherever possible. Because of the multi-method approach of this investigation, observations, interview and experimental findings are all presented together in the result sections.

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1. The following assumptions would be violated if more sophisticated inferential statistics were used:
   a. Subjects were not randomly selected
   b. Small sample size for analysis of variance
   c. Fewer than five subjects per variable
   d. The five variables in the question- asking task were different and therefore repeated measures were not appropriate.

   If these assumptions had not been violated, I might have used analysis of variance and other tatistical techniques.

CHAPTER 3

Cultural-Historical Analysis of the Development of the Fastener Industry and the Changing Work Activities.

Human Activity assimilates the Experience Of Humankind
(Leontyev, 1981, p.56)

In order to provide a context for this study and in keeping with the concept of activity the historical origin of telephone sales work will be examined and the great transformations both social and cultural that produced telephone sales clerks as an occupational group. The development of this practical activity must be viewed in relation to historical time, the culture in which it is embedded, and with whose help culturally future phenomena will be produced.

The cultural-historical aspect of activity theory was emphasized in Vygotsky's work. Leontyev stressed more the structure of activity and its dynamic aspect. Both approaches, cultural and structural, agreed that human activity mediates man's relation to the environment.

In this chapter I will describe telephone sales from a cultural-historical approach to activity.

Telephone Sales Activity As a Social Historical Category.

With the emerging new technologies, such as the integration of computer-aided design and manufacturing resource planning, history has allowed us for a brief moment in time, to gather data on the work activity of telephone sales clerks in the industrial fastener industry, - a last look before the old patterns of psychological and social experiences of these workers are transformed or inexorably altered.

In Vygotsky's work one encounters the profoundly interesting idea of a historical approach to the study of higher mental functioning and the view that historical-psychological research should be a central part of any investigation. This approach stems from his theory, and that of his followers, concerning the relationship between individual and societal development (Vygotsky, 1978; Wertsch, 1981; Wertsch & Stone, 1985; Scribner, 1985). The theory of activity was developed originally to apply to a collective subject and society. Although neither Vygotsky nor Leontiev were ever engaged in a concrete-historical investigation of specific work activity, Engestrom and Engestrom (1986a; 1986b) recently operationalized and extended this approach to house- cleaning work and physician's work activity as objects of psychological analysis. In the present study, I will attempt to show how the social- historical process

converges on a particular work activity in the fastener industry and how this historical process is being developed by this activity. I shall limit my discussion here to the most general description of the historical development of fastener items, and the social -historical conditions which contributed to the creation of the activity of telephone sales for the individual.

Historical Development of Fastener Items

Fastener items are cultural objects with a long history created by technological and societal needs. They are the product of generations of human activity. The family of fastening items consists of bolts, nuts, screws, washers and rivets. They are called fasteners because they fasten machines and other man-made structures together.

The evolution of modern production and work activity in industrial fasteners has a long history. The phases in the development of fastening work can be analyzed and characterized as the emergence of new types of work activity based on changes in production, product and demand.

Modern threaded fasteners have their origins in the metal nail and the screw which date from before about 3000 B.C. and 300 B.C. respectively (McBain & Uhlig, 1984). Although unthreaded bolts were used to provide static clamping from about 1200 A.D., nails and rivets remained the most important fasteners until the early nineteenth century.

In actuality ,however, the threaded nut and bolt date only from about the middle of the fifteenth century, when they were made by hand, and a nut that fit one bolt was not likely to fit another bolt (Graves, 1985). Until the late eighteenth century, the standard technique for forming large threads was for a blacksmith to pound a special swage, or forming tool, against a hot blank bolt. Usually, the cutting tool had to be held against the blank by the operator, and so it was virtually impossible to get uniform threads. Until the beginning of the nineteenth century most bolt threads were still cut manually using stock and dies and engineering firms and blacksmiths still produced their own bolts and nuts.

Historical Cultural Origin and Transitions Leading To the Job of Telephone Sales Clerk.

Gradually independent craftsmen were displaced by larger metal working shops. In the United States, commercial bolt production started first in 1839 based on hand forging but then mechanical forging was finally adopted. This mechanization stimulated, the machine-building sector and caused a change in the skill requirements of the labor force in the bolt trade and a "splitting up of functions" (Leontyev, 1977). The hand forging of bolts is a skilled craft activity but forging machines only require unskilled machine-minders, a small number of skilled designers, markers and setters of tools, and a small group of supervisory and adminis-

trative personnel. This marked the beginning of greater division of labor and the creation of many "unskilled" manual jobs as well as jobs dealing with these products only in terms of prints and numbers in an abstract decontexualized way. Technical progress during the middle years of the twentieth century was rapid. Machines were designed to handle wire of large diameter and at great speeds. Machines became available for cold forming screws, bolts and nuts- up to six hundred pieces a minute. New products and improved fastener materials were introduced, such as the vibration resistant nut with nylon inserts (stopnuts), increased use of high strength fasteners and greater precision of product associated with the development of precision machinery.

More recently, manufacture and sales came to be undertaken both by large factories employing several hundreds of people and small workshops employing only one or two workers. Because of the proliferation of thousands of new products , factories began to specialize in particular product items. It became impossible for one factory to make, profitably, the large variety of fastening parts required for industry. This produced what is commonly called the "middle man" or the sales distributor, who is willing to carry a large stock of items and save buyers of large industrial firms (Fortune 500), from going to a large number of factories to fill their bill of material. Furthermore, distributors of industrial fastening products are willing to

sell small quantities, which is not the case for factories. Large industrial companies, moreover, hire purchasing agents who buy many different products but have little in- depth knowledge of the products they buy and find, therefore, buying from a distributor easier.

The Development of Telephone Sales Activity.

With the emergence of distributors in the industrial fastening industry, the job of telephone sales clerk was created leading to a further "splitting up of functions." These distributors needed clerks who had the ability to deal effectively with vast quantities of information and technical knowledge so that when a purchasing agent called to place an order, they had the skill and knowledge to ask and answer questions dealing with every type of fastening product made. Gradually, telephone sales were introduced as a discrete occupation performed basically by unskilled white collar workers who were trained on the job. They rarely had 'hands on' knowledge of the product they were selling or the manufacturing process required to make the fastener item.

There have been few technological changes, however, for these office workers (i.e. telephone sales clerks) and their work is still comparable to an earlier period preceding mechanization. Shepard (1971) gives a detailed description of the major stages in the application of machines to paper work among office workers. Telephone sales workers in the fastener industry are situated between the craft stage and

the early mechanization stage. They often employ only pencil, paper, their arithmetic ability and only occasionally make use of adding machines or computers, a practice which does not alter their manual processing of information and is more an adjunct to the many functions that they perform. These sales clerks also shoulder more responsibility and have more freedom than clerical workers in other types of office work.

Telephone Sales As A Process In Change.

With the development of concepts such as zero-defect, EDI (Electronic Data Interchange) and JIT (Just In Time), old patterns of activity in fastener work sites are being revolutionized. For example, with the introduction of the concept of 'zero defect' by industrial giants or the Fortune 500 companies, the job requirements for telephone sales clerks have already become more exacting and are in rapid transition. Sales clerks can no longer get away with selling even the slightest off spec.(specification) item to particular customers and much more depends on the end use. This partly accounts for the variation in performances by experts in the present study.

The recent introduction of computer- integrated manufacturing concepts such as E.D.I (electronic data interchange) which is now being perfected, requires of software programs that will translate and issue purchase orders for materials needed from (OEM) customer computers to the

computers of fastener distributors. The data that will be transmitted will consist of purchase order numbers, part numbers, quantity of each item required, delivery dates, etc. This will gradually create a whole set of new job demands. In other words, the wheeling and dealing and personal contact, to be discussed in the chapters that follow, soon will no longer be in the hands of the sales clerks, because large contracts for yearly requirements are usually negotiated with upper echelon of these companies.

The JIT (just in time) concept is another example. It requires large stocks of material to be warehoused with the supplier to be routed through OEM factories 'as needed' to maximize operating time and remove bottlenecks. This will eliminate the necessity for sale clerks to negotiate for delivery dates.

What will changes such as computer-to-computer buying do to the job of telephone sales? Who will be the experts of tomorrow? Experts of what? Although the ultimate consequences of these transitions in technology for telephone sales clerks are hard to predict, it would certainly appear that in the near future the personal and social interactions and day-to-day negotiations with customers and vendors will be virtually eliminated.

In sum, what is important here is the change of a <u>particular</u> individual activity within a system of social relations embedded in a <u>particular</u> culture at a <u>particular</u>

time in its historical development. The theory of activity was developed originally to apply to the collective subject and society. As Lomov asserts: "With regard to practice, what is meant is historical practice of society, in particular, production, not the activity of each individual taken separately, even though that individual may participate in the production process (1982, p.58)." This suggests that the cultural-historical view traces the course of expertise (mastery) of the collective subject and that human psychological processes are determined by mankind's historically developing, culturally mediated practical activity (Luria, 1976; Vygotsky, 1978; Leontyev, 1981).

CHAPTER 4

PHASE 1: DESCRIPTION OF THE FASTENER CULTURE

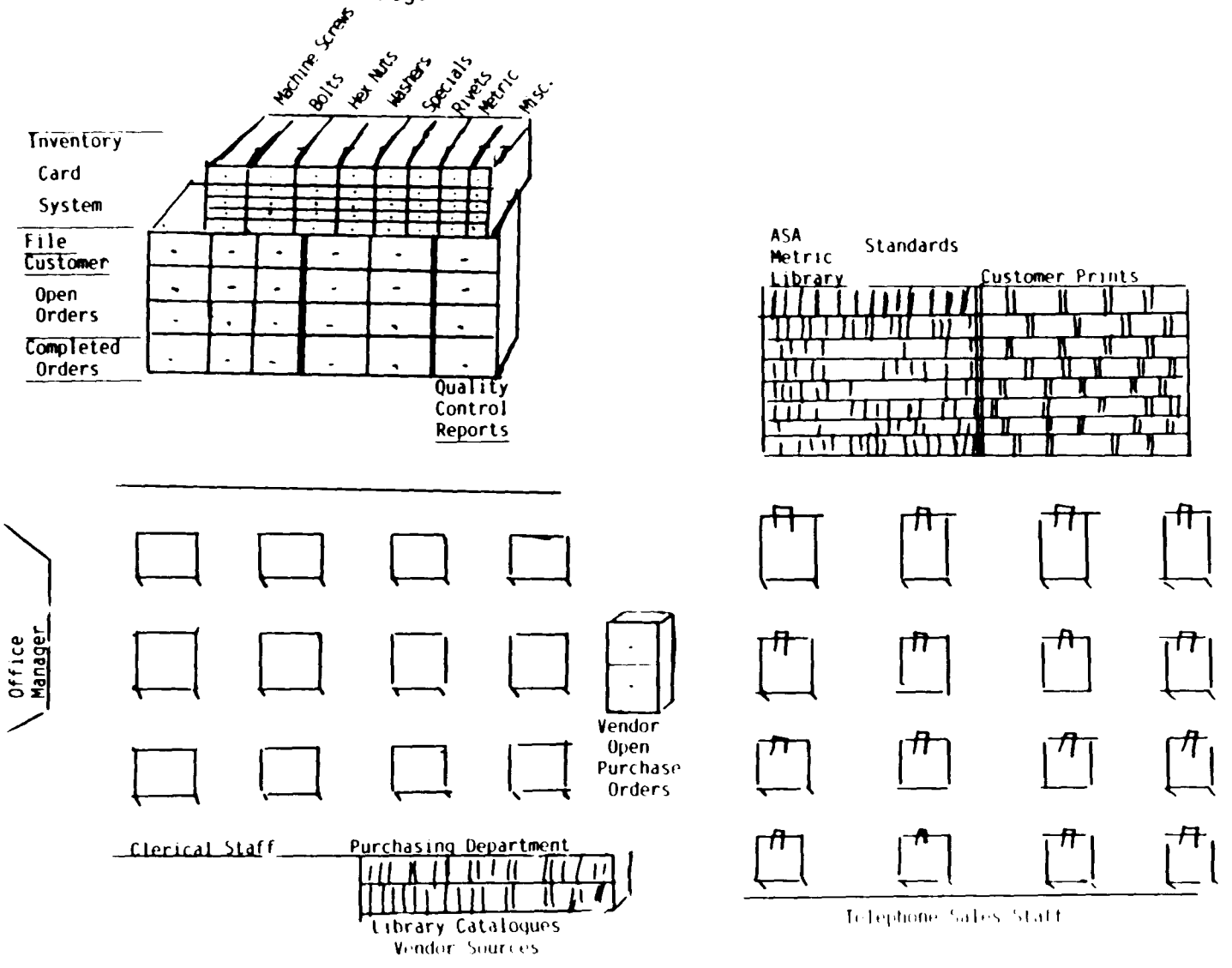
The Industrial Work Setting .

The sites chosen for this study consisted of five small- to medium- sized industrial fastener companies. Each site contained both an office (where management and middle-level employees worked) as well as a warehouse (where material is stored and workers were responsible for packaging, shipping, and quality control). Each site employed 30 - 75 workers and had between 2 - 6 telephone sales clerks. All five sites were major suppliers of industrial fastening items used in the electronic, aerospace, and computer industries. It has been well documented (Scribner, 1986a) that such a setting has an environment which is well-suited for the investigation of cognitive skills, especially in practical activities. Five sites were chosen in order to maximize the representation of the sample chosen. It should be noted as-well that all five sites were necessary in order to obtain a sufficient number of employees with significant work experience.

The Office Setting.

The office component of these work sites was the focal point of this investigation. Each site was remarkably similar. The prototypic environment is illustrated in Figure 1.

Fig. 1 Prototypic Office Layout



The office environment depicted in Figure 1 lends itself to a host of work activities and additionally serves a functional role with varied information sources. Files, catalogs and books are available which enable workers to obtain information on the state of current and filled orders; the state of the company's inventory status, the history of the product being sold (date, number of items and price of previous sales) and the cost of the items. Table 1 illustrates the system of coding for the physical resources of the office.

Table 1

Product Information Resources At Each Site

Resources	Coding
Inventory File	A sequential listing of all inventory material (e.g. steel, brass, and metal alloys) and product category (e.g., bolts, screws, nuts and washers)
Closed Inventory file	A listing of when inventory was sold
Vendor Open File	An alphabetical list of vendors
Blue Print File	A file of all schematic diagrams of fasteners organized in numerical sequence of various OEM[1] customers
Open Order Files	An alphabetical list of customers
Completed Order Files	An alphabetical list of customers
Fastener Standards book	A listing of product categories starting with bolts
Vendor Source Book	An alphabetical listing of vendors and their products organized by product category
Nationwide catalog	An Industry wide source book of all surplus fasteners which are currently in demand.

Reference materials such as the inventory, catalogs, the Vendor Source Book and Nationwide catalog and the Fastener Standards book all index information in

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1.OEM customers are defined as original equipment manufacturers, i.e., end users.

different ways. Here are some examples of the different product information resources located at each site.

For example, the Vendor Source Book[1] lists vendor sources alphabetically and their product categories. The Nationwide catalog lists the product categories by starting with bolts, then nuts, screws and finally washers. Many listed items include prices. Other information sources list product categories alphabetically by material.

Each site maintained a listing of the inventory (inventory file). Products were organized hierarchically in the inventory according to the type of material such as steel, brass, monel or plastic (Figure 2). The inventory of "screws" was subdivided into machine screws, sheet metal screws, and wood screws and cross-classified according to diameter, class of threads, length and head style (binding head, flat head etc.). A typical inventory card lists when, to whom, and at what price the item is sold. It also lists the location and quantity of the material in the warehouse, the supplier sources, and costs.

The "closed inventory file" has product items listed according to the date of the last purchase made by a customer before being sold out.

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1. The terms vendor and supplier are employed here interchangeably.

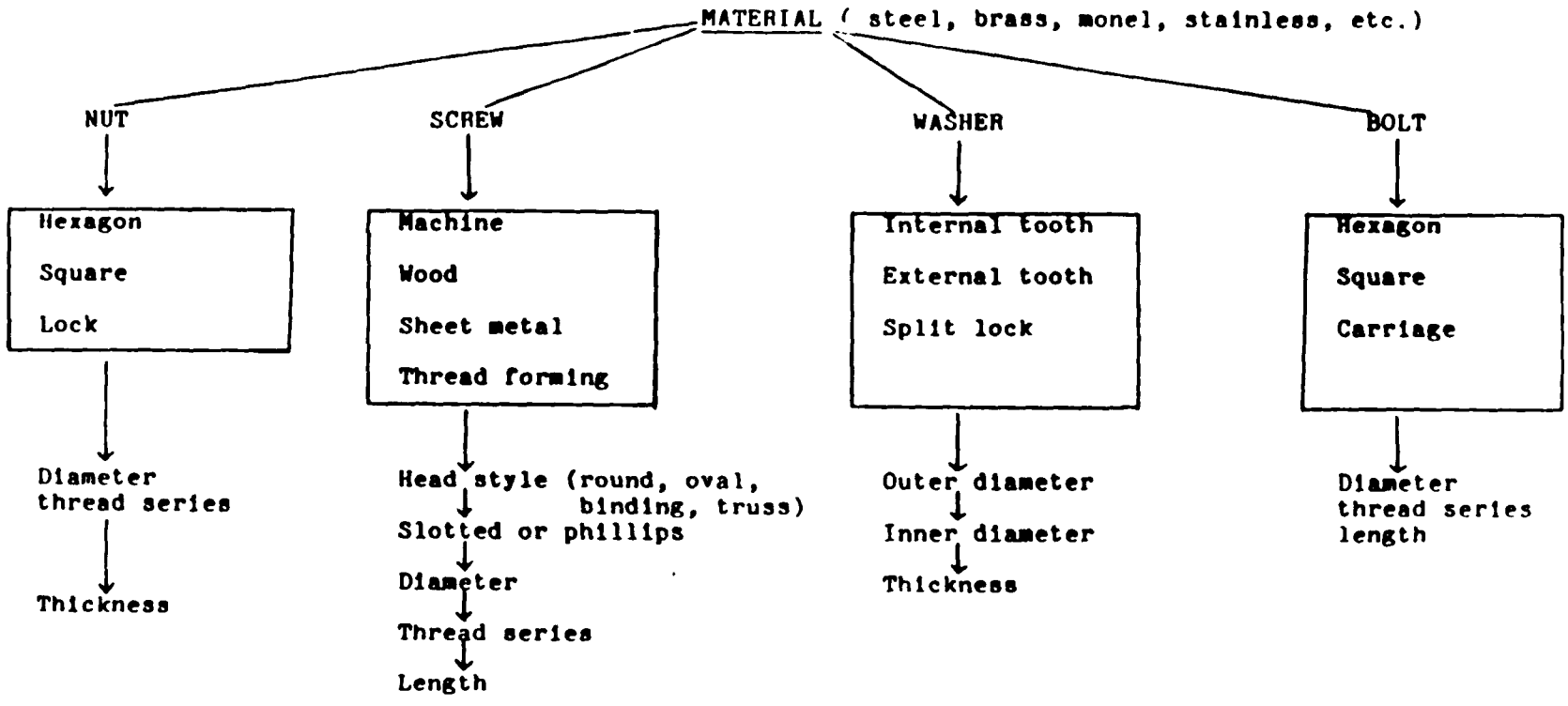

Fig.2 Hierarchical Ordering of Fastening Products as found in the Inventory

New or recently hired workers are often referred by more experienced workers to the inventory as a means of learning the official nomenclature of the fastener industry and other industry - specific information about all products. For the experienced worker, the inventory represents an important information system and a medium for negotiation and bargaining. For example, large blocks of items bought at surplus prices (prices which are below cost) can be used to attract new customers by selling these items well below market value with the hope of higher returns in the future on other product items. This suggests that the office setting has different functional potentials for these workers depending on the level of their expertise.[1] It has previously been shown that experienced workers know how to draw information efficiently from the physical environment so that the environment becomes part of the work activity (Scribner, 1984). For the novice, however, the multiple codings of the office setting only serve to reinforce their lack of knowledge and need to obtain information from other sales persons.

In sum, the office as context for this study is the product of Western cultural, political and economic formations that exist independently and prior to the employment of a particular population of workers. It is also a setting for business or work

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1. According to Leontiev: " Things appear not only in their physical properties but also in that special quality that they acquire in human activity - in their functional meaning" (1979, p.126).

activity in which each salesperson experiences, transforms and is transformed by the work activity.

The Knowledge Domain.

The fastening products that these companies distribute are bolts, nuts, screws, washers, and other miscellaneous items (e.g.,rivets, cotter pins and rods). These product items come in various materials such as steel, brass, bronze, plastic and other metal alloys, in different sizes and shapes as well as different hardness and plating. Table 2 lists the kinds of fasteners and their characteristics.

Table 2

Kinds of Fasteners and Their Key Characteristics

Fastener Category	Type	Head Style (slotted or philips)	Material	Size
Screw	Machine	Round	Steel	Length
	Wood	Pan	Brass	Diameter
	Sheet Metal	Flat	Bronze	Thread series [1]
	Thread forming	Oval	Plastic	
	Shoulder	Truss	Nylon	
	Captivated	Hex	Stainless	
		Binding	Alloy Steel	
Bolt (machine)	Carriage	(same as above)		
	Square			
	Hexagon			
	Elevator			
Nut	Hexagon	(No head style)		Thread Series
	Square			WAF[2]
	Round			Thick-
	Locknuts			
Washer	Flat	(No head style)		Outer Diameter
	Split Lockwasher			Inner diameter
	Internal -External			Thick ness
	Belleville			
	U-Bend			

1.Thread series are groups of diameter pitch combinations distinguished from each other by the number of threads per inch applied to a specific diameter.

2. Width across the flats.

The Fastener Standards book identifies fasteners and products as industry standard fasteners(a uniform list of items and their dimensions based on product category). According to this guide a standard fastener is defined as one that meets the requirements of the nationally recognized American Society of Mechanical Engineers and can be produced by any fastener manufacturing facility or cold heading[1] plant. All other fasteners are classified as "Special or non standard" and fall into two groups:

a. A modified Standard defined as a part which is a standard with one or more of its features or char acteristics slightly changed.

b. An engineered special part requiring special tooling, new engineering concepts and other factors in making a usable part, usually made from bar stock (raw material drawn to a specific diameter).

Although there are many permutations among non-standard items, the domain of fasteners is essentially a closed system which can be fully if not exhaustively specified.

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1. Cold heading is a process whereby metal is forced to flow into dies to form thicker sections and different shapes. The operation is performed in specialized machines where the metal, in the form of wire, is headed and formed.

There are thousands of standard cold- heading fastener items in the industrial fastener industry and special items made from bar stock run into the millions. In fact with the vast technological advances, a whole new language has emerged in this industry resulting in a new dictionary of terms (McBain & Uhlig, 1985). This is what makes the work activity in this industry very complex. Many purchasing agents, whether due to lack of knowledge, time, or false assumptions, do not specify all the dimensions for their fastening requirements. Thus, when speaking to customers and suppliers, the worker in this industry must obtain very specific information without making any presumptions. Here is how one sales clerk whom I interviewed states the situation:

> "Buyers (purchasing agents) are frightened...I'm a buyer, you're my boss. Buyers of fastener products in a production environment often are on the lowest level of dollar value. They usually buy the sweeping compounds, toilet tissue, dust clothes - it's you're starting slot. Then you move to electrical stampings, mechanical whatever...So they know very little about these items. Yet a high degree of technical knowledge is required. For example a 20-30 million dollar company that makes stacking p.c. boards and micro processors fasteners is at the bottom of the list. The bosses say you have to get 3-5 competitive prices. Generally the fastener purchasing agent is in the slot for 1-2 years, and then moves up or leaves. It's like a yoyo. If you're dealing with people that haven't reached a high level of expertise, they don't understand. Some of them are so naive!"

Structured and Unstructured Observations.

The early phases of this research consisted of informal observations of ongoing activity, and discussions in two office sites. Thirty-eight hours of taped interviews with upper and lower level management, expert and novice sales clerks, file clerks, and attendance at meetings and weekly "bull sessions" provided much of the information for the descriptive data of this dissertation. These descriptions according to Leontiev's activity theory are the first level of analysis because they are more concerned with the general activity of work embedded in a socio-cultural environment. These observations, for example, resulted in descriptions of social interactions, joint problem solving, individual problem solving, novice/expert interaction, cultural knowledge exchanges.

A surprising observation was that few workers, from file clerks to top management sat at their desks for any length of time. The world of the office was a center of constant interaction, workers with other workers, or with inventory files, order files, prints, and catalogs. These interactions indicate that work activities in these office sites existed in a dynamic cultural milieu and suggest that there is a relationship between internal and external uses of knowledge. More important, they suggest that social

interaction is an important factor in this work activity. Moreover the back and forth flow of social, cultural, and material interaction occurred within a background of the changing collective industry specific knowledge domain. New and improved products, materials and production methods are always developing in this industry. In addition, individual corporate organizations, such as the sites examined in this investigation are continually discovering new suppliers, different overseas markets and cheaper sources, knowledge specific and private to each fastener corporation.

Systematic observations of telephone workers during work hours revealed many patterns of social and external interaction between workers and the office environment in problem solving situations. Office work has been called a group activity to the extent that workers share a great deal of knowledge (Wynn, 1979).

Extending Vygotsky's thesis, that human development is essentially first a social interactive process, to work activity, this study started with on-the-job observations of ongoing social and material interaction in the office of two industrial fastening companies. To understand the job of a telephone sales clerk and learn how inquiries and orders are handled, I observed four telephone workers individually, for a period of three hours in the morning and three hours in the afternoon, a total of twenty-four hours. Two workers were novices promoted from the bookkeeping and

expediting departments; two other workers had twenty and twenty-seven years of experience working in telephone sales.

I placed myself strategically in the back of the office close to the person I was observing. I was therefore able to observe and record how these workers answered inquiries, checked inventory, consulted with others, looked up information in prints, books and catalogs and used the computer. Every action and interaction was recorded. Social interactions were classified according to who initiated them.

Analysis of the data confirmed my expectations that novices initiate more social interactions than experts. During a six-hour period, two novices initiated a total of thirty- six social interactions as compared to nine initiated by experts. Table 3 illustrates the various actions when participants were observed for periods of six hours each, three hours in the morning, and three hours in the afternoon.

Table 3

On the Job Observations of Sales Workers' Interactions

Subject	H.S.	J.M.	S.O.	C.F.
Self initiated social interaction	5	4	22	14
Other initiated social interaction	11	13	22	10
Telephone self initiated	8	16	4	6
Inventory checking	13	12	6	10
Catalog and Standards book	1	2	2	0
Computer use for inventory check	1	0	4	8

Note S.O. and C.F. were novices

Observations and tape recorded interview data were analyzed and served as the foundation for my dissertation and the formulation of the semi-naturalistic task employed in this study.

Job Description.

The work activity of telephone sales clerks is the primary focus in this dissertation. Although the sales position has no formal educational requirements in these sites, it does require a large body of very complex industry-specific knowledge.

Office managers and top management at the five sites are hesitant to disclose what specific qualifications they

looked for when hiring. "I look for a person with telemarketing experience and telephone personality. The rest is knowledge, stuff you learn here."

Sales of fasteners involve: (a) receiving orders from buyers, (b) checking inventory to fill these orders, (c) buying products from other manufacturing sources if not found in stock, and (d) pricing items. Sales workers follow an order from its inception to its completion, and are entirely accountable to the customer. Each sales person needs to maintain up-to-date information on all orders even after orders are filled and shipped.

Learning industry-specific tasks takes place primarily in the context of the worker's daily activity. Most information is acquired informally, on a day-to-day basis. There tend to be multiple correct solutions to problems, multiple methods of obtaining answers. Generally much depends on prior experience and the ability of workers to extract information from the social and material environment of the office required to survive in the culture of the fastener industry.

One novice sales clerk described her first experience:

> First it's a different language. It's like a nationality if you want to call it that. When I first started in the fastener industry, I started as a receptionist. I knew nothing. I didn't even know the difference between a slotted screw and a philips. I knew nothing at all about hardware. Just being exposed to

> the language. I exposed myself by concentrating on what I was typing. Not just typing but transposing stuff from one paper to the next. That's how I began to familiarize myself with this totally different language. I don't know about the average individual but I speak for myself.

Novice sales clerks are usually asked to carry out the simpler aspects of a task first and only much later are they allowed to do the whole task. For example, at first, novice sales clerks are instructed directly about what has to be done for each phase of completing an order, hoping in that way they will learn by doing and pick up the cultural "lingo" in the process. Only much later are novice clerks allowed to take and fill a whole order. This is very similar to observations of instructions for problem solving between children and adults (Wertsch, Minick & Arns, 1984; Rogoff & Gardner, 1984). Here, however, it minimizes financial loss for mistakes and maintains the good standing of the company vis-a-vis vendors and customers. In this case, learning is structured by factors associated with the cultural and social constituents of business practice. Instruction and learning are only distinct insofar as they are in the service of needs (fit into) of the company agenda. This is very similar to Lave's (1977) analysis of apprenticeship among the Vai and Gola tailors in Liberia and differs from formal education where learning often is achieved through error and the responsibility for tasks is given regardless of success

or failure of the outcome. Novice clerks also learned by example (the expert clerk is often asked by the novice: "How would you go about doing so and so?") and joint sharing of knowledge (weekly "bull sessions" where information is exchanged by all workers and management).

For example when asked:" How do you think your education has helped you in this company," a novice replied:

> [1]N : I actually think that I have learned more here than in my school aside from mathematics and writing.
>
> E: How has school helped you here?
>
> N : This work is similar to a research project in school. You have to go through catalogs and catalogs if it is a rare item. You have to search through four or five books to find out if it is a standard or a special item.
>
> E: Is that to know where to find the informa-tion?
>
> N : You learn who you can go to and ask for more information for the customers questions. Here, fortunately we pool our knowledge on work we have been doing for years. Customers come to us and ask us: "What do you think?" I also go around asking people about difficult items.
>
> E: Who do you ask?
>
> N : Mainly I go either to H. or E.
>
> E: Why?

---

1. N stands for novice and E stands for experimenter.

N : Because they are here a long time. If I ask them about a particular item they take time to look it up for me.

E: Would you go to people who are less experienced than you?

N : Yes. I try mainly to see if they have learned something that I haven't picked up on yet. Evi is here a short time yet; I go to her sometimes because I know she works with items I suspect that I may not touch for months.
I have been here a year working on filling orders a certain way. I am learning to cut corners and use my knowledge.

E: Explain to me what you mean by cut corners.

N : Well, where....I would try to fill an order myself and do all the research myself without speaking with anyone...it would take me twice as long because I would go through so many books. I have learned it's not a one person job...its collective work. So I have learned that if I have any doubt and questions, I don't hesitate to go and ask someone. You can do the job a lot faster and you learn to do it.

E: So the cutting of corners is going to someone to ask?

N : Instead of trying to take on the entire responsibility, I mean, and try impress someone by saying ' I did it all by myself... You are in a work place and everyone, 10, 20 people are doing the same type of job, its collective knowledge the way it should be and they should all interface with each other.

All sales clerks build on bits of information, and every one in the company continuously learns about new products and technology. "I learn from the customer who call me" confided an experienced sales worker. "They ask me

questions which I have never dealt with and I must get the answers. Recently someone called to ask me for my inspection criteria. I didn't know and had to look it up in my Standards book. I am constantly challenged by my customers."

In sum, interviews and observational data indicate large differences in the way workers performed their jobs and made use of their knowledge. Less experienced workers are more concerned with obeying company rules and being accurate because a mistake can cost the company a fortune. Experienced workers are more interested in booking orders and "getting the job done."

Management's evaluation of the sales clerks' performance is based on what they produce in orders and their dollar sales volume.

Filling Product Orders

Taking orders for fastening products requires sales clerks to question customers carefully to obtain and record all the information needed. Each promise to a customer is based on a combination of factors such as product availability from vendors, time required to manufacture the item, plating, secondary processes, etc. Purchasing of basic repeat items ("bread and butter" items) or stock items does not usually present problems. It is the non-standard items that require an estimation of "lead time" (how long it takes to manufacture and process each item) and this is usually calculated by the sales clerk, working back from the "due

date" of a particular customer order.

Bills of materials are broken down into types of items (eg.,lock washers, flat washer, etc.) and either drawn from inventory or ordered from vendors by the sales clerk. An order is not considered complete unless all the items are shipped. However individual items arrive at different times, and must be inspected when received for quality, plating, etc. Sales clerks are required to have up-to-date information on the status of all orders in progress, inventory, billing, shipping and estimate dates when items are expected to be ready for shipment. These interrelated tasks are very complex and processes must be coordinated for the system not to break down.

This is a formal description. The actual working of these companies is much more complicated and does not always run smoothly. In fact one telephone clerk joked: "If there are no problems, I get bored." It is not a clear-cut, step-by-step process, but a constant round of negotiations and problem solving.

The philosophy of these corporations is to encourage negotiation and social interchange if it facilitates order taking, results in profit for the company and 'on time' delivery to the customer. Similar to Schneider (1985): "a greater part of the production planning and control processes involves the social acts of persuasion, negotiation and at times arguments. It all depends on working relationships

with people in other departments, purchasing, quality control, manufacturing and engineering. It is a matter of trust built up over time" (p.17). Therefore, much depends on the working relations of sales clerks with each other, with other departments within the company and suppliers and customers on the outside. Often some of the large industrial companies and priority customers that buy large quantities of fasteners get preferential treatment especially if the sales clerk is friendly with the purchasing agent. This can result in the neglect, however, of other companies.

Thus, the day for these clerks consists of a continuous series of informal negotiations and renegotiations and "putting pressure on to someone to get things done" or getting and performing favors for suppliers and customers with the hope of future return of favors. As one sales clerk summed it up: "The trick is to find the right vendor, negotiate the lowest price, negotiate with customer - both sides of the fence, and most important your personal relations with customers. I dial a joke every morning so I can tell them to my customers."

CHAPTER 5

PHASE 2: KNOWLEDGE ORGANIZATION. A SORTING TASK

Rationale for Selecting a Sorting Task.

Problem solving in more complex domains is not possible without a knowledge base containing substantial amounts of specialized knowledge about a domain. Therefore, in this investigation, it is important to specify not only the content of this knowledge base but also how this knowledge is organized and to facilitate efficient information retrieval for at least some aspects of the quasi- naturalistic work task such as the question- asking component. Sorting tasks are suited for examining organizational processes. This sorting task was selected for several reasons:

a. Observations, interviews, and pilot data indicated that sorting is very much a part of a sale's clerks daily job. Inventory cards are customarily removed from the inventory bins to check stock and at the end of the day sorted and replaced. Thus, this laboratory task was not unlike what these workers do every day.
b. To investigate the variations in knowledge and knowledge organization between expert and novice participants. The

assumption is that expertise in classification is based on more knowledge and a more structured knowledge base (Chi,1981; Chi & Koeske,1983).

In sum, this sorting task was expected to reveal, first, the nature of the telephone sales workers' representation and the structure of their knowledge base (depth and stability) based on the standards and norms of the industry; second the effect of experience on the organization of their knowledge; and third, how that knowledge interacted with certain aspects of the quasi- naturalistic order filling task that follows.

Participants

Twenty- four participants were recruited from telephone sales workers presently employed in industrial fastener companies. They were divided into two groups based on the number of years of experience in telephone sales. Twelve telephone sales people were selected who had less than three years of experience and belonged to the novice group and twelve people in telephone sales that had more than seven years of experience and belonged to the expert group. The expert group was significantly more experienced than the novice group ($t = 6.14$, $df = 11.3$. $p<.01$) and had a mean of 16 years of experience compared to 20 months of experience of the novice group.

Identification of expertise is not necessarily a

simple judgmental matter. Various criteria exist by which a person can be judged an expert. These typically involve experiential accreditation such as academic training, years of experience, or the judgment of a person of authority in the domain of expertise.

In this study, two independent judges within each of the work sites studied, one a member of upper management and the other an expert telephone sales clerk, ranked and evaluated all participants. Their judgment was based on two criteria: sales volume and dollar earnings. These criteria correlated significantly with the employees number of years of experience in sales. Based on these criteria sales clerks were considered novices if they had less than three years of experience but needed a minimum of seven years of experience to qualify as experts.

Telephone sales clerks are the highest paid workers outside of management in the industry. Table 3 shows that those workers that management considers experts earn more than six times the commission and/or bonuses, and book three times as many orders as those that they considered novices.

Table 4

Analysis of Mean Sales and Commissions or Bonuses Based on Three Different Monthly Statements (1987)

	Novice	Expert
Mean monthly gross sales	$15,968.22	$105,401.67
Mean monthly earned commissions or bonuses	$80.06	$527.67
Mean monthly orders processed	44	115

Note. Not all companies revealed this information. n=18; 9 novices and 9 experts.

There were nine female participants among the novice group and no female participants among the expert group. Female clerical workers were only recently promoted to telephone sales jobs and therefore female experts could not be found for this study. Nowhere in the literature, however, does it suggest that there are gender differences with respect to performance measures on sorting. It was therefore assumed that the gender difference between the two experimental groups would have no effect on their performance of the sorting.

The mean age for novices was 39 years (SD = 13.15) and 51 years (SD = 9.88) for experts. This difference was

significant (t =2,58), df =11, p<.05). Not surprisingly, age and experience were significantly correlated (r = .53, p<.01). There was no reason to believe, however, that this relationship affected the results on the performance of these tasks. First, there was considerable overlap between the two groups. Second, even though on the average the age of experts was ten years older than of novices, no one in the literature has ever suggested that there are any cognitive changes between the ages of forty and fifty.

There were no significant differences in the number of years of education: novices averaged 13.42 (SD = 2.7), and experts averaged 13.58 (SD = 2.23). Table 4 provides a summary of the descriptive characteristics of all the participants.

Table 5

Description of Participants (n = 24)

Variable		Range	M	SD	T
Age (years)	N	22-64	39.08	13.15	2.58*
	E	37-64	51.30	9.88	
Exp.(months)	N	1-36	20.5	11.8	6.14**
	E	84-384	201.0	101.06	

Note. N= novice; E= expert.; *p<.05. * **p<.01.

Every participants was compensated with a $100 U.S. saving bond upon completion of the investigation.

Stimulus Materials

The experimental material for this sorting task consisted of a set of 58 3x5 index cards. Each card listed the name and full description (eg. type, size, material, etc.) of a fastening item very much the way it appeared listed in the manual inventory card system of these companies. Twenty- nine frequently used and twenty- nine rarely used items, were drawn from each of the four categories of bolts, nuts, screws and washers.

The four kinds of product items: bolts, nuts, screws and washers were chosen to build into the stimulus materials the possibility of applying a category form of organization. Kind of item in this case was defined as a category. This was the official division of the products in this industry and the basis for my selection.

The other dimension on which these items were selected was frequency of use. This dimension is of central importance to this industry because it forms the basis for price and delivery. A previous study (Laufer, 1985a; Laufer 1985b; Laufer, 1986) has shown that this dimension of knowledge also plays a role in the way participants represent these items.

Frequently and rarely used items will hereafter be referred to as Standard and Special items respectively. A Standard was defined as any product item that met the standards created by the American Engineering Society and was listed in the Fastener Standards book. A Special was defined as any product item

that in some way deviated from a standard item.

[1] The list of items as they appeared on the experimental cards can be found in Appendix A.

Procedure

For the sorting task, a modified sorting paradigm developed by Mandler & Pearlstone (1966) and further developed by Laufer (1985a) was employed. Participants sat in front of a large spacious desk in a private office and were instructed as follows:

"Pretend that you received and have to fill a large order of fifty eight items. To help you do this you have to arrange the items in a certain way. Please group all items on these cards so that they belong together and so that it will help you fill the order. The group can be as large as you wish but it can't consist of less than two items. Please think aloud so that I can understand why you are making the groups."

After the first sort participants were instructed as follows: "Can you group these items the same way again? You have to repeat grouping these items until you have sorted

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1.The five stimulus items from the order filling task were included in the 58 experimental items. In order to accommodate for the five items, ten additional stimulus cards were employed. Thus, although the basic four kinds of product items were retained, the experimental material was modified from my previous study to include more stimulus cards and their presentation was reduced from two sessions to one session.

them the same way twice in a row."

After each trial, the investigator picked up each group one at a time. For the sake of expediency each stimulus card of a group had a number ranging from 1-58. After the first trial the shuffled deck was returned to the participants and they were instructed as follows: "Can you group these items the same way again? You have to repeat grouping these items until you have sorted them the same way twice in a row." With the participants' instructions to group items that " go together " to a criterion of two successive sorts they were permitted to view the array while sorting. Succeeding each trial, the number on each card and grouping made by the participant was recorded by the investigator.

Following the last trial, participants were instructed to: "Return each pile to me and explain why you grouped these items together that way."

Four trials were the maximum number permitted. The fourth trial was considered the last trial. A previous study indicated that if participants do not achieve stable sorts by the fourth trial they are not able to reach criterion even after seven trials (Laufer, 1985). Throughout the sorting task and post- task interview the participants were tape-recorded and the verbal protocols were later transcribed for subsequent analysis. These protocols served as data for the verbal explanations of the groupings.

Data Collection, Definitions and Coding.

Data Collection. Participants' verbalizations were taped recorded on the final trial and post-test interview. The recorded "think aloud" protocols were then transcribed. The sorting data and protocols were segmented into two types of episodes: analysis of the participants' actual sort and their verbal justification for the groupings made. Only the terms and codings that are not self- explanatory will be described here.

Definitions and Coding Procedures.

A feature was defined as a characteristic of an item that served for me as an organizing principle. Classification was limited to six classes of features and to various combination of these:

1. MATERIAL (M) i.e., steel, brass, bronze, etc.
2. KIND OF ITEM (K) defined as a category i.e., bolt, nut, washer, screw.
3. TYPE OF KIND (T) defined as a sub category i.e., flat washer, sheet metal screw, hex head bolt, etc.
4. SIZE (S) i.e., diameter, length, thread series, head size, etc.
5. HEAD TYPE (Hd) i.e., binding head, hex head, etc.
6. SECONDARY PROCESS (Sp) i.e., slotting, captivation, etc.

These features are commonly used in the industry to identify their product items. For example an item identified as:

8/32 X 2 CAPTIVE PAN HEAD MACHINE SCREW, STEEL

illustrates all six classes of features 1) Kind = screw; 2) Type = machine screw ;3) size includes: # 8 = the diameter,

32= tread series, 2 = length; 4) captive = secondary process; 5) head type = pan head; (6) material = steel. This is also the way these items are listed in the inventory cards.

A shared or Common feature was defined as a characteristic that all items in a group had in common, i.e. steel; Hexagon head, etc.

Number of Features consisted of an actual count of the number of classes of common features of items within a pile upon which participants based their classification which ranged in this study from 1-6.

Figure 3 shows a protocol fragment illustrating the features I employed to organize the sorts and the coding procedure:

Figure 3

Coding Procedure Of A Sorting Protocol

Pile 1 consists of 4 features: 1. kind= screw; 2. type= cap screw 3. length = 1 1/8; 4. head type= hex

1/4 - 20 X 1/8 hex head cap screw, brass
1/4 - 20 X 1 hex head cap screw, silicone bronze
1/4 - 20 X 1/2 hex head cap screw, steel

Pile 2 consists of 1 feature: material= steel

#6 cup washer,steel
#10 External countersunk washer, steel
1/2 "Beveled washer, steel
6/32 X 3/16 slotted flat head machine screw, steel

Pile 3 consists of 1 feature: secondary process= drilling

5/16 -18 X 1 drilled fillister head machine screw, steel
3/8 - 16 X 2 drilled hex head bolt, steel
1/4 - 20 X 1 drilled fillister head machine screw, silicon bronze

---

Pile 4 consists of 2 features: 1. kind= screw; 2. material= brass

1/2 -13 X 2 shoulder screw, brass
8/36 X 1 oval spanner head machine screw, brass
1/4 - 20 X 11/2 hex head cap screw, brass
4/40 X 5/16 binding head machine screw, brass
6/32 X 5/16 binding head machine screw, brass
6/32 X 1/4 binding head machine screw , brass

This protocol excerpt is characterized by one pile with 4 features, two piles with only one feature and one pile with two features. The features (classes of dimensions) consisted of two Kind and two Material and one Type, Secondary Process, Size and Head Type. In coding, each feature received a score of one.

A residual group was defined on the " basis of features shared by some members of a group, but also by members of other groups...but no feature shared by all members of the group" (in question)(Gobbo and Chi, 1986, p.235). Residual groups will hereafter be referred to as miscellaneous groups.

" Inventory-bound" statements are defined as explicit statements ma ry as their grouping explanation during or after their last

trial.

" Order-bound " statements are defined as explicit statements made by participants of the use of order taking or order filling as their grouping explanation during or after the last trial.

Results

With my original hypotheses in mind, seven aspects of sorting were measured for novice and expert groups: (1) the number of trials to reach criterion; (2) mean time per trial; (3) the number of groups; (4) the average number of items per group; (5) the number of features per group; (6) the types of features used as criteria in a group and finally, (7) the verbal justification for the sorting pattern.

The data on five measures of sorting on the last trial are shown in Table 6.

Table 6

Mean Performance Scores on Five Measures of Sorting

Measure	Novice (n=12)		Expert (n=12)	
	M	SD	M	SD
No. of trials to criterion	2.92	1.16	3.83	0.94
Mean time per trial (min.)	11.83	2.59	8.87	2.56
No. of groups made on the last trial	15.00	5.01	12.09	3.53

Analysis of Groupings. The following were the major findings:

First, fifty percent of the novices were able to achieve a stable sort within two trials whereas all experts needed at least three trials (X^2 = 12.0; df = 1; p =<.005). Four experts and two novices never achieved two consistent sorts even after four trials. According to previous findings (Mandler & Pearlstone, 1966) two consecutive identical sorts indicate a stable mental representation. The present findings therefore suggest that generally the sorting pattern of novices was based on some meaningful representation whereas the sorting pattern of experts was more ad hoc.

Second, experts compared to novices took on the average significantly less time to sort (t= 2.82; df =20; p= <. 01). These results could have been due, however, to the fact that because experts required more trials, they may have had more practice and therefore needed less time.

The third and fourth aspects that contributed to the differences in sorting schemes were number and size of groupings. In general, experts produced fewer and larger groups on their last trial than did novices. Experts averaged 12 groups with 5.2 items per group and novices averaged 15 groups with 4.3 items

each. Thirty-six percent of the novice groups, however, consisted of only two items compared to 17% of the groups made by experts.

Fifth, when the number of features per pile were broken down for both novices and experts, as a whole, novices based their grouping criteria generally on the same number of features as experts. The mean number of common features per pile on the last trial for novices was 2.9 and 2.5 for experts.

Finally, the class of shared features used as grouping criteria for each pile shown in Table 7 revealed no expert\ novice difference.

Table 7

Sorting Organization by Features

Feature	Novice	Expert
% of groups		
Material	25	25
Kind	30	33
Type	26	22
Size	6	10
Secondary process	5	4
Head style	8	6

Of interest was the fact that 75% expert participants formed a miscellaneous or residual group(s); only 33% novice

participants left residual group(s). Contrary to these findings Gobbo and Chi (1986) demonstrated in their studythat experts made more exhaustive sorts and novices left more residual groups.

Figures 4 ,5 and 6 represent examples of three different types of protocols. Based on my request to "sort like an expert", the first protocol consisted of an ideal sort generated by an owner of one of the companies. The other two protocols were specifically selected to illustrate the typical differences found in the expert and novice sorting schemes and therefore are not totally representative of all the protocols in each group for that reason. Generally, on the standard items, there was some overlap between the sorting patterns of the novice and expert groups. More interesting, however, as these sorting protocols illustrate, novices typically performed more closely to the "official" or "ideal " standards of the company than did experts.

Key: Material = M
Kind of item = K
Type of item = T
Size = S
Head type = Hd
Secondary process= SP

Figure 4

Officially Suggested Sorting Scheme

Sort Groups	Shared Features	Score
1. 4/40x5/16 binding hd. m/s, steel 10/32x1/4 " " " "	M,K,T,Hd	4
2. 4/40x5/16 binding hd. m/s, brass 6/32x1/4 " " " " 6/32x5/16 " " " "	M,K,T,Hd,S	5
3. 8/32x1 oval spanner hd. m/s, brass 8/32x 2 pan hd. captive m/s, steel 6/32x3/16 slotted flat hd. m/s, steel	K,T	2
4. 4x1/4 slotted pan hd. sheet metal, steel 6x1/4 " " " " " " #10x1/2 " " " " " "	M,K,T,Hd,S,Sp	6
5. 1/2-13 slotted hex nut, WAF3/4 th.9/16, steel 1/2-13 slotted hex nut, WAF7/8 th.1/2 , "	M,K,T,Sp	4
6. 8/32 square nut, WAF11/32 th.1/8, steel 8/32 square nut, WAF3/16 th.1/16, steel	M,K,T	3
7. 6/32 hex nut, WAF1/4 th.3/32, brass 6/32 " " , WAF5/16 th.7/64, " 8/32 " " , WAF1/4 th.3/32, " 8/32 " " , WAF5/16 th.7/64, " 8/32 " " , WAF11/32 th.1/8, "	M,K,T,S	4
8. 4/40 " " WAF3/16 th.1/16, steel 4/40 " " WAF1/4 th.3/32, " 8/32 hex nut, WAF11/32 th.1/8, "	M,K,T.S	4

Figure 4 (continued)

9. 2/56 hex nut, WAF 1/8 th.1/16, st.steel 2/56 hex nut, WAF 3/16 th.1/16, "	M,K,T	3
10.#6 cup washer,steel #8 U-bend washer, steel 1/2 diam. beveled washer, steel	M,K,S	3
11.#4 internal lockwasher, steel #6 int.-ext. " " #8 int.-ext. " " #10 ext.countersunk lockwasher, steel	M,K,T,S	4
12.#6 split lockwasher, phospho bronze #8 " " silicom bronze	M,K,T	3
13.#4 split lockwasher, steel #10 " " "	M,K,T	3
14.#4 flat washer ,steel #6 " " " #10 " " "	M,K,T,S	4
15.#4 flat washer, brass #8 flat washer, brass	M,K,T	3
16.1/4-20x1 drilled hex.hd., phospho bronze 5/16-18x1 drilled fill.hd. m/s ,steel 3/8-16x2 " hex hd. bolt, steel	Sp,S	2
17.1/4-20x1/2 hex hd. cap screw, steel 5/16-18x1 1/12 hex bolt, steel 3/4-10x2 hx hd. bolt, steel 3/4-10x5 tank bolt, steel	M,K,T,S	4
18.1/4-20x1 hex hd cap screw, silicon bronze 1/4-20x1 1/8 hex hd cap screw, brass 3/8-16x2, " " " " silicon bronze 1/2-13x2 hex bolt, silicon bronze 3/4-10x2 hex bolt, brass	M,T,K,S	4

Figure 4 (continued)

19.	10/32x7/8 thumb screw (shoulder), steel 1/2-13x3 stripper bolt, " 1/2-13x2 shoulder screw, brass	SP,S	2
20.	1/2-20x2 carriage bolt, steel 3/4-10x2 elevator bolt, steel	M,K	3
	# of Groups = 20	Features =	70

Figure 5

Novice Sorting Scheme

Sort Groups	Shared Features	Score
1. 4/40 hex nut, steel 1/2-13 slotted hex nut, steel 4/40 hex nut steel 1/2-13 slotted hex nut steel 8/32 hex nut steel	M,K,T	3
2. 8/32 square nut, WAF11/32 th.1/8 steel 8/32 square nut, WAF 3/16 th.1/16, steel	M,K,T	3
3. 8/32x1 oval spanner hd. m/s, brass 1/2-13x2 shoulder screw, brass	M,K	1
4. 8/32x2 pan hd. captive m/s, steel 5/16-18x1 drilled fill. hd m/s, steel 6/32x3/16 slotted flat hd m/s, steel 10/32x1/4 binding hd. m/s, steel 4/40x5/16 " " " , steel 10/32x7/8 thumb screw, steel	M,K	2
5. 3/4-10x5 tank bolt, steel 1/2-13x3 stripper bolt, steel 1/2-20 x2 carriage bolt, steel 3/4-10x2 elevator bolt, steel	M,K,T	3
7. #6 cup washer, steel #8 U-bend washer, steel 1/2 diam. beveled washer, steel	M,K,S	3
8. 1/4-20x1 drilled fillister hd m/s, bronze 4/40x5/16 binding hd m/s, brass 6/32x1/4 " " " " 6/32x5/16 " " " "	M,K,T[a]	3
9. #10 split lockwasher,steel #4 split lockwasher, steel	M,K,T	3

Figure 5 (continued)

10. #8 int.-ext lockwasher, steel #6 " " " " #4 int. " " #10 ext. countersunk washer, steel	M,K,T	3
11. 2/56 hex nut, WAF1/8 th.1/16, st. steel 2/56 hex nut, WAF3/16 th.1/16, " "	M,K,T	3
12. 6/32 hex nut, WAF 1/4 th. 3/32, brass 6/32 " " , WAF 5/16 th.7/64, " 8/32 " " , WAF 1/4 th.3/32, " 8/32 " " , WAF 5/16 th.7/64, " 8/32 " " , WAF 11/32 th.1/8, "	M,K,T,S	4
13. #8 split lock washer silicon bronze #6 split lockwasher, phospho bronze	M,K,T	3
14. #4x1/4 slotted pan hd sheet metal, steel #6x1/4 " " " " " " #10x1/2 " " " " " "	M,K,T,Hd,S,Sp	6
15. 1/4-20x1 hex hd. cap screw, silicon bronze 1/2-13x2 " bolt, " " 1/4-20x1 1/8 hex hd. cap screw, brass 3/4-10x2 hex bolt,brass 3/8-16x2 hex hd. bolt, silicon bronze	M,K,T	3
16. 3/4-10x2 hex hd. bolt, steel 5/16-18x1 1/2 hex hd. bolt, steel 1/4-20x1/2 hex hd. cap screw, steel 3/4-10x2 elevator bolt, steel	M,K,T	3
17. #8 flat washer, brass #6 flat washer, brass	M,K,T	3

Figure 5 (continued)

18. #6 flat washer, steel #8 flat washer, steel #10 flat washer steel	M,K,T,S	4
# of Groups = 18	Features =	53

Note.[a]- Brass, phospho-bronze and silicon bronze are all non-ferrous metals and therefore for the purposes of this sorting task are grouped together.

Figure 6

Expert Sorting Scheme

Sort Groups	Shared Features	Score
1. 6x1/4 slotted pan hd. sheet metal, steel 10x1/2 " " " " " " 4x1/4 " " " " " "	M,K,T,Hd,Sp	5
2. 10/32x7/8 thumb screws, steel 1/2-13x2 shoulder screw, brass	Sp,K	2
3. 5/16-18x1 drilled fillister hd. m/s, steel 6/32x3/16 slotted flat hd. m/s, steel 10/32x1/4 binding hd m/s, steel 4/40x5/16 " " " " 6/32x5/16 " " " , brass 6/32x1/4 " " " , " 4/40x5/16 " " " , " 1/4-20x1 drilled fillister hd. m/s, silicon bronze 8/32x2 pan hd. captive m/s, steel 8/32x1 oval spanner hd m/s, brass	K,T	2
4. 3/4-10x2 hex hd bolt,steel 3/8-16x2 drilled hex hd. bolt, steel 5/16-18x1 1/2 hex bolt, steel 3/4-10x2 hex bolt, brass 1/4-20x1 1/8 hex hd. cap screw, brass 3/8-16x2 hex bolt, silicon bronze 1/2-13x2 hex bolt, silicon bronze 1/4-20x1/2 hex hd. cap screw, steel 1/4-20x1 hex hd cap screw, silicon bronze 1/2-20x2 carriage bolt, steel 3/4-10x2 elevator bolt, steel 3/4-10x5 tank bolt, steel 1/2-13x3 stripper bolt, steel	K	1

Figure 6 (continued)

5. #10 flat washer, steel #4 " " " #6 " " " #8 " " , brass #6 cup washer, steel 1/2" beveled washer, steel #6 flat washer, brass #8 U-bend washer, steel	K	1
6. 6/32 hex nut WAF1/4 th.3/32, brass 8/32 " " WAF1/4 th.3/32, brass 8/32 " " WAF5/16 th.7/64, brass 1/2-13 slotted hex nut, steel 8/32 hex nut WAF 11/32 th.1/8, brass 6/32 hex nut WAF 5/16 th.7/64, brass 1/2-13 slotted hex nut, steel 2/56 hex nut WAF1/8 th.1/16, st. steel 2/56 hex nut WAF3/16 th.1/16 " " 8/32 hex nut WAF11/32 th.1/8, steel 4/40 " " WAF1/4 th.3/32, steel 4/40 " " WAF3/16 th.1/16, steel 8/32 square nut WAF 11/32 th.1/8, steel 8/32 " " WAF 3/16 th.1/16, steel	K	1
7. #10 split lockwasher, steel #4 split lockwasher, steel #6 int-ext lockwasher, steel #8 int.-ext lockwasher, steel #10 ext. countersunk washer, steel #4 int lockwasher, steel #8 split lockwasher, silicon bronze #6 split lockwasher, phospher bronze.	K	1
# Groups = 7	Features =	13

The novice and expert protocols shown illustrate the differences generally found for each group. On comparing these three protocols, taxonomic relations played a role in the grouping operations of both novice and owner. They grouped frequently into taxonomic categories and sub-categories similar to those found in the inventory. For example, the novice and had 4 sub-categories of nuts, 5 sub-categories of washer, 3 sub-categories of bolts and 2 sub-categories of screws. The owner sorted similarly with 5 sub-categories of nuts, 5 sub-categories of washers, 2 sub-categories of bolts and 4 sub-categories of screws. The novices organized the items into 18 groups employing 53 features compared to 20 groups and 70 features by the owner.

In contrast the expert formed larger categories with only a total of 3 sub-categories consisting of sheet metal and machine screws and split lockwashers. In addition the experts also employed only 14 features as criteria for organizing the items into seven groups. Thus, both novice and owner used many more features as organizing principles for their groupings than the experts with more groups consisting of fewer items. This was a surprising finding. It suggested that not only did this novice sort more like I would have expected an expert to sort but also that his sorting scheme was closer to that of the officially accepted

pattern in the industry. In other words the preferred mode of classification for this novice was taxonomical and conformed more closely to the ideal or canonical representation of the fastener culture than that of the expert.

These novice/expert protocols illustrate the differences in the patterns of sorting generally found between the expert and novice groups.

Analysis of Grouping Explanations: Analysis of grouping explanations refers here to the verbal statements in the protocols made during and after the last trial. The verbal justification of the two groups had different general explanations for their sorting behavior. Nine out of eleven novices gave the inventory as the predominant explanation for their sorting pattern whereas ten experts viewed the sorting task from an order-taking perspective, i.e., order-taking or order-filling as a way of accounting for their sorting behavior. Subjects were classified on the basis of their predominant explicit verbal statements. Those statement referring to the inventory were coded as inventory-bound and those statements referring directly to order taking or implying order taking such as" these items have to be ordered" or 'when I do my buying that's what I do first" were coded order-bound.

Explicit verbal statements by all participants relating to inventory and order type explanations are shown in Figure 7. The protocol excerpts are specifically chosen to

illustrate the way experts and novices responded to the experimenter's question of their groupings on the last trial:

Figure 7

Inventory Type Explanation

Novice 1: " They're from the same family - that's how you'll see them in the inventory. When I check stock it's easy to find them."

Novice 2: " Starting with machine screws (pile 1) we have all our machine screws in inventory and I arranged the cards by diameter and length just that way."

Novice 3: " It seems like the easiest and the fastest way. I am not sure how these things go together because I am not here long enough but this way is a little bit like the inventory except I don't have enough cards to do it like that. Is this right?"

Novice :4 " I follow the inventory form so that I can see how many items I have in stock or if I can modify some of them."

Novice 5: " Because it is a little bit like the inventory except I don't have enough cards to do it like that."

Novice 8: " Basically they are sorted according to type and they progress from small to large. I took machine screws - I put them together and then according to their size just the way we have it in our inventory."

Novice 10: " Well, because I know how our inventory cards are and I know that washers are always going to go numerically from one drawer to the next. I know what I would put in drawer one, what I would put in drawer two..It's location in the inventory."

Novice 11: " I go to the inventory to check stock - that's how I did it. I thought of the inventory. When I don't have items in stock I worry further."

Novice 12: " I did it according to categories, material and type of item and size. See, that's how we have it in the inventory. I am doing it according to the inventory because when I set it up this way, I think this way. I did the same for each batch."

Expert 14: " Exactly...but our inventory is based...I think we might even have a section under nuts for slotted nuts. So, I would look under slotted nuts. But, basically I would look under steel nuts and under that would be slotted or it would be special."

Expert 18: " I am doing it according to the inventory because when it is set up this way I think this way - I will do the same for each batch... I'm sorting them to fill an order, but my mind is set up the way my inventory is set up... These are miscellaneous bolts..specials...these we never have in stock. They have to be ordered...they are screw machine parts."(Transitional stage)

Figure 8

Order-filling Type Explanations

Novice 6: " I worked in the shipping department and they used to tell you washers with washers, screws with screws...because as I said when I used to fill orders in the shipping department, you'd go down an aisle and it was ,marked washer and you'd pick the orders for the washers."

Novice 7: "That's not the way I would handle an order".
E. How would you handle an order?
Novice 7: "I'd get a list. I'd see what I have in stock and I'd buy what I don't have and then I'd write it up."
E. How would you write it up?
Novice 7: " I'd give it to Al to check stock and then after the stock is checked what I don't have in stock I buy."
E: What did you do here?
Novice 7: " Well you saw, I looked at my

fillister manual to go through sizes. It depends on how many I had. Like slotted

machine screws, I had only three, so they were no problem"...

Expert 13: " Based on material mostly and then the items. To me these are small usage items. In other words few people carry them. Very few people- that's why I put them together this way. Yeah, (for this order) I would have to call one or two or three vendors to see if they carry these."

Expert 15: "I divided them up quickly for my own benefit- the machine screws, sheet metal screws ,the carriage bolts, the washers, the nuts - thumb screws and drilled fillister head screws are special. While initially it's 7 areas to the order, I can further break them down to check them out with what we have in stock."
Experimenter: Is that what you did here?
Expert 15: " No, not really because I know pretty much what we have and what we have to order."

Expert 16: "In order to fill this order quickly I thought the less piles I would have to work with - as long as I know this group of machine screws is brass or steel -I'd know all my machine screws were in this particular pile."

Expert 17: " If I was going to process a buy, here are my internal and external lockwashers, which I would buy from Everlock or I'd classify according to the source we buy from."

Expert 19: " When I put brass in one pile that's because a lot of the suppliers I use in some cases carry many of those items. From that I subdivided afterwards to more specific from the more general. When I do my buying, that's what I do first."

Expert 20: " As I write up my orders, I like to have screws in sequential order, followed by nuts and followed by washers and bolts toward the end. Also not too common items towards the end. This makes it easier if my

customer calls me; then I can pull out the order which consists of 5 or 6 pages. I can

leaf through right away instead of having to read through item by item to see where it is. I have the idea where the item is. I think by being organized like this, it helps me all the way through the length of the order. It gives me more time to myself by doing the job where it's right."

Expert 21: " Usually when peoples' shelves are stocked, they put bolts first, then they put machine screws, the washers. They don't intermix different material. Generally your steel is all in one section, brass is all in one section, bronze next. That is how I order it."
Experimenter: How is it in your inventory?
Expert 21: " Not the way it is shelved. I think machine screws come first."

Expert 22: " I put them in like specials because there's only like 6 or 7 so I put them in one pile and marked it specials. That makes them easier to order because I know they are not in stock."

Expert 23: " It does have to do with type of material but then it's common- I mean it's a family and you can buy it from the same place....because it's all lock washers and I can buy them from the same place....They're family. You can go fast without wasting time. If you have to check stock for an order, it's quick and more or less it's a family."

Expert 24: " Hex nuts, some square nuts, but they can all be found in the same catalog. These are all machine screws ; these are self- tapping screws. This is another category - hex head caps and hexagon bolts."
Experimenter: Why?
Expert 24: " Because sometimes customers would call out hex bolt and really want hex cap and vice versa - they're very close. These are both slotted nuts. These are all flat washers; these are lockwashers whether they are internal, external or split. These are all special washers like U-bend -miscellaneous washers. Drilled fillister head, stripper bolts and shoulder screws are very

close. I took the same category for those - these are miscellaneous crazy parts -spanner

heads. These I would first look up in my standards book and catalogs for dimensions. That will give me an idea where to buy them. They would be large diameter bolts - very special -some of them. They cost a lot more than standards. These we rarely carry in stock."

Table 8 summarizes the major verbal sorting explanations employed by all participants unrelated to any specific feature of the items.

Table 8

Verbal Sorting Explanations Not Directly Linked To Any Feature Descriptors Of Items On The Last Trial

Category of Explanation	Number of participants using each category of explanation	
	Novice	Expert
Inventory bound	9a	2
Order bound	2	10b
Groups to differentiates between Specials and standards*	3	9
Groups to buy (from vendors)	0	5
Groups to save time	0	6

Note. Many participants gave more than one verbal explanation.
*Made miscellaneous pile(s) and explained that these are special items.
[a] One out of 12 novices did not give any explicit explanation.
[b] One expert gave both inventory and order as an explanation and it was counted here as an order type explanation.

These findings suggest that experts employed a greater number of grouping principles and exhibited more variability in their choice of grouping principles than novices. Interestingly, nine experts differentiated between standard and special items by verbally labeling their miscellaneous or residual piles as 'special' and the remaining groups as 'standard' items in their verbal explanations. Among the four novices who formed miscellaneous groups only three

employed 'special' as a verbal label.

Further insight into the way participants categorized was given by their justification of the feature descriptors directly linked to the item that they employed as they talked about the groupings they created on the last trial. Table 9 shows the feature descriptions. For example, in responding to the experimenter's question:"What was your sorting criteria on these piles? ", Novice 12 responded: "I did it according to categories, material, type of item and size. See, that's how we have it in the inventory. "Expert 16 : "What I did is, I grouped all my bolts together... all my machine screws ...washers, in other words again, the less families that I have to work with the quicker it would be for me to process these orders rather than double the number of piles...mostly the basic categories....not material or size."

Consistent with previous findings , novices employed more explanatory criteria directly linked to the physical aspects of the items than did experts. Seven novices explained their sorting patterns according to the three major categories, material, kind and type, which is also the pattern typically found in the inventory (see Table 9). Only one expert used these three feature descriptors. Eight experts gave explanations not directly related to the physical characteristics of product items.

Table 9

Verbal Sorting Explanations Directly Linked To Feature Descriptors Of Items On The Last Trial

Feature Descriptors[a]	Novices	Experts
Material	7	7
Kind	8	1
Type	10	6
Head type	2	3
Size	2	3
Secondary process	0	0
No rule	2	5

Note. n=23; one participant missing.
[a] Ten novices and 4 experts used multiple feature descriptors.

Most experts separated those items that were standard and possibly in stock from those that might have to be bought, to save time because "the customer is always in a hurry."

For example expert 23, indicated that time was the most important criteria: "For the right way to do it there should be a sequence. Let me repeat, first would be 4/40 nuts, then 6/32 then 8/32 and then 12/24. But for an order it doesn't really matter. What matters is that it goes fast. It's easy to save time. The time factor is very important because

you get lost. Someone can take two hours." Here the participants make sure that the experimenter understands that there is a standard or official way to organize the material but for the sake of efficiency he has found an alternative way of sorting. Elsewhere he continued to discuss his own sorting scheme:" I put these together- one is steel, one is brass and one is silicon bronze. The batch is together, but for my edification I know first is steel, then brass..." Another expert in discussing his own sorting scheme explains: "I put them together so I can buy them from the same source."

Several experts mentioned that they sorted in the course of their work, implying that they had no generalized sorting scheme but sorted as they went along. (For an example, see chapter 8). Two experts used price as a grouping principle. Comments such as: "These are brass items -I put them together because brass is more expensive than steel." and "These flat washers are junk - I don't handle these. They're only a penny a piece" are illustrative.

In sum, from the novice/expert means of the combined data shown on Table 22, it can be seen that the sorting schemes of novices differed from experts in several respects. On the performance measures, experts generally reached fewer stable groupings and needed more trials than novices. They also used fewer features per group as sorting

criteria than novices. However, experts formed fewer groups with more items per group than novices and required less time doing so.

An inspection of individual protocols indicated that each group of participants was highly consistent in their use of either order or inventory rule in the piles of their final sorting trial. Experts often employed additional general approaches in tailoring their sorting schemes not always directly related to the physical aspects of the stimulus material. Novices' sorting explanation on the other hand was generally more directly tied to the product items. These were similar to the official standards of the fastener industry. This suggests that experts and novices exhibited different sorting patterns. In short, sorting for experts represents not an end in itself, nor is technical knowledge for them the salient structuring aspect of this activity. They have many other alternate approaches. For novices, on the other hand, inventory knowledge and knowledge organization appears to be the major structuring agent.

Discussion

Sorting tasks have been known to be promising techniques for the study of mental representation of knowledge (Mandler, 1983; Chi, 1985).

In recent years attention has been focused on developmental changes that are linked to specific domains rather than age. For the purpose of this study, focusing on domain-

specific knowledge enabled me to broaden the scope of the field and find support for my findings, drawing from both developmental and adult psychological literature. In Mandler's words (1983):

> " To the extent that acquisition of knowledge is domain specific rather than consisting of sets of broad principles applied to many areas of thought and behavior, major implication for development follow. This view allows shifts in representation to occur but neither confines them to particular periods of life or assumes that they are concentrated in a particular period. Instead it stresses continual shifts in the accessibility of knowledge as a function of experience in a domain (Mandler, 1983,p. 474)."

This sorting task was selected to reveal the nature of the telephone sales worker's representation, the nature and structure of their knowledge base and the effect of their experience on the organization of their knowledge of industrial fasteners. It was difficult however to make predictions of the results in the present study on the basis of data already available in the literature because of the nature of the industry- specific materials employed and the large number of different sorting criteria.

Findings as they relate to predictions.. The findings are described as they relate to my original hypotheses:

I expected that with increased expertise the knowledge base of telephone sales workers would be more hierarchically organized into taxonomic categories and subcategories, (Chi, Glaser & Rees, 1982 ; Reif & Heller, 1982) more elaborately

represented (Gobbo & Chi,1986) and more stably organized (Laufer, 1985).

Contrary to expectations, the sorting performance of novices and experts exhibited a reverse trend on several measures. I will discuss the findings with respect to my original hypotheses. The four major points that I will discuss in this section are the number of trials, the number of features, the number of groups and items per group and finally the participants' sorting explanations.

Analysis of the sorting performance measures revealed that:

First, experts required a greater number of trials than novices to achieve a stable sort. In addition, fewer experts were able to achieve stable sorting schemes (one in which all items were sorted the same way from trial to trial) with the limit of four sorting trials. Thus my hypothesis was not born out with respect to stability of organization and on this measure experts and novices exhibited a reverse trend.

Second, experts also employed fewer features as grouping principles in comparison to novices. The features used by novices generally involved taxonomical relations such as the three "Material," "Kind," and "Type." Experts more frequently employed only one or two of these features as organizing principles. Since number of features in this study was used as a measure of richness of knowledge and an

indication of an elaborateness of knowledge representation, my hypothesis was not born out based on this measure. These findings again exhibited a reverse trend. In short, using the number of trials as measure, novices exhibited more stability of organization than experts. Based on number of features as a measure, novices had a richer representation of the experimental materials than experts. In marked contrast, experts' sorting indicated a more unstable, inconsistent and idiosyncratic pattern often associated with an unstable mental representation based on the number of linkages exhibited by younger children and novice participants, and the quality of their representation was less elaborate.

Thus a major discrepancy between Chi's investigation and the present study was in respect to the number of features used as sorting criteria. According to Chi(1983) (Gobbo & Chi, 1986) the number of features attributed to one item is indicative of a participant's knowledge organization (Chi, 1983) and the quality of their representation. Patterns of sorting for Chi's child dinosaur expert exhibited far greater number of linkages within groups for the familiar than for the unfamiliar dinosaurs.

Third, novices formed smaller sorting categories (fewer items) and hence formed a greater number of groups than experts and required more time doing so. These findings are

consistent with previous developmental research (Annett, 1959; Lange & Jackson, 1974; Worden, 1974; Chi, 1985). Results of these investigations indicated that young children and adult novice's sorts were smaller and more fragmented than those found in older children and adult experts. As previously stated, the focus here is on domain-specific knowledge and organization and not on age. In the present research, these findings are, however, difficult to explain based on the different sorting patterns (number of trials to criterion) exhibited by the two experimental groups. According to the sorting patterns, experts should have formed more groups consisting of fewer items because this in fact would make these groupings more difficult to reproduce.

Findings from verbal explanations of their sorting criteria revealed that even when novice and expert sorting groups were similar based on the overlap of their sorting patterns of standard items, their explanations for doing so was not the same. Novices were more rule bound and generally their grouping explanations were linked more closely to the surface or physical characteristics of the product items listed on the experimental cards and the organization of the inventory. Experts, on the other hand, exhibited generally more variability in their sorting approaches. Although experts also used physical features as a basis for their sorts, they justified their sorts based on more practical

considerations such as time saving, vendors (money saving), etc. This suggested that experts had many different kinds of knowledge available to them and were able to integrate that knowledge as shown in their varied justifications. In other words, they were able to reorganize for function. Novices' knowledge was more limited and therefore their justifications were linked more to the product item.

Results of a prior study are useful in interpreting the present findings (Laufer, 1985). A sort-recall task was administered to three age groups of telephone sales clerks. The experimental sorting material consisted of four kinds of fastener products, bolts, nuts, screws and washers drawn in equal number, and participants were asked to sort and recall frequently and rarely used product items in separate sessions.[1]

The principal findings pertinent to the present research were that: 1) in sorting, education was the best predictor of the number of groups formed on the last trial; and 2) years of experience was the best predictor of the number of features recalled for all items.

In the present study, because of the limited experience of novices with fastener items, one possible explanation for

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1.In the present study, experimental material also consists of these two types of product items, but are renamed and referred to as "special " and "standard" items.

their sorting pattern was that they relied on their school learning to help them in their sorts. Thus, the finding on this measure may be comparable in the two experiments . The significantly greater recall of features by experienced sales clerks in the previous study also supports findings of the present study, namely, that experienced sales people have many alternative kinds of knowledge available to them. In other words, the previously found richer recall of the experienced sales people further supports the present finding, that experts compared to novices have a more profound and more diverse knowledge base suggested by their explanations.

Recently, Boster (1989) had similar results in comparing expert and novice fishermen's judgment of similarity among fish. Novice fishermen were closer to the scientific classification of fish and based their judgment on morphology whereas expert fishermen judged similarities among fish both on the basis of morphology and function.

Information Processing Approach To The Analysis Of Results Of The Sorting Task. Domain specific knowledge according to this theoretical approach can take two forms: declarative or factual knowledge and procedural knowledge (Chi, 1985). Declarative knowledge is content knowledge, i.e., what is known, can be discussed and is typically represented as a node-link network structure (Collins & Lofties, 1975; Chi, 1883). Procedural knowledge is about how to do something,

and production systems have often been used to model this type of knowledge (Anderson, 1975). Both semantic networks and production systems are effective analytic tools because they model knowledge at a relative specific level.

Novice performance. One explanation possible for the stable and well structured representation reflected in the sorting performance of novices was that they had already the necessary declarative and procedural knowledge available to them to perform this task. For example none of the telephone sales novices wasnew to the field of industrial fasteners. Many had previously worked as expediters, inventory clerks or in the warehouse and therefore had some familiarity with these product items or content knowledge. In addition, the sorting task required knowledge similar to that necessary in many school tasks. Almost any schooled individual could hypothetically have sorted hierarchically or taxonomically because all the conceptual information was available to her/him within the stimulus material (experimental cards listing the items).

Another explanation for the novices' sorting behavior was that because their knowledge was more stimulus bound and therefore readily available, it enabled novices to sort more consistently than experts. Most important, the physical information upon which they made their judgments was also correlated with more taxonomical modes of classification (Chi, 1985).

Similar to Chi et al. (1982) are findings on the classification of physics problems, novices' sorting performance and explanations, on a level that related to the surface or physical characteristics of the industry specific material. According to Chi (1985) one likely explanation was from findings coming from studying young novice children learning about dinosaurs (domain specific knowledge). These novices sorted stimuli into their respective categories," not because the knowledge is necessarily organized in a taxonomic way, but the task explicitly demands the assessment of specific links and not the integrated knowledge structure (p.480)."

Expert Performance. But how can we explain the performance of the experts? What does sorting for an order mean? There are several possible explanations.

Experts participants indicated by their verbal justifications that they relied primarily on sorting criteria that called for linear approaches and did not allow for hierarchal ordering or a taxonomical classification as indicated in Table 8. For example, classifying according to vendors reflected a functional classification system afforded the worker by the many possibilities of the world of suppliers. In another example, grouping according to whether an item was a special or a standard indicated greater structural perceptual differentiation of fastener items on the part of the expert than that of the novice participants with respect

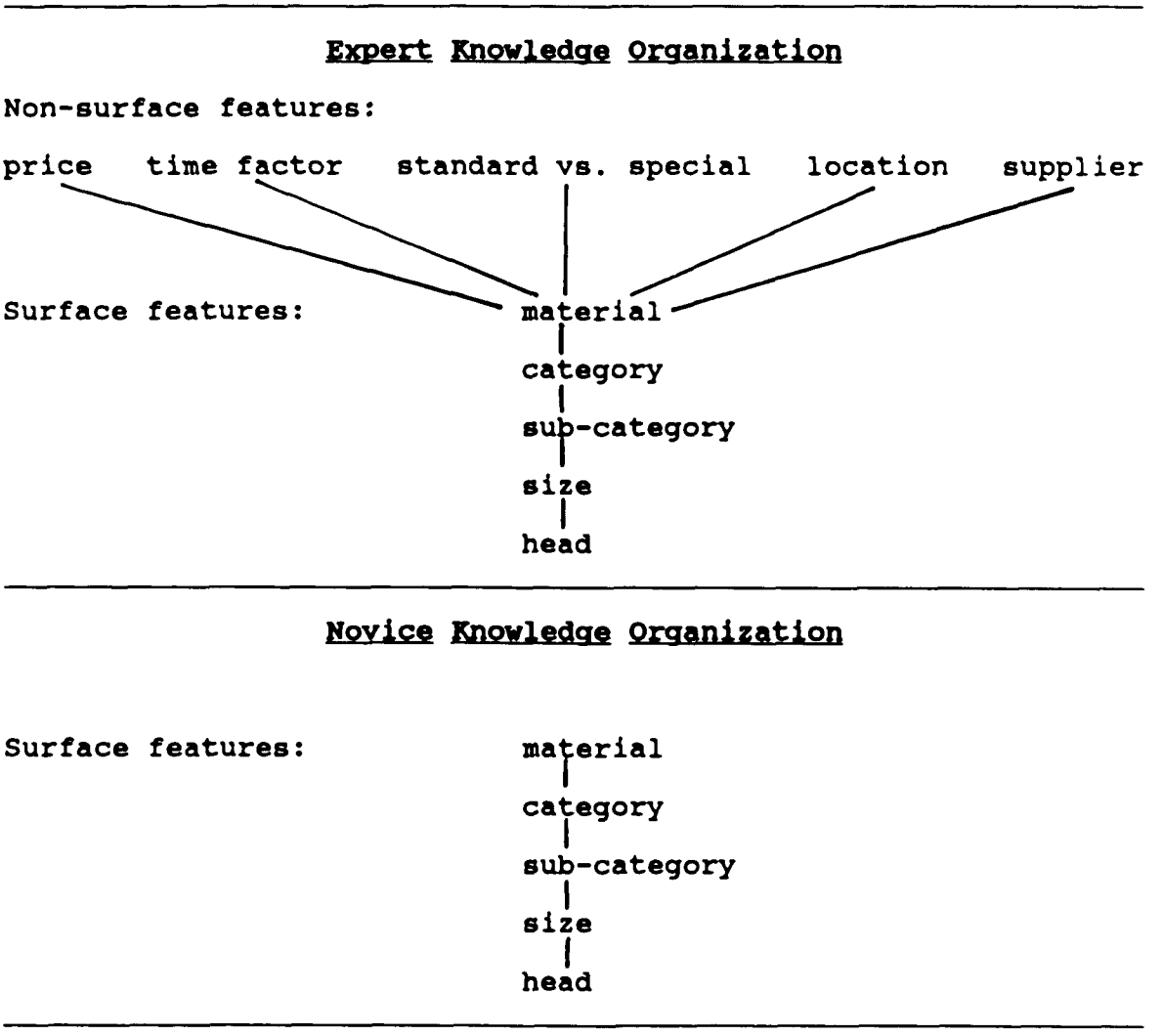
to getting "the job done" in the universe of orders and suppliers. This suggests that knowing and having more experience with these product items as their "base domain" led experts in sales to have other forms of classification systems or other ways of processing this material available to them.

If we accept this interpretation, however, we must redefine what is meant by abstractness. Typically in current psychological literature descriptions of abstractness refer to hierarchical constructions. In this sorting task, to group a product item according to a potential customer, however, also suggested abstract thinking. According to this interpretation the expertise of these workers lay in overriding the novice classification system based on surface features of the material and classifyingthe product items according to some other non-surface functional aspect of the task. In other words, expertise results in the acquisition of many alternative ways of structuring a knowledge domain. This interpretation suggests a two-level knowledge organization similar to that formulated by Chi, et al. (1982) in the sorting of physics problems; knowledge common to both groups pertaining to the physical characteristics (exhibited by both in their grouping of standard items) and an additional higher knowledge level attained by experts of non- surface characteristics more relevant to filling orders.

The two-level knowledge organization is illustrated schematically in Figure 9.

Figure 9

Two Levels of Knowledge Organization



The idea that there were different classification systems employed by the two groups lends support to the idea that the nature of the internal representation of novices was qualitatively different from that of the expert group. Additional evidence for this change will come from a more detailed analysis and discussion of the performance of participants on the order filling task in the next chapters.

Another explanation for these findings is that by using number of trials to criterion as a measure of stability of organization and number of features as a measure of richness of content I have excluded the many alternative sorting schemes and the rich knowledge of vendors and function that these experts do have. So in fact, the hypothesis that experts have a more elaborate representation "is not born out" because I am using as a measure of elaborateness of information the number of features and I am not allowing my measure to tap the rich knowledge base that they do have. In using number of trials to criterion as a measure of stability of organization, I am not capturing the large body of stable and organized knowledge upon which the many alternative functional and efficient sorting schemes employed by experts were based. This suggests that although these measures have some merit, they do not tell the whole story.

Central to current developmental and information processing theories is the notion that a major component of expertise is based on the possession of a large highly structured domain-specific knowledge base. The finding of so called 'reverse directionality,' of number of trials, number of features and taxonomic ordering of the material, is not in line with these current theories. It is still difficult to explain these findings in terms of these relatively static theories of knowledge wherein the assumption is made that there is just one "ideal standard" of development based on material structure. For example, these theories simply do not enable us to address three important questions: 1) why experts show such unstable representation of this knowledge domain; 2) why such different sorting approaches are taken by the two groups; and finally 3) why novices performed closer to the officially accepted mode for the Fastener industry.

My position is that activity theory represents a more useful framework in which to examine these findings. A discussion of these findings within an activity framework will appear in chapter 8.

CHAPTER 6

PHASE 3: ORDER-PROCESSING; A QUASI-NATURALISTIC TASK

Rationale For Designing A Quasi-Naturalistic Work Task.

The order-filling task was designed to provide a bridge between my previous laboratory type sorting task and my interview and observational accounts of every day work activity. In that way I expected that this task would capture the richness of daily work activity and still retain some of the rigor usually found in laboratory tasks. The development of this task flowed directly from my observations. The lengthy explanation that follows is necessary because of the nature and the novelty of the task and because the actual process of adult work activity has only rarely been examined in a normal setting except in the field of electronic trouble shooting (Rasmussen & Jensen, 1974); Scribner's dairy study (1984), and the Engestrom & Engestrom (1985) study on house cleaning work.

Thus, the decision to simulate this task was prompted by very specific theoretical and methodological considerations which I will list here:

First, the task is more ecologically valid than the customary school-type tasks commonly used in information processing problem solving studies by drawing from actual orders given in the past. Crucial to this task is the

presence of meaningful activities and goals.

Second, to understand this task requires very specific knowledge and asking the right questions. To ask the right questions is an essential element in everyday thinking processes. Many problems are solved in just this way. Here participants are placed in situations which make questioning necessary and where the information is not directly at hand.

Third, much knowledge is stored in the environment and jointly with other people. This task explores the use and relationship of self- generated knowledge and external information by allowing the participant to draw information from people and other external sources.

Fourth, it is expected that this task will capture some of the special ongoing social interaction and joint or collaborative activity between participants and co-workers, extending Vygotsky's ideas of inter- and intra - psychological processes in children to working adults, making adult interaction an object of study.

Fifth, an interpretation from an activity framework of this task allows for the analysis of actions, operations, goals and subgoals to accounts for change, rather than relying solely on mental structures and knowledge organization.

Sixth, finally guesstimating in this task is used to circumvent the need to discuss real vendors and real prices for material since there is great reluctance on the part of

workers to reveal industry secrets. It is expected that the role of knowledge and the solution paths of experts and novices will be revealed by guesstimation. The present task is general enough so that it can be used across different corporate environments.

Participants

The same respondents participated in this task as in the previous sorting task. This task was administered to alternating subjects from each group before and after the sorting procedure discussed in chapter 4, to control for practice effects.

Stimulus Materials

The experimental material consisted of five items from four categories of fasteners, carefully chosen with the help of two expert sales clerks from an actual work order. These particular items were selected for very specific reasons. They represented four major categories and different levels of difficulty in respect to specification. This enables the participants to ask a wide range of questions and display their knowledge and know-how. An adequate description of these items demands very specific information. The five items are:

Item 1: 1000 pieces of 8/32 X 2 Pan Head Captive Machine, Screw, Steel ,non-standard because of a special head diameter and requiring captivation as a secondary process.

Item 2: 100 pieces of 1/2 X 2 Shoulder Screw, Brass, non-standard because only hexagon socket shoulder screws, also called stripper bolts, are the only shoulder screws sold as standard.

Item 3: 1000 pieces of 1/2 -13 Slotted Hexagon Nut, Steel, non-standard because of special dimensions of thickness and width across the hexagon or flats (WAF) requiring slotting as a secondary process.

Item 4: 1000 pieces of #8 U Bend Spring Washer, Steel non-standard because of a special dimension on the outer diameter (OD) and special steel and hardness requirements.

Item 5: 100 pieces 5/16-18 X 1 Drilled Fillister Head M/S, Steel non-standard because of a special head diameter and a secondary process of a hole placed into the head.

All these items deviate from standard parts on one or more dimension which make them special. In addition, three of the items require secondary or special processes. Standard 'run of the mill' parts are run in mass produced quantities by a cold heading process. Special parts are run from bar stock from scratch on machines that have to be retooled for the special dimensions. These special items are usually run in smaller quantities because they are of limited use except for the particular customer. Any time a part is special it becomes far more costly to produce. Therefore special items are sometimes a hundred times more costly than standard items.

These items are illustrated in Appendix B

Procedure

The simulated order filling task was performed in the same situation in which it is normally carried out. In other words, the task is presented under actual working conditions in the customary office setting. Subjects were tested individually and sat at their desks with all the usual materials (catalogs, inventory files, order files, etc.) readily available.

The experimental session was divided into three parts: In the first part, the investigator was a participant observer, acting as a customer and the participant was required to ask salient questions to fill a hypothetical order consisting of five items drawn from an actual order. Participants were asked to "think aloud" throughout performing this task.

In the second part, participants were asked to guesstimate price for the first item, again thinking aloud and explaining how they arrived at their answers. Guesstimation on the other four items depended on who initiated pricing. If the participant did not initiate price after asking all the questions, and gave indications of going on to the next part of the task, the experimenter then asked the participant to guesstimate. By guesstimation here is meant "an estimate without adequate information" based on the definition in Webster's Collegiate Dictionary (1980, p.505) or an

approximate correct price.

In the third part, participants were required to rate the items on a five point scale in order of difficulty. Participants were also told to evaluate the simulated task they had just performed and asked how it differed from filling a real order.

Instruction. Instructions given to the participant can determine the validity of the verbal report and are therefore very important. Each participant was tested individually at his/her desk with the usual information available and instructed to talk aloud throughout the experimental session which was tape recorded.

The initial instructions were as follows: "Pretend I am a customer and am giving you an order with the following item(s), What would you need to know? In order to follow your thoughts, I ask you to think aloud, explaining each step as thoroughly as you can. You are permitted to use any information you find necessary to fill this order. By that I mean, you can ask the advice of someone here in the company or use the inventory or reference materials such as the Fastening Standards book, or catalogs. You are also allowed to make diagrams, use calculators and pencil and paper if you like." Further prompts during and after completion of the tasks were: "How did you do this? " or "Can you tell me what you were thinking of when doing this part of the order?" If the participant did not understand the instruc-

tions to "think out loud," further explanations were given, such as, for example, "Just say whatever you're thinking or whatever is going through your head. Say it." During the first phase of the task probes like, "Why do you need to know that ?" were also employed. After each component of the task the participants were reminded:
"Remember! It's important to think aloud." These protocols provided the basic data for the analysis of this task.

Data Collection and Transcription. These verbalizations were recorded using an audio cassette recorder and later transcribed for analysis. The investigator noted every action, i.e., going to the inventory, looking up file, etc. These observations were inserted into the protocol data. Pre and post- test interview data were also recorded.

The recorded "think aloud" protocols of the research participants were transcribed. The following instructions were given to the transcriber:

"Record every word regardless of repetition and do not attempt to determine ends of phrases. Type 'pause' for each pause that is longer than 5 seconds and begin a new line. Do not place any punctuation marks in the transcript."

Following the transcription of all verbal protocols, the investigator listened to each recording to discover any error in the transcription, to segment the protocols, and eliminate any irrelevant verbalizations. Protocol segments consisted of verbalization of the question asking and

pricing phases of the task in addition to the pre- and post-test interviews.

Validity of verbal reports depends not only on the method of collection but also to a large extent on the instructions given to the participant. Ericsson and Simon (1984) proposed a processing model and a set of procedures which is used in the present study to insure that the "think-aloud" protocols and immediate retro spective reports reflect the cognitive processes "in the most direct way."

In this study, the particular timing and form of demands for verbalization are in accordance with Ericcson and Simon's formulation. First, the request to verbalize was made concurrent with the first two phases of the task. Second, the participants were at no time asked to describe the general process they were employing, but only to verbalize what they were thinking as they worked. Third, the probes themselves did not suggest any content or internal representation. Finally, the task itself was relatively amenable to verbalization.

Following the coding of the segmented protocols, the analysis of each of the coded categories began. Specific dependent variables in each coded category were employed in the analysis.

Coding and definitions. The subsequent analysis is based on a scheme which I developed and was derived from many hours of interviews with management and individuals who had years of experience in telephone sales. The measures that I employed in this task were designed with direct help of management, expert and novice workers in the companies that I studied. Although no other literature is available for the task I devised here, the measures were constructed so as to closely reflect the official standards and explicit agenda of the fastener industry. In Appendix C are a list the official or ideal prescribed information needed to fully specify each of the experimental items.

Related to this physical description of each item, I worked out with the help of management, sales workers and pilot studies, a specific number of questions that each participant had to ask of each item to meet Q.C. (Quality Control) standards of the companies that participated in this study.

According to Bakeman and Gottman (1986), " developing a coding scheme is very much a theoretical act...the coding scheme itself represents a hypothesis...it embodies the behavior and distinction that the investigator thinks is important for exploring the problem at hand (p.19). " I devised a coding system in order to examine every step of the problem- solving process relating to filling an order

and the items in question.

In order to understand the coding system specific terms and measures that were employed must be defined. These definitions will become clearer as concrete examples are presented. For the sake of clarity, measures dealing with item judgment will be defined under that section. Here are the definitions of the terms that will be employed in this section:

A Step was defined as a means, either a self generated question or one involving external means, directly related to the item in question, leading to price initiation by either the participant or the investigator. Thus, all categories of steps in this investigation will be referred to as means; all means, however, will not be referred to as steps. Means employed in price calculation were not counted as steps. In other words, steps were not included in the actual process of pricing or pricing phase. Each item had a specific number of dimensions. Some of these were standard dimension and others were special. In order to understand which dimensions were standard and which dimensions were special, a participant had to ideally ask 'ALL' the questions to fully specify the item and fill the order effectively.

To reflect the specific nature of the various catego ries of steps, 'steps' were further subdivided into three subcategories:

Self generated (s.g.)questions, were defined as steps that were question- generated by the participants themselves, relating to some aspect of the item, without the direct use of external means. These questions were counted only if they were addressed to the investigator. (The above labels were employed in order to avoid the implication of the use of 'intra' and 'inter' psychological).

Self generated (s.g.) critical questions, were defined as steps or specific questions that must be asked of the investigator-customer, according to the official standards of the industry, about the characteristics (dimensions or material) of an item to understand its specialness.

The number of steps involving external means were defined as the total number of times that participants sought information from others or accessed various resources (catalogs, books, inventory, etc.) of the office.

A "Standard" was defined as any product item that met the standards created by the American Engineering Society (AES) and was listed in the standards book (For more details see earlier discussion).

A "Special" was defined as any product item that has non- standard dimensions or deviates in any way from the AES fastener standards.

The five question-asking segments in the verbal protocols were coded by assigning sequentially each "means" of

obtaining the required information about the item with a number, starting with number one. For example if a participant's first question was : "What is the diameter of the screw?" this question was assigned number "1" and was the first means of asking the customer information without external aides. If thereafter the participant decided to look up a dimension in a catalog, this action was then assigned number "2" and counted as a step using external means to obtain information, etc. Each step was assigned a number:

a. a verbalization via a question stemming from the knowledge the participant had.

b. a external behavioral act involving external resources (e.g., going to the inventory file or checking catalogs).

c. a communicative act such as asking the help of another person.

The participant received a score reflecting how many of these steps s(he) used. The purpose of numbering the steps was to determine if there was a pattern to the steps and how knowledge is organized in the ongoing process of fill ing this simulated order.

Only those statements directly relating to the experimental item in question were coded as a steps. Other statements such as, "I work backwards and don't need to ask any questions," were coded in other measures or were included in the descriptive results section.

Table 10 shows number of company prescribed self generated (s.g.) questions and critical questions. To meet the standards of these companies and fully specify all five items, a participant would have to asks all sixty five s.g. questions or a minimum of nineteen critical questions to hypothetically prevent the items from being rejected by the customer.

Table 10

Officially Decided On Number of S.g.Questions and Critical Questions

Item	s.g. question.	s.g. crit.question.
1	15	5
2	14	3
3	13	4
4	9	3
5	14	4

Figure 10 shows an example of a protocol fragment from a novice in telephone sales illustrating the coding system:

Figure 10

Verbal Protocol Segment Illustrating the Coding System

Exp.:[a]: Allright, let's go to item #2. I need a 100 pieces of 1/2 X 2 shoulder screw, brass.

STEP 1
S.C.:[b]: Is there any plating on this part?

Exp.: Yes, nickel plating.

S.C.: O.K. A shoulder screw I am not too familiar with.

Exp.: Well, how would you go about getting the information then?

S.C.: I would ask one of the senior salesmen on a shoulder screw, what would be the standard.

Exp.: Why don't you ask him?

STEP 2
S.C.: Normally I go to the fastening standards book to see what they have as a standard, but I don't see it here.(checks Standards book)

STEP3
O.K. My book doesn't tell me... to me doesn't explain very much because it tells me hex socket head shoulder screw. I would need to ask H. Usually if he is too busy I look at my own books that I have. One thing, what head would the shoulder screw have?

Exp.: Hex Head.

S.C.: Shall I go and ask H.?

Exp.: Yes, why don't you.

STEP 4
S.C.: I will ask him when he gets off the phone. (asks expert H.)

H: (Explains that these are stripper bolts listed in the Fastener Standards book).

S.C.: We don't have them in the Fastener Standards book?

H:[c]: Yes, under socket cap area. Here are the shoulder screws. These are everyday items. There are items that certain customers use called shoulder screws and shoulder bolts, but they have their

own dimensions...they could be slotted, could be phillips, could be whatever - where the shoulder diameter is bigger than the thread diameter in most cases.

S.C.: (asks H. for a general point not counted as a step) Can the head be normal or different?

H: Could be anything. When a customer calls in a shoulder screw, could be anything. These are standard socket (pointing to the book, page G16), these are shoulder bolts. They will always be dimensionally this way. O.K.?

S.C.: Thank you, H. So you want a hex shoulder screw in brass with nickel plating. That covers the information. Who would I call for shoulder screws in brass? Sometimes if I don't know where to go directly for an item I go to the inventory.

STEP 5
(goes to the inventory) I have no inventory.

STEP 6
(looks at a catalog)

Exp.: Now that you didn't find it in the catalogs, what are you looking at now?

STEP 7
S.C.: I am looking at another catalog where I can call the man and get prices directly from them. It showed in their book.

STEP 8
(Asks A.) "Does BR. carry shoulder bolts with standard heads? Who would carry shoulder bolts on non-metric standard hex?"
I am going to call for 100. It's great to sit next to an expert who has all the information right at his finger-tips.

Exp.: You are calling who now?

STEP 9
S.C.: I am calling B & C who is one of our sources. "Yes, this is, C. how are you, Jay. On a hex shoulder screw, do you guys carry any brass? I haven't any idea? O.K. great. Thanks." A lot of times you just keep investigating if you don't know. Ask people who are ready to give you information.

Exp.: Did he know?

S.C.: Yea. He didn't have any. He directed me to another vendor.

STEP 10
(Telephones another source) "Good Morning. Sales, please. X is calling. Hi Barbara, C. of X company, on a shoulder screw, hex shoulder screw, brass, 1/2 X 2 100 pieces hex shoulder screw...correct...do you have brass? O.K. about 100 pieces.

Exp.: What is this - K. fasteners?

S.C.: Yes. This is a distributor that I called for this material. So when I go back and find out the information I look there.
So she has with brass and nickel plated ready and she quoted me for $140/C. So what I would quote you is 55% as my mark-up that makes $217/C.
Usually, instead of saying such a large number, and scaring people off, I would give them a price per each.

Exp.: Oh , I see.

S.C.: So that would be $2.17 each. O.K. and delivery on that can be one week because she has them in stock. All I have to do is place the order.

Note. [a]Exp.=experimenter; [b] S.C.= participant; [c] H. =expert

The total number of steps found in this protocol segment was coded according to the means employed to obtain the information.

1. Question asking steps without the use of external aids consisted of: step 1 and 3
   (Total = 2 steps).
2. Steps involving external aids such as physical resources in the office consisted of:
   Step 2 - ASA Standards book; Step 5 -inventory;
   Step 6 and 7 - catalogs.
   (Total = 4 steps).

3. Steps involving external aids such as the help from other people consisted of:
Step 4 & step 8 - participant asked information from a more experienced worker; step 9 & step 10 - participant obtained information from a vendor.
(Total of 4 steps).

Since all five items were special, unless these questions were asked the items would not meet all the officially required specification and might therefore be rejected by the customer.

Ideally, everyone of the questions that a sales clerk was required to ask (according to management consensus) was necessary. High standards had to be met to produce the right product item for the customer and to meet the need for high precision quality parts ("Zero Defect" policy) that large industrial OEM companies require.

Findings from observations and interviews previously indicated that in practice this did not happen all the time. Experienced sales clerks often did not even ask what was considered 'key' questions. As one sales clerk confided:" Everyday, with my Zero Q.C.(quality control) department I get at least one rejection on items that do not meet the re quirements of the customer.

In transcribing the verbal protocols great effort was taken to note any and every possible statement relating to information- seeking by the participant. Every behavior relevant to the task was coded, i.e., that defined the item further. However there were obvious limitations. As the

protocol segment in Figure 10 illustrates, not all the steps coded are the same size. The reason for this difference was that often the investigator was out of hearing range when questions were addressed to other co -workers and could not be tracked. For example, in Figure 20, S.C. asks H.: "Can the head be normal or different?" This was not coded as step 5. Only those questions addressed to the investigator were coded as s.g questions. Thus, the findings may underestimate the number of s.g. questions noted for novices. This point will be discussed in the result section.

In sum, devising original measures presented some drawbacks especially since the participant's performances could not be precisely repeated. On the other hand much confirmation was derived from the total picture of the results and the different measures employed in the examination of the data.

Inter-rater Agreement In Protocol Analysis

In order to determine the degree of coding reliability in the protocol analysis conducted by the investigator a second rater was used for validating the coding process. Verbal protocols for items of six participants were randomly selected, three from each experimental group. These were coded independently by both investigator and one rater. The protocols were presented in random order to the rater who was not aware of either the participants or the group from

which they were chosen.

The analysis investigated wether the two scorers reached identical judgements on the number and category of steps, decision points, and pricing. Since these judgments represent a nominal scale of measurement, the recommended analysis determined the inter-rater agreement which reveals the proportion of agreement between the two scorers. This agreement proportion was adjusted to remove the proportion of agreement predicted by chance (Bakeman & Gottman, 1986, p.78). The adjusted coefficient, Cohen's $\underline{k}$, was calculated as follows:

$$k = \frac{Po - Pc}{1 - Pc}$$

where Po = proportion of ratings in which two rater agree and Pc = the proportion of ratings for which agreement is expected by chance. The interrater agreement between the investigator and second rater for three protocols randomly selected from each group was determined. The average over-all mean proportion of agreement was .89 and the overall $\underline{k}$ was .87 for all schemes. Thus, there was a high proportion of agreement and the average correction for chance agreement was only .02.

Results And Discussion of the Question-Asking Part

This section, is divided into two parts. With my hypotheses in mind I will first analyze the number and types of steps participants employed up to the process of pricing. Subsequently, in order to understand expert/novice differences in making judgments about the specialness of an item, I will examine their judgments and the steps leading up to their decisions.

Analysis Of Steps. On examining the numerical sequence of the steps, for experts, I discerned no particular pattern. However, sixty three percent of the first three steps taken by the novice group, for all items, were external steps and of those 25% percent involved other workers (only 10% and 2% respectively for the expert group). This suggests that from the very beginning of the problem- solving process novices needed external resources and the help of other people. In marked contrast it showed that experts were able to generate almost all questions on their own with or without the material objects of the office. It also indicates that my first hypothesis, which stated that expert problem-solving was expected to be characterized by linear or sequential steps towards a solution, whereas novice problem-solving was expected to jump back and forth between different steps of the process, was not borne out.

Table 11 illustrates the quantitative novice-expert differences for all categories of steps taken by participants for the five experimental items combined. It shows that except for those that employed external aids, all categories of steps by experts were significantly higher than those by the novice group.

Table 11

Novice-Expert Differences for All Categories of Steps

Variable	Novice		Expert		
	M	SD	M	SD	T
# S.g. crit.quest.	5.0	3.21	10.5	3.63	3.93***
# S.g. quest.	12.9	6.99	27.3	10.12	4.06***
# Ext. steps	9.5	4.58	4.6	2.54	3.25**
Total # steps	22.5	9.83	31.9	10.47	2.29*

* p <.05; ** p <.01; ***p <.001
Note. S.g critical questions, S.g. questions and external steps are subsets of the total number of steps

The "Total Number of Steps", is defined here as all the means that participants employed to fully specify a product item in order to be able to formulate a price.The purpose of the category 'total steps' was to determine if there exists a quantitative difference between the novices and experts in mediation (activity theory) or knowledge organization (information processing theory) in the process-

ing of an order. Experts took significantly more steps than novices.

As expected, experts asked significantly more s.g.questions and s.g.critical questions. Novices averaged a mean of 2.6 s.g. questions and a mean of 1.0 s.g. critical questions whereas experts averaged a mean of 5.5 s.g. questions and a mean of 2.1 s.g.critical questions for each item. This is in keeping with previous findings which showed that experts ask more question than novices, particularly when the text is difficult (Miyake & Norman, 1978).

Experts asked a total 328 s.g. questions, compared to 150 s.g. questions by novices out of a maximum 780 possible s.g. questions or 42% and 19% respectively, directly related to the required dimensions of the items (i.e., 24 participants X 5 items X 65 questions). As previously stated (in the coding section of this chapter), the total maximum of sixty-five questions for the five items decided upon by the investigator directly related to the particular features of the items selected for this task and was based on the advice of many company employees. Experts generated more than twice the number of questions than novices.

The reverse was true for the number of steps employing external means. Novices took a mean of 1.9 steps compared to .9 steps taken by experts for each item. This difference was significant. Thus, as expected, novices drew more

frequently on external resources to formulate the appropriate questions to ask of customers. These findings may have underestimated the number of questions asked by the novices to co-workers, which were not coded because the investigator was out of hearing range.

These findings support the hypothesis which predicted that novices would employ more and different external aids than experts in solving a problem.

Table 12 shows that there was a consistent pattern across all five items for all categories of steps. Neither one or two items individually accounted for the group difference. Experts were consistently higher on all s.g. questions and critical questions over all items and novices were consistently higher on external steps over all items.

Table 12

Mean Number of S.G. Questions, Critical Questions and External Steps For Individual Items

	Novice			Expert		
Item	S.g. quest.	S.g.crit. quest.	Ext. steps	S.g. quest.	S.g.crit. quest.	Ext. steps
1	3.66	1.9	1.58	5.83	2.7	.67
2	2.00	0 .5	2.17	5.42	1.75	.75
3	2.42	1.33	2.17	5.33	2.22	1.17
4	3.08	.66	1.92	5.83	1.75	.67
5	1.75	.58	1.67	5.17	2.25	1.33

Intriguing, however, was the fact that experts generally asked less than half the number of officially prescribed s.g. questions. In addition, not one expert asked ALL the required critical questions for all items. Two experts asked all the critical questions for three of the items and two novices asked all the critical questions for only one of the items. This suggests that the official specification of items was either not known or not carried out by some experts or that even though this measure had some merit, it did not tap all aspects of the knowledge base. In other words the official description of expertise was different from the actual performance of these expert participants.

In fact, based on these results and according to management, many items would likely be rejected by customers. An alternate explanation for the poor performance of experts is that they had the knowledge but didn't always follow on it, especially if they felt they could get away with an easier solution.

Explanations for Experts' "Poor Performances." In keeping with the multimethod approach the investigator returned to the work-place for further observation and interviews to shed light on the less than optimal performance of the experts. Two likely explanations were given. One upper level manager suggested that:

> " many old time experts use items even when they are off spec.(specification) Therefore they don't care about getting all the dimensions. Up to eight years ago this was common in the industry and in many cases it worked. The threat of Japan's superior quality products changed specs for the U.S. Industry and introduced the 0 defect concept. Some old timer experts still sell off spec. parts and get away with it. Much depends on who you are selling. They are usually Schlagg operators - they usually sell you anything."

Second, [1] according to an expert clerk, sales clerks often ask what they call "trigger questions" when taking an order. These questions pertain to one or two very specific dimensions that are responsible for the high cost of

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1.Suggestion given by J. Glick (personal communication, June 1989).

production of the item. Since the goal for the expert participant was to give a quick "ball-park price" in this study, this suggests that by asking one or two of these trigger questions (knowing one or two price sensitive dimensions e.g., head size, WAF etc.) a participant could approximate the cost and price for an item. In other words, even though all five items were special, and generally more expensive than standard items, these specific aspects made them even more costly. Table 13 shows the so-called number of trigger questions for each of the items asked by expert and novice participants. For all items novices asked a mean of 5 trigger questions compared to a mean 11.6 by experts.

Table 13

Number of Participants That Asked Trigger Questions

Questions	Novices	Experts
Item #1 Head diameter	1	6
Item #2 Asked if item is standard socket stripper bolt	4	8
Item #3 WAF	7	11
Thickness	7	11
Item #4 Outer diameter (OD)	6	11
Item #5 Head diameter	1	8

This finding suggests that frequently expert participants may have bypassed asking many of the required s.g. questions because they concentrated on those dimensions that were highly price sensitive.

Expert/Novice Item Judgments. In the course of gathering information for pricing it is customary, according to the members of the fastener organizations that I interviewed, to come to a decision on whether an item is standard or special. Because of the infinite number of variations in the dimensions and characteristics of specials , they are often less familiar to customers and even to sales clerks.

They are referred to rightfully as "blind items" and this partly accounts for the large variation in prices often quoted by sales clerks even in the same company. In other words, prices of standard items are not only much lower, but more important, are generally far more uniform.

In order to understand the decision process of the participants, the following measures were designed:

a. Item judgment. defined as a decision of whether the item was standard or special.

b. Point of decision defined as a statement coming right after a particular step in the analysis, whereby the participant verbally decided on whether an item was a standard or a special. A coding determination was based on an explicit statement accompanied by, or right after a step, in the transcribed verbal protocol referring to the item as either "special" or "standard." The absence of an explicit statement did not imply the absence of a decision but merely that a decision was not expressed. In spite of this limitation, this measure was very revealing. Figure 11 presents protocol segments illustrating the point of decision:

Figure 11

Protocol Segments Illustrating Point Of Decision

Subject 13 : I would have to refer to a catalog in this particular case (checks catalog - **External Material Step**). I tell you, normally from past experience I can give you every price. This item here is highly special(**Decision Point**). On an item like this, I would have to, if I was giving a price immediately, I have to estimate a price of $3.50 each.

Subject 19: would you need brass plating? (**S.q. Question**)

Experimenter: Yes, There is .002 zinc plating.
Subject 19: Unfortunately, this is not a standard part.(**Decision Point**) so we have to go to our machine shop and find out the cost.

Just as experts generally asked more questions they also made more frequently an item judgment compared to novices. In other words, experts more frequently arrived at a decision (regardless of special or standard) for an item than novices. As shown in Table 14 cross tabulation of items by expert/novice condition showed that experts were over twice as likely to make an item judgment as novices.

Table 14

Expert/ Novice Differences On Making Judgments

	Novice	Expert
Made a judgment	21	44
Did not make a judgment	39	16

Out of the sixty possible instances, novices made an explicit statement of a judgment in only twenty- one cases or 35% of the time, and of those ten were arrived at jointly with another person in the company as shown in Table 15. Experts reached a judgment in forty- four instances or 73% of the time and employed the material resources of the office in fourteen instances. This suggests that in more than half of the instances novices did not know that any item judgment was involved in formulating prices for these items. When disregarding whether they reached the right decision, a majority of experts made a judgment.

Out of the 44 instances that experts made a judgment, thirty- five were correctly that of "special." Nine experts reached a judgment of special for three or more items and one expert made that judgment for all five items. In contrast novices made 13 correct judgments of "special" out of 21 judgments and only one participant arrived at more than two correct judgments. These differences are even more

remarkable if we consider that one third of the time (33%), novices received help from co-workers.

To shed some light on the decision process, Table 15 shows how participants arrived at a judgment(regardless of whether it was special or standard), right after a particular step. In other words, how they used their knowledge or made use of outside information. For example, if a participant consulted a catalog before or while making the statement: "This item is very special," it was considered an instance of the use of external information. On the other hand if a participant made a statement question this was considered self-generated knowledge.

Table 15

Novice/Experts Use Of Knowledge and Information At The Point Of Decision Step

Means	Novice	Expert
Self Generated knowledge	2	30
External* material information	9	14
Another person	10	0

* External (Standards book; catalogs; inventory; another person).

These results demonstrate that experts made more knowledge-generated decisions while novices used more external information.

Of further interest was the finding that in 13 instances experts reached a point of decision right after they asked a critical question. This indicated that these participants understood the nature of the item and were able to link their decision to the specialness of the item. None of the novices were able to make that connection.

A simple count of the number of steps leading to a decision point show that novices needed an average of 4.1 total steps and an average of 3.7 external steps; experts required an average total of 5.2 steps and a mean of 2.0 external steps leading to either decision.'Although experts needed more steps, they took significantly fewer external steps compared to the novice group.

Further examination of the data reveals, that those novices that made the correct judgment required a mean of 4.2 total steps, compared to a mean of 5.4 for experts leading to the decision point. These results suggest that experts may have spent more time analyzing these items qualitatively than did the novices. Larkin (1980) similarly distinguished novice from expert physicists, finding that experts seem to apply a "qualitative analysis" to a problem,

prior to its a solution. Because of the small n's, the present results must be interpreted with caution.

In sum, experts as a group asked far more s.g. questions and s.g. critical questions than novices. Novices used more external means in describing these items. In other words, their efforts were directed and often redirected by others and the interdependence of actions with others determined the form of their steps and judgments. However, even when their efforts were guided by others, they often had difficulty in delineating the items.

Contrary to expectations, however, expert performance was far from optimal on all measures by company standards. In fact several experts asked only a few s.g. questions and critical questions. This may have been due to the fact that the goal for experts was different from that built into the experimental situation. The design of the task may have truncated the need for information before arriving at a price because in their daily work activity these sales clerks often ask the required question after obtaining the order. Moreover, as in my prior findings in chapter 4, these results suggest that experts have many alternative routes available to them, such as, for example, asking price sensitive or " trigger" questions, and therefore could take the risk of guesstimating price without obtaining all the required information. These findings suggest that experts

may often be working backwards, seeking to price first and then obtain all the required information. Additional support for this idea will be found in the results on pricing in the next section of this chapter.

Experts also made twice as many judgments (correct or incorrect) as novices, relative to type of item. In the majority of cases novices did not know enough to know that any judgment was necessary. Generally, in those cases where novices did make a judgment, it was with the help of a co-worker or some external material means. Not only were most judgments by experts self- generated but they also made three times the number of correct judgments compared to novices. This suggests that experts knew that they had to make a judgment and focused more on the specific dimensions of the items germane to the correct judgment. Novices may have concentrated on different information.

Pricing Product Items

In the fastener industry, price and pricing may be the most immediate means at hand for expressing the divergent social, material actions, meaning and sense of this task. Price is structured by the organization of the business practice. Question asking, social relations, motivation and goal components all contribute. In other words, prices are structured out of the total activity of order filling and often depend on many considerations other than money.

The official policy on pricing in most fastener companies is a 50- 55% mark-up over cost. Much depends, however, on quantity requirements, competition, delivery schedules, plating costs, etc. Although there are catalogs which list prices, telephone sales workers do not have a master price list. Prices are often highly flexible especially on non-standard items that do not appear in catalogs. As one expert stated:

> "It is very hard to have a set formula and say 'this is it'. Catalog houses do. They publish a price list and have their discounts. With OEM (Original Equipment Manufacturer) customers and the varied items we carry, we cannot have a set or standard price. "

On the whole, prices are directly negotiated with the supplier and customer, especially if the material is special. Thus, the official company price policy is not always implemented by telephone sales workers, but depends on a variety of factors, not always explicitly stated. Most workers talked openly about extra cost based on high quality, quick service, availability, etc. but some sales clerks also reluctantly admitted that price often depends on personal and previous relationships with the customer and supplier.On the whole the implicit unofficial policy of these companies gave several conflicting messages according to one expert of many years: "Charge what the traffic can bear" rather than one "right price." However, the motto of

the company was: "Don't lose the order! A little is better than a lot of nothing. Get 10%, get 5%, it's better than nothing. What's the good if you don't get the order. If you don't make much this time, you will get them next time."

Experts worked Backwards. Eight experts confided that they 'worked backwards' in pricing most items, especially those not listed in catalogs. Working backwards means first quoting a very high price to the customer; then, if the customer balks, negotiating the price downward. If as a result the profit margin is not sufficient, it requires renegotiating the price downward with the supplier. An expert described the process as follows:

> "Quote them where you think you're going to be safe...leave yourself a ' margin for negotiation'...where you're going to make money. Some customers will always negotiate price so automatically add 10% or 15%, so you can give them their discount. Get the order from the customer and then negotiate for a lower price with the supplier. It's like juggling." One sales expert, however, emphasized : "We must build into our price, potential problems en route, or a good mark-up to protect ourselves. For example, if a vendor from overseas does not meet his time requirement, we have to buy the material from a local manufacturer at a higher price. The same goes for split deliveries: if we have four different shipments -that costs money to warehouse and is packaged differently."

Another expert explained: "I guesstimate and get the order. If it isn't right then I will make it right by working backwards and negotiating with the vendor for a better price." Or as another expert joked:

"If I guesstimate wrong, I bull-shit, more or less lie. I don't just want go back to the customer and say: 'I made a big mistake - I didn't know the damn things were so expensive.' That makes me look incapable of doing the work I am supposed to do. So you go back and say : 'There's a shortage of this type of material, right now - they are not going to have the material for another 8 weeks. If you want it in 4 weeks you have to pay a premium price to get the stuff sooner, or 'This is not a common, standard , off the shelf type item. I presumed that it was. There are certain tolerances and certain dimensions that are not standard, which changes the price.' You have to know how to talk and what to say and to be able to get away with lying. In other words, if you sound like you don't have enough confidence, that can lead the customer to think you made up the story."

Five experts also discussed 'low balling' (selling fasteners items below or at cost) as a way of getting a 'foot in the door' into desirable large industrial companies with the expectation of making large profits later.

"If you really want to get into a company, come in at a real low price. That's in the beginning. Show the customer that you can supply the part - good delivery - good material. Then when they begin to like you, raise the prices slowly every time."

When asked why none of the novices discussed price in this way, the expert responded:

"I negotiated with the supplier really to cover my mistake in judging the right price. The novice would not think this way. The novice does not know that he can negotiate with vendors. He hasn't been exposed sufficiently to buying and selling and wheeling and dealing. He knows only that if something costs $1.00 he must get $1.50 - $1.60. I can

> approximate price based on my past experience with similar items and knowing the type of customer. Novices are afraid to take a chance."

When asked if novices are taught 'wheeling and dealing' or the standard methods of pricing, the expert replied:

> "First you must know the standard procedures and have the technical knowledge. Once you have that in place, you can deviate from that system. First you have to know the standard way to deviate from it."

This suggests that with the acquisition of a larger data base and more organized technical knowledge, novice sales workers become free to learn to develop and exercise "business acumen," i.e., negotiate with customers and suppliers.

In short, with experience, hard bargaining, wheeling and dealing become part of the expert's knowledge and business practice, but these are always conducted with a veneer of friendship and cooperation. In order to better understand the complexities of these social ties which directly reflect upon price, the horizontal and vertical links formed both within the office and between sales clerks and outside the office with suppliers and customers will be more fully examined in the following chapter.

Other mechanisms for relationships with customers and suppliers are evidenced by sociable lunches, dinners and token gifts.

Each telephone sales person handles her own accounts and receives commissions or bonuses based on her total sales dollar volume. Observations and interview data suggest that novices are more closely tied to the standard price policies than experts.

Pricing Part Of The Task

As previously described in the procedure section, after the participants asked all the questions on the first item, the investigator instructed the participants as follows: "Now guesstimate price for these items and explain exactly how you arrived at this price." These instructions were not repeated for the other four items unless the subject reported that she/he had no more questions and was ready to go on to the next item. The investigator would then intervene and ask the participant again to guesstimate price.

Results And Discussion Of Pricing

Price Initiation. Novices were significantly less likely to initiate price than experts on the last four items and the difference was significant (X^2=7.08, df=2, p.<.05). This suggested that novices either perceived the question-asking and pricing phases as two tasks or that they were reluctant to guesstimate. Experts, on the other hand, by initiating the price, perceived the question- asking and pricing phases as one task. Pricing for them was not dependent on the dimension of the items.

This findings gives additional support to the idea

that novices may have been working forward by getting all the information first and then formulating the price. Experts, on the other hand, may have been working backwards seeking to price first and then obtaining the required information. Additional support for this idea comes not only from the interview data but from findings of the question-asking segment of this task. As previously suggested, although experts did not ask all the required questions, they had many alternate paths available to them compared to novices such as asking more price sensitive questions and thereby getting the required information needed to guesstimate price. Even though novices asked fewer questions than experts because they did not have enough knowledge of the item, they worked forward because their goal was to fully specify the item first, and then price.

Analysis of price. Not surprisingly, there was a significant difference between the two experimental groups in how many participants priced and the number of prices they gave, for each of the five experimental items. A partitioned chi square indicated that significantly more experts gave a price than did novices (X^2= 7.94 ,df=2, p<.05). Experts calculated prices 91% of the time compared to only 70% of the time for novices. Furthermore experts calculated significantly more prices per item than novices (X^2=14.6, df=2, p<.001). The frequency scores are shown in Table 16.

Table 16

Price Calculation of the Five Items[a]

	Novice	Expert
No price	18	4
One price	32	24
More than one price	10	32

[a] N=60 instances; 12 participants x 5 items.

These suggest that novices thought that the task required one right answer whereas experts were more flexible and gave several prices based on factors such as availability, type of customer, quantity, etc. For example in working backwards one expert salesman gave the following account:

> "I always have a 75% mark-up. I like to work on a minimum of 50%-55%. So I like to use the 20%-25% as a "margin of negotiation." Then, if a customer asks me to come down 15%-20%, in price, I can tactfully come down on my price. I will, however, always say that I will have to call him back. Even though I could give the customer the lower price right away, I don't want to because he may think that I took advantage of him. I call him back after a while and say for example: "Look, I spoke to the plater, and he can put this in with other items and will give me a lower price. I also spoke to the machine shop and they happen to run 8/32 threads within the next few days and I can put these in with the other lots, so I think that I can meet your price."

Cost Factors Included In Pricing. To arrive at a the total cost and the final price of an item, participants had to include, when required, the following factors: cost ofthe material, plating, cost of secondary processes, set-up charge and total cost. Analysis of the verbal protocols, scratch sheets and calculator outputs revealed that novices employed a mean of 1.96 factors (operations) and experts a mean of 2.68 factors (operations) to arrive at a price and that these differences were significant ($t= 2.21$, $df=21$, $p=<.05$). These figures included only those participants who arrived at a final price. As shown in Table 19 it suggests that experts consistently included more factors (operations) than novices across all five items. In other words experts included additional cost factors significantly more often than novices to arrive at a final price. For example, 61% of the time experts included plating in their price compared to the 29% of the time for novices. More important, experts calculated the total cost of the item 71% of the time whereas novices calculated total cost only 44% of the time. Table 18 illustrates frequencies and percentages for the various cost factors.

Table 17

Number Of Times Cost Factors Were Included In Price Calculation

Factors	Novices	Experts
Cost of screw	26 (47%)	32 (58%)
Plating and stripping	16 (29%)	34 (61%)
Secondary processes	17 (30%)	20 (36%)
Set- up charge	3 (6%)	6 (11%)
Total cost	24 (44%)	39 (71%)

Note. n=55; One participant missing. Numbers represent total number of instances that factor was calculated into price. Percentages represent percent of total number on instances.

Expert/ Novice Price guesstimation and Vendor Prices. Generally novices guesstimated lower costs and prices compared to experts. A summary of all participants who quoted both cost and price is given in Table 18. As shown, except for item 3, experts gave consistently higher prices compared to novices.

Table 18

Cost and Price Of The Five Items[a]

	ITEM	N	MIN	MAX	MEANS	SD
COST	1					
novice		10	11.7	35.00	17.22	8.07
expert		9	11.5	15.95	204.64	522.19
PRICE						
novice		9	.2	295.00	153.43	80.01
expert		12	168.00	2450.00	469.22	667.57
COST	2					
novice		2	237.00	316.30	276.65	56.07
expert		6	100.00	400.00	195.83	107.72
PRICE						
novice		5	72.00	813.00	353.80	287.29
expert		8	299.00	975.00	498.00	251.50
COST	3					
novice		6	2.87	150.00	32.19	38.06
expert		10	2.00	80.00	17.22	23.97
PRICE						
novice		10	5.00	370.00	77.40	105.92
expert		12	11.75	160.00	70.42	47.86
COST	4					
novice		6	2.90	165.00	48.82	61.88
expert		7	20.00	162.40	57.49	53.37
PRICE						
novice		2	6.25	301.5	84.71	111.26
expert		11	60.00	259.84	138.01	62.39
COST	5					
novice		5	2.68	8.31	5.00	2.89
expert		9	3.00	40.00	12.32	12.55
PRICE						
novice		8	10.70	100.00	40.27	33.48
expert		11	13.60	365.00	119.24	106.62

[a]For those participants who gave cost and price.
[b]Although the means were very different, the SD were so high that there was no significance.

The median quoted prices by experts, novices and suppliers are presented in Table 19 . The 'median' measure, when compared to the mean, is unaffected by extreme scores. Because of the large number of differences in prices exhibited by suppliers and by the two experimental groups, the median price for all items was also determined. Table 19 shows that the median price on all items of experts was higher than the median price of novices. There was no particular pattern to the median vendor prices. Except for the first item, supplier prices were higher than those of novices. This suggests that novices underpriced, either because they thought the items were standard or they were too afraid to risk pricing the item too high.

Table 19

Median Prices[a] of Novice, Expert and Supplier

Product item	Novice	(n)	Expert	(n)	Supplier[b]
Item 1	181.00	(9)	218.30	(12)	61.00
Item 2	357.00	(5)	350.0	(8)	237.00
Item 3	46.00	(10)	72.50	(12)	99.00
Item 4	20.00	(7)	142.00	(11)	125.00
Item 5	24.50	(9)	57.00	(11)	85.00

[a] For those who priced. [b] Actual quotes from suppliers.

Surprisingly, prices differed among supplier for the same item as shown on Table 20. Moreover, each supplier seemed to have her/his own pricing pattern. For example, supplier 1 was consistently lower than supplier 2 and 3.

Table 20

Supplier Prices[a]

	Supplier 1	Supplier 2	Supplier 3
Item 1 per/100	60.00	61.00	148.00
Item 2	155.00	237.00	323.00
Item 3	91.00	99.00	115.00
Item 4	125.00	165.00	
Item 5	60.00	85.00	145.00

[a] Actual quotes from suppliers.

This finding suggests that generally both vendors and experts were aware that some of these items were very special and therefore "blind items," and charged what they thought "the traffic could bear." Novices on the whole did not have the knowledge to price some of these items and therefore priced them lower to be safe. This suggests that prices in this industry are extremely flexible and depend on the type of item, the cost, availability, the technical knowledge of the sales clerk, the type of customer and inter-

personal relationships.[1]

One expert explained his guesstimation by responding:

> " These items are not standard. Do you need a price for quotation, do you have to bid on something, and do you need these pieces right now? I'll give you my best estimate what the price would be. When you get the order, I will be more exact. Most of the time fasteners do not represent a big portion of an order, therefore if a customer makes them for big pieces of equipment, even a 200% -300% off in an estimate for fasteners is not going to affect the whole thing. We are talking pennies compared to their talking hundreds of thousands of dollars...A purchasing agent is a very, very busy person and wants to concentrate on things that are of real value. They are least diligent in terms of fasteners. If you have someone that is very busy and they just want to get the order placed and off their desk, and they want a supplier, and want to get rid of the stuff, you work on a great mark- up. Besides I tell the customer: 'when the time comes and you place an order, we will do better' because I always give myself a leeway."

Hidden Cost Factors. In keeping with the multi-method approach, I returned to a work site for further questions. In response to my questions raised in respect to the high mark-up and great variation in prices of experts, top management cited many hidden cost factors. Among the cost factors stated were cancellation of orders due to late delivery from the factory which leaves the company often with items that

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1.Cost and availability also depends on labor conditions in different parts of the country and availability of machines, if the item has to be made from scratch.

they can't use; late or non-payment of customers or split delivery cycles requiring the maintenance of items in the warehouse for many months necessitating monetary outlay and cost of warehouse space; air-freight cost due to late deliveries, etc. In addition management claimed that often the company worked on a very close mark-up or on a low percentage, in order not to lose the good will of the customer. One manager explained: " You can't make money on a 10- 15% mark-up if your overhead is 30% or more."

Knowledge and Outside Information in Pricing. On closer analysis of the protocols, there was a significant difference on how much outside information experts and novices needed to avail themselves of to arrive at a price, X^2=53.5, df=2, p<.001. Table 21 allows us to compare the two groups in respect to the following three categories: First, participants who used exclusively "outside information" defined as any information obtained from files, books and catalogs in the office or from vendors and people working within the company. Second, participants who employed 'part outside information/part personal knowledge. These participants, for example, were able in part to guesstimate price but required some outside information such as the cost of plating to calculate the final price. Finally participants who completely guesstimated the price of the item and came under the category of 'internal knowledge.' These findings

are especially interesting if viewed from an activity perspective because the course of transition from external to internal is made so visible. According to Zinchenko & Gordon (1981):

> ... the initial and fundamental form of human activity is external practical activity. The internal plane of activity, inner mental operations and actions, is formed in the process of internalization. Internalization is the 'transition' inwhich external processes with external, material objects are transformed into processes that take place at the mental level, the level of consciousness. During this transition these processes undergo specific changes - they become generalized, verbalized, abbreviated; and most importantly, they become the means for further development that transcends what is possible with external activity (p.74).

In current information theory, actions are studied in relative isolation from each other, outside the system of activity and regardless of goal. Here they are viewed from the point of the gradual transition from one functional equivalent means to another.This suggests that experts and novices employ different functional equivalent means to reach a goal.

Of interest was the fact that 85% of the time novices used outside information exclusively whereas experts guesstimated price 59% of the time. Thirty- six percent of the time experts, however, required some outside information to guesstimate price. This suggests that some experts were at a transition point, i.e., they had some knowledge but still

needed outside support.

Table 21

Knowledge and Outside Information In the Total Number of Price Calculations

Information	Novice	Expert
Outside information only	36(85%)	3(5%)
Part outside information part internal knowledge	2 (5%)	20(36%)
Internal knowledge	4 (10%)	33(59%)

* Instances at arriving at one or more price: novice =42; expert n=56.

On closer analysis, external steps were qualitatively different for each group for the total task of order filling. Table 22 presents the total number of external means employed.

Table 22

Use of External Information Resources to Define and Price All Items

External means	Novice[a]	Expert
Checks inventory	38	13
Checks catalog	35	30
Check Standards book	18	18
Checks Nationwide	12	0
Asks manager	9	0
Asks expert worker	27	3
Asks experienced novice	12	0
Makes joint decision*	12	9
Checks with vendors	22	22

[a]n=60 instances requiring price regardless of whether they did or did not arrive at a price.

There are several interesting differences to note in the above table. First, novices drew a mean of 3.17 times (sd=1.76) information from the inventory compared to a mean of only 1.08 times (SD=1.44) for experts. This difference is significant ($t=4.04$, $df=22$, $p<.01$.), and further substantiates previous findings that novices were tied to the inventory. Second, novices exclusively accessed Nationwide, a publication that deals with surplus sale material. Experts did not consult this publication because they knew that the

items they required were special and therefore would not be listed there. This suggests that experts may know where in the office to access the right information more efficiently and make sense of the multiple conflicting coding in the office as compared to novices and therefore save time.

Here is an example of a novice and expert telephone sales clerk and their differential use of the office setting as told to me by an expert sale clerk:

> "A yearly requirement for this part came into the office and was given to L. who was a total novice. The quotation went to him because no one else in the office was available. When I asked L. what he was doing with the quote he told me that he had taken a columnar pad and laid out all the 100 parts to check the inventory, pull out all the cards and see what material was in stock and how to price it. When I told him that he would have to price it within the day he was shocked.
> As an expert I took the price of the last year by looking at the print file and in two hours I priced all the items. The back of the print had a history of all the prices. In most cases I knew the product. It was not a matter of do I have it in stock or not. This was a buy for the whole year so I knew that I could buy it in time to fill any requirements and therefore didn't have to check stock. So I eliminated all that time to check 100 items with all different cards and eventually putting them back. The print was a far better way to go. The inventory wasn't a factor. The goal was to price it up and get rid of it as soon as possible. They wanted to place an immediate order. That's the goal - cut all the corners and say 'this is the price'."

This suggests that the dialectic between setting and activity may be more finely tuned for the expert and that knowing where and what to access depends on a participant's level of knowledge. In other words, these expert/novice differences support the idea that the office setting may have different functional potentials for telephone sales workers depending on their level of expertise. This issue will be raised again in the next chapter.

The Interpersonal World Of The Sales Clerk. As shown in Table 22, novices consulted fellow office employees such as managers, experts, and even novice workers, a mean of 4 times to fill the order for five items. In contrast, experts conferred a mean of .25 times only with other experts.

Upon further examination three forms of social interactions and power relations were distinguished during the performance of this task: (1) Vertical interaction —— defined as an interaction with more knowledgeable and / or higher status individuals in the company; (2) Horizontal interaction- defined as an interaction with equally knowledgeable or equal- status individuals in the company; and finally (3) Joint cooperation within the company and with customers and suppliers defined as a joint working together regardless of knowledge and status.

Simply stated, novices usually start out as office

clerks who are guided and are told what to do piecemeal using the inventory as support. In other words, it is through informal contact with co-workers and managers that their appropriate course of action is determined. Much of their work is the result of vertical collaborative efforts. What is communicated to them in this effort consists of the standard company information, much of which is technical. What is communicated between experts, horizontally, is official and unofficial information. With this layered knowledge, experienced telephone sales experts are able to fill orders all by themselves. Although managers still have the last word, they are rarely consulted. This indicates that social interaction for novices is different with a more diverse number of co-workers than with experts. More importantly it also suggests that there is a novice/expert shift in power relations within the office setting. In other words, there is a shift in control and resposibility for tasks by virtue of differential work experience and also a shift in the position of the social structure of relations.

Novice/ Expert Judgment Of Item Difficulty. Due to statistical problems with this measure it was dropped. Further justification for dropping this measure came from the item analysis shown in Table 12 of this chapter, which demonstrate the same novice/expert difference across all items.

Realism of the Order Filling Task.

This task was designed so that as a participant observer I was required to interact with the experimental participant at every step of the problem-solving process. It was therefore of interest to determine how realistic this task was perceived to be by participants within such an unusual experimental situation.

All responses to the question:" How did this order filling task differ from a real order?" were coded along five dimensions of realism. Table 23 illustrates how realistic participants in each group perceived the order- filling task.

Table 23

Expert/Novice Differences In Reported Realism Of Order Processing

Realism	Novice	Expert
1. Very realistic	3	7
2. Realistic but items too special	2	4
3. Quite realistic but worker has different relationship with customer	1	1
4. Not realistic but a good simulation	1	0
5. Unrealistic	5	0

It is important to note that 90% of the expert group considered the experimental task realistic compared to only 42% of the novice group; 50% of the novices perceived it as unrealistic and none of the experts described any aspect of the task as artificial.

Figure 12 illustrates these differences with several protocol segments:

Figure 12

Novice/Expert Perception Of Realism In Performing The Order Filling Task

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Novice 1 (rated 5): This is not natural. I would never quote someone in a hurry on this. I would have to go back to them. I would make calls to find out what items actually cost. It made me think but it was not realistic.

Novice 4 (rated 4): Honestly, first I realized it was a fake order. You know you take that into consideration. It had to be filled immediately, where I would not ordinarily fill an order immediately... I think it was done very good because it made the salesman have to think and investigate and do it under pressure which is how we work a lot of the time.

Novice 5 (rated 3): Well at that point when I was dealing with that order I wasn't so experienced in pricing. So if I had a customer I would have to say I would have to get back to you with certain information because there is more information that I would have to get.
Experimenter: How was that different with what you did with me?
Novice 5: First of all, I wouldn't have had to go into so much details with the customer. I would have been more general.
Experimenter: Anything else?
Novice 5: Well the difference is that I wouldn't

have my customer sitting next to me going around asking questions. I would have to be more diplomatic and try maybe to tell her: "Okay, I will get back to you another time."

Expert 13 (rated 1): No different from a real customer.
Experimenter: Do you guesstimate often?
Expert 13: Oh, absolutely.Otherwise I would spend all day on the phone.
Experimenter: So this would be something very natural that you would do every day?
Expert 13: Absolutely.

Expert 17 (rated 1): It's realistic. It happens every day that I have to,extract information from a buyer without a print who doesn't know much about what he is buying. It's a pretty fair test. You included everything. I think it's realistic.

These results are not surprising. Seven novices expressed concern about the time constraints of the task and half were concerned about guesstimating price. Since novices perform more routinized, clerical-type transactions in their everyday work they have a narrower functional perspective, suggesting that they experienced guesstimating as unrealistic. As previously noted, they rarely completed the whole order-filling process or guesstimated price without the help from co-workers.

In marked contrast, experts were accustomed to dealing with time pressures(suggested by their sorting approaches) as shown in the previous chapter and were able to navigate through the information-rich environment of the office with ease. All agreed that guesstimating price for their customers was an everyday occurrence. This suggests that experts have a highly detailed know- how which they keep in their

heads and display in their actions. These results lend further support to the idea that novices and experts were performing very different tasks.

General Discussion

Examination Of Hypotheses. Novice/expert differences will be examined in the light of my original hypotheses:

I expected that experts compared to novices were more likely to use more and different external aids to solve problems. Novices would more often ask the help of other people.

Novices utilized the inventory and co-workers in the performance of both parts of the order-filling task. Experts, on the other hand, rarely asked the help of other people, used fewer but more diverse external means in the performance of both phases of this task. These findings only partially support my hypothesis because the use of external material resources by novices was constrained by their limited knowledge of where to go. Experts, on the other hand, when necessary, used the full range of available material resources of the office setting.

I expected that experts' problem- solving would be characterized by linear or sequential steps toward a solution or goal. In contrast, novices would jump back and forth between different steps of the process.

This hypothesis was not borne out. Experts did not exhibit a particular pattern of steps. Novices, on the other hand were found to employ the first three steps using external means 63% of the time and of those half involved co-workers.

Although neither group exhibited any particular pattern in pricing, findings suggest that experts may have been working backwards. This will be discussed in the next section.

I expected that expert workers would choose certain principles. Once a principle was applied (e.g.,"Is this item standard or is it special?") it would narrow the range of possible solutions. Novice workers were expected to proceed by stringing together the checking of miscellaneous external knowledge sources only loosely connected with the task.

Experts asked generally price-sensitive questions and made judgments twice as often as novices. This suggest that they were aware of the underlying principle needed for pricing. Contrary to expectations once a decision of special or standard was made, it enabled them to calculate the cost of the item more effectively, but not the price. Prices given by experts were generally structured in terms of the type of customer or what the 'traffic can bear,' rather than one ideal price. Novices used significantly more material and social means to arrive at a judgment and often did not know that a judgment was required. This suggests that they were not aware of the underlying principle of the task. Thus, except for the fact that experts gave multiple prices, my hypothesis proved to be borne out.

To summarize, novices perceive order filling as two tasks, collecting information about the physical aspects of the item first and then calculating price. For experts, order - filling generally appeared to be one task and their main concern rested with the cost of the item and how much to charge the customer.

Experts guesstimated price more often, imposed greater structure by including more factors in the price and generally estimated higher prices compared to novices. No particular pricing pattern, however, was found for either group or for suppliers, which suggests great price flexibility in this industry. Analysis of material and social resources employed to fill the order and price the items supports several previous sorting results. Novices accessed the inventory more often than experts. They also required the guidance of co-workers for both parts of the task. Experts used principally their knowledge and information from material resources to fill and price all items.

In sum, these findings suggest that with experience there is a shift in the organization of knowledge from one centering around information of the physical dimensions of the items obtained from external material and social resources to order-bound skills relying on knowledge of both the physical factors and non-physical factors only indirect ly related to the items. More importantly, although experts out-performed novices for all measures devised for this

task, they did not meet company standards for any of those measures.

Findings Difficult to Explain In Terms of an Information Processing Framework.

Recent studies in problem solving have focused on the influence of content or domain- specific knowledge for the understanding of expertise. In general, empirical findings from domains such as physics (Chi, Glaser, & Rees,1982) suggest that expertise is the result of highly organized, hierarchical knowledge structures that are acquired over years of learning and experience. Findings from solving real-world problems with large knowledge bases have not been as straightforward and present different challenges (Glick, 1985).

I will briefly discuss three specific findings in the present study which differ from results in current problem-solving research.

First, analysis of the number and type of steps revealed that experts used more s.g. steps (asked more questions and critical questions without external means) than novices. This suggests according to current information-processing theory that the experts' representation is constructed in the context of the knowledge available for this particular problem and that the poor quality of the novices' representation required them to make use of external aids. The difficulty with this explanation rests with the fact

that experts generally asked less than half the number of officially prescribed s.g. questions. In addition, not one expert asked all the critical questions. Several explanations previously given suggest that experts possess many different kinds of knowledge compared to novices. One example was asking price- sensitive questions without needing to obtain all the required information. This, however, suggests that experts may have been working backwards, pricing first and obtaining all the information later. In other words, here, price structured questions-asking. Novices on the other hand, may have been getting all the information first and then formulating price and therefore question- asking structured the process of pricing. Support for this idea comes from the fact that novice considered order filling two tasks, question asking and pricing, whereas experts were mostly concerned with price. This finding represents a major departure from that of current problem solving research in other domains (Simon & Simon, 1978; Larkin et al. 1980). For example Simon & Simon (1978) found that expert physicists used a working forward strategy to generate successive equations solveable from given information. On the other hand, novices employed a backward strategy.

Second, experts made twice as many judgments about item type and three times as many correct judgments as novices. According to current information- processing theories, this

suggests that experts distinguished the 'deeper structure' or principle involving the specialness of these items. Nov ices generally examined the literal dimensions or surface qualities without looking for deeper principles. Although this explanation is in keeping with other problem solving studies (Chi et al,,1981), on closer analysis, experts did not perform optimally since they came to no decision 27% of the time. This finding remains difficult to explain.

Third, results obtained from a variety of problem-solving tasks suggest that once a specific representation is developed, a particular solution will follow from that representation. Since the question- asking process (part) of this task is analogous to the process of developing a problem representation, the solution is based on the quality of the problem representation. Therefore, it was expected that experts would arrive at a correct solution more often than novices. Results, however, indicated that novices guesstimated one price more often because they believed that the task required one right answer. Experts, on the other hand, generally gave more than one price. Tasks employed in all of the investigations of physics problem solving (e.g. Chi, et al., 1981; Larkin et al., 1980; Simon & Simon, 1980), have been problems with one known solution and were usually referred to as well-defined problems. Here, results suggest that the representation established by the novice was guided by the company standard requiring one price whereas experts

guesstimated the prices that they thought would work.

This raises the question of whether order-processing is what can be considered a problem-solving situation or rather a conflict such as for example between charging a high price vs. losing an order and/or the customer. In other words, giving "one right price" does not constitute a solution here. There are multiple and complex relations involved in the processing and filling of orders. It is a reflection of business practice rich in meaning and personal sense. Having the customer accept price with a high margin of profit, or price to get repeat orders and maintain good social relationships are both acceptable solutions. But this suggests that the usual methods and tasks employed for problem-solving in information processing studies may not be adequate for this particular work situation.

In sum, ill-defined problems are those that evoke a highly variable set of responses (Reitman, 1965). According to Simon, experts find solutions to ill-structured problems by reducing them to well- structured problems and must have the expertise of doing this transformation. In the present study the reverse is true. **Experts took well-structured problems in terms of formulation and standard prices and transformed them to ill- structured problems.**

Although experts outperformed novices in many respects, the above findings are difficult to explain within an information processing framework based on one cognitive ideal.

As previously stated, an activity approach will enable me to reexamine these results and find alternate explanations.

Relationship between Tasks.

The findings will be discussed in terms of my final two hypotheses:

To examine the relationship between the two experimental tasks it was expected that :

1. A more stable, hierarchical and elaborately organized knowledge base would facilitate more efficient access of information i.e., more key questions.
2. The number and type of classifying dimensions used in the classification task would be positively related to the number of questions and key questions asked because subjects drew on a similar knowledge domain for the performance in both tasks.

Neither hypothesis was fully borne out. The number and type of classifying dimensions used in the sorting task were positively related only for the novice, to the number of questions and key questions asked in the question- asking part of the task, even though both groups of participants drew on similar knowledge domains for the performance of both tasks. For novices the number of features in sorting was positively related to number of questions and key questions for order filling (for questions r=.5, p=.1; critical questions r=.13, p=.6). For experts, on the other hand, findings demonstrated a strong negative relationship

between the two tasks (r-=.32; [1]p=.31; r=-.35;p=.26). This, however, came as no surprise if their performance on the sorting task is taken into account.

Although no quantitative relationships were detected, qualitative results suggested some relationships between tasks. Novices, for example, demonstrated greater concern with the physical dimensions of items both in their sorting criteria and order- processing of the task. In other words, novices considered the order- filling task to be two tasks, focusing on question- asking first which involved the physical aspects of the item as a prerequisite for pricing. The expert, on the other hand, had many alternative ways of arriving at price. This suggests that the two tasks were related for both novices and experts by the qualitative aspects of their knowledge and information.

1.The Pearson correlation coefficient employed here measures the strength of the linear relationship between two variables. However, because of the small sample size (n=12), high positive and negative values may be the result of deviations among participants.

CHAPTER 7

PHASE 4: RESULTS OF POST TEST-INTERVIEWS

In keeping with the multi-method approach, the final phase of this investigation consisted of additional observations of work activity and a series of one- hour sessions with participants, where questions were raised and responses noted. The interview questions, to all participants, covered four areas which centered around descriptions of their customer interaction, their job, their present goals and what it means to be an expert telephone sales clerk. Despite the similarities between novices and experts in many of their answers, there were many subtle differences.

My interview data revealed that relations among sales workers, buyers and suppliers are composed of social and economic components often hard to distinguish. As shown in chapter 5 novices consulted fellow office employees such as managers, experts and even novice workers, whereas experts conferred only with other experts. Expert/novice joint interaction with vendors and customers was found to be qualitatively different for both groups.

Joint Interactions. There were several patterns of joint interactions that characterized the relations of each group. Experts, for example, reported that their customers looked towards them for guidance and advice on the choice of

items, plating, cost factors etc. which suggests that friendship was only one aspect of their expertise. " Should I modify a standard item or make it from scratch? Will I save money on nickel plating?" are examples of some of the questions. Although still a horizontal relationship for the expert sales clerk, the friendship relationship was often transformed into a novice/expert relationship with the customer this time in the role of novice. Moreover, although all experts agreed that friendship plays an important part in being an expert, eight experts felt that even more important is to feel the customer out, listen to the tone of the voice and, from that, gain information on competition, previous costs, etc. One pattern noted, characteristic of experts I shall call 'feeling out interaction' defined as sales clerks, customers, and suppliers, each feeling the other out for some privileged information. This pattern of social interaction is illustrated by protocols from interview data.

While these descriptions do not include first-hand documentation of customer - sales clerk interactions, their accounts present additional evidence for the transformational effect of work experience on these relationships. Figure 13 shows some protocol excerpts illustrating the various interactions:

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Figure 13

Expert/Novice Differences In Social Interactions

Novice C described as part of his job, for example, that :" I try to understand the people, their personalities, so that our conversations go a lot smoother, therefore making it easier to speak about other things and maybe getting more business out of it. So I draw from that a lot. How to get along with people, not to sound ignorant or hard on the telephone."

Novice Ev confided that her goal is: " to be more comfortable on the phone talking to my customers. Sometimes I get a little nervous."

Upon being asked what contributes to being an expert sales person expert S responded: "The ability to talk naturally with somebody, to feel them out and see if you can joke around with them, curse at them a little bit. They curse back at you, develop a friendship on the telephone. The friendship translates into business. You like to talk to the people -- what's new with them -- what's new with their families. The business part comes naturally once you develop that relationship."

E: Do you find that it makes people more tolerant when something goes wrong?

Expert S: " Absolutely. If you're late on a delivery, if you have a rejection, knowing someone helps get over that problem. Not all the time. I'd say 85% of the time. If you have that relationship you could almost find out how much you can charge."

E: Can you expand on that?

Subject S:" It's like a feeling I get when I talk to somebody depending on the item they give me. If they give me a wild item or if they're calling from California -- why are they calling S in New York for a crazy item? Because they can't get it in that area, I'm able to think maybe I could get x dollars

instead of y. I might be right 80% of the time and in that way get that extra 2 or 3 dollars per thousand...
I try to imagine it was me and I'm a desperate buyer and I'm trying everybody in the world and if somebody finds it and I need it tomorrow, I don't care what the price is."

Expert ER stated that:" A person who is average or below average as a sales person takes the information down and tells the customer he will call him later.Both the sound of the voice and their enthusiasm for what they are doing is limited by their response. You need to be involved on the phone in a personal way."

Expert J commented that: "It's that familiarity that you feel with the item. It's just something you feel and the knowledge that you have that you can probably get it for him (the customer). Being in the field for maybe ten or fifteen years, it's something that you feel you can get for him...if I can't, it's almost like feeling that it doesn't exist for me."

Expert G confided that: " My prices are sometimes dictated upon what I feel. ..The price depends very much on how I feel the customer out. I would know just by his response on the phone with me. Instinctively I know how to price... I know when I am talking to someone that doesn't care how much I charge...like I read his thoughts. You know how far to go up and down...
I can recall one sale made on an item which was a very large order and I really wanted to generate that order and I was speaking to that particular customer and I had given him a price of 17.50 per 100.As I was talking, and this was an order for 100,000 pieces, discussing the price I felt I had the order, even at a price which was very high to be quite honest."

Upon being asked if that is expertise, expert G replied:

"Yes, because it gives me the edge. You have to feel it. I say to myself, he's a very nice guy, I've impressed him and right then I know

where my pricing is at."

Expert H stated that: "A lot is the ability to deal with people on a one- to- one basis outside the realm of fasteners. Part of it is for lack of a better word, 'feeling.' You talk to someone on the phone and you size up the demeanor of the person on the phone. The little things . For instance, a person calls you up on the phone and says: "Hi, I've been trying all day to find such-and such" and immediately the price goes up 100% if you know enough to pick up on that."

Expert A argued that:" A lot of this business is feeling each other out. Whether he is trying to manipulate you.....He was glad that when he spoke to me he felt that I know what he is talking about. You could see in the tone of his voice that I'll be talking to him again."

Expert B stated that: " Anticipating what your customer wants and feeling your way in terms of this kind of back and forth in terms of price you know how to price because of your customer's reaction and voice."

Expert H stated that: " An expert sales person must be very aggressive. He must be willing to learn. He must have a feeling for the product....He's got to have some kind of feelings to learn constantly. Much depends on the tone of the voice of the person on the other side. In other words if he says to me to "Give it to me lower", I respond and if he doesn't say anything I don't bother. So I kind of feel my way of how much to charge."

Expert D: "You know right away from the tone of the voice and from the few questions you ask. Okay, someone says, 'Oh, is this XYZ Bolt? Can I please have sales?' It's a quick tone.'I have an order to place.I need it right now.' That means the customer is very, very desperate. You charge a very high price -- not very high but you can charge money. He may ask you to send it by Federal Express or next day air. Then you take a chance and say, "By the way, did you call anybody -- do you have any other prices?

> What is my competition? " and he replies "No, you're the only one. I'm calling you -- I had no luck with anybody." or when he says "This is impossible to find." -- that's your base paycheck -- that's where you make money. You don't kill the goose -- don't get me wrong, but that's where you make money. It's each individual's feeling. It's experience."
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> ---

These excerpts suggest that the form and the pattern of social relationships is different for novices and experts. Novices participate in more surface, monologue-like, vertical and horizontal relationships. Experts' social practices, on the other hand, were characterized solely by horizontal and often intense and deeply reciprocal relationships. They sought to develop a "feel" for the situation, often using a 'public language' with the people they communicated with. In other words, their relations were finely tuned to the particular people and the particular situation. Much of this interaction is reminiscent of Vygotsky's assertion that:

> Every sentence that we say in real life has some kind of subtext, a thought hidden behind it... Every thought creates connections, fulfills a function, solves a problem...Thought itself is engendered by motivation, i.e., by our desires and needs, our interests and emotions. (Therefore), behind every thought there is an affective -volitional tendency, which holds the answer to the last 'why' in the analysis of thinking (Vygotsky, 1962, p.149).

and Volosinov's (1973) concern with the social role of verbal utterances and dialogical exchanges.

Job Description. Several differences between expert and novice participants were noted in response to: "Can you give me a brief description of your job?" For seven novices, personal relationships were part of their job description. Only one expert included personal relationships as part of his answer. Five experts stated that offering customers alternate product items was an important part of their job. Four experts also mentioned selling off inventory as part of their job description. Novices' answers generally showed concern with checking stock, answering customer calls and researching price.

Table 24 lists the job titles participants gave themselves.

Table 24

Job Self Definition

Title	Novice	Expert
Sales Engineer	7	1
Salesman/woman/person	3	3
Other	2	8

Novices were significantly more likely to use sales engineer whereas experts used other titles (X^2=8.1; DF=2; p=<.017).

Personal Goals And The Company Agenda.

Some questions elicited diverse responses and clearly differentiated between novices and experts. To illustrate the different themes that characterized their responses, verbatim answers given by individuals from each group are examined to the experimenter's question:" What are your goals and how do they differ from those of the company?" This allowed for different degrees and different types of ideological structurig. Figure 14 lists the main responses elicited.

Figure 14

Novice/Expert Differences in Company and Personal Goals

Company Agenda	Personal Goals
N1: Working here I go along with company goals of increased sales.	N1: I want to learn and advance.
N2: I am happy if I get a good account for the company.	N2: Company does well and is happy with me.
N3:Book business for the company.	N3: Increased sales is my main personal goal.
N4: Improve service along with improved quality. Satisfy the client.	N4: My goal is the same as that of the company. Satisfying the client gives me personal satisfaction.
N5: Increase sales for the company.	N5: To become more experienced, gain knowledge. Be more comfortable on the phone talking to customers. I get a little nervous and want to overcome that nervousness.
N6: To get as much sales as I can. To help the company because if the company has work I have work.	N6: Personal satisfaction. The more I sell, the more I make.
N7: To get as big an order as I can. To get the highest price I can.	N7: To be a 'self starter'. I want to do things on my own.
N8: The ultimate goal is to satisfy the customer.	N8: To be able to fulfill the request of the customer, the rest is icing on the cake. It's a nice feeling.
N9: My goal is to gain customers for the company. To keep customers happy. Keep them coming back. Make a nice profit for the company.	N9: To get orders shipped out on time.
N10: Get many more orders.	N10: Generally I'm still trying to find my goal. My immediate goal is to get orders. I like getting repeats. I like what I'm doing. I separate my personal life from this.
N11: I feel I am doing well at this job. I want to continue pleasing every one here in the company.	
N12: Getting the right material on	

time.

E13: No goals for the company.

E14: To get as much business as possible. Push for business. To have the customer in mind. To make sure the order is done and filled correctly and as expeditiously as possible.

E15: I want to be sure that I give competitive prices and meet delivery dates.

E16: My goal here is to achieve 0 defect in my work with my customers with the delivery schedules that I keep. I want there to be no late orders.

E17: My goals are those of the company but they should also keep my goals in mind. Satisfy my customers and make money for the company.

E18: Make a profit for the company and myself.

E19: Satisfaction that the customers orders are growing. You know bring in more business.

E20: The goal of my job is to serve my customers in the best possible way that is beneficial to the company.

E21: To write a lot of profitable business which will hopefully hold me in good stead with the company. To see the company make money and share in it.

E22: --no goals for the company.

E23: My goal is to ship the item on time, on or before the in-house

N11: I want to learn more of the technical aspects and make sure that the parts I ship are quality parts and correct material.

E12: The more orders I book the more money I make.

E13: My goal is to retire. I'd like to continue as long as I can, but I think at this point in time as anyone my age, I would like to have more time to myself.

E14: To make as much money as possible. The satisfaction of filling an order that is almost impossible to fill time wise or otherwise. Follow through on my accounts for more orders. Make sure orders are properly filled.

E15: Make money from commissions. Get out of here. Sometimes I don't know why I'm here. I should be doing this for myself.

E16: In this job, there are times that I think I would like to reach more like general manager but I know it is difficult here.

E17: There is not much further that I can go in the company unless there are drastic changes. If that happens, yes, I figure I can go a lot further. I don't see a great future here for myself. Sometimes I feel ' boxed in'. My goal other than that is to make more money and higher commissions.

E18: Satisfaction from completing the initial phone call to the requirement, the research, to the buying, to the shipment of the guesstimated period -the satisfaction from having the phone call

date and not to antagonize the customer.

E24:To keep my customers happy so that they come back.

until the goods are in the warehouse. Customer is happy, and I made a profit for the company and myself. That's my goal.

E19: Personal satisfaction in terms of commission. Also satisfaction that the customers orders are grow ing even bigger. You know, bring in more business.

E20: For me it is kind of contradictory working for someone else. I try to make the most commission possible. I don't like selling common items. I am only challenged by difficult or impossible requests. Anyone can sell common items.

E21: My goal is to make a living number one. To satisfy the customer but get the biggest, most profitable order I can. If it's a difficult order, the challenge of trying to get the order knowing I have competition. When he sends the order confirmation to me, I feel real satisfaction.

E22: Make a living and support myself and my family. Pay my bills. Nothing more.

E23: Not just to make money. My goal is become somebody... a big business man. Right now I have to survive. I have a family to support and I wanted a stable company. On the side I own a small part of real estate property. I want to advance here and make more money. Money always comes first.

E24: Financial, get raises and provide for my family.

One notable difference between novices and experts centered on the perception of their futures and expectation about promotions and vertical mobility. Novices spoke of immediate goals and were solely concerned with the company requirements. Experts were caught in conflicting demands between personal and company needs. In other words novices' goals appeared to be in agreement with those of the company whereas experts had multiple, diverse and often conflicting goals not always those in the interest of the company. Interestingly, only one novice referred to money whereas ten experts alluded in diverse ways to monetary considerations.

The role of motivation and goals is central in the cultural - historical theory of activity and since " motives are only revealed to consciousness ...by means of analysis of activity and its dynamics" issues relating to this approach will be discussed in the next chapter.

Descriptions Of Expertise. In response to the question: "What do you consider necessary to be an expert telephone sales person in the field of Industrial Fasteners?" only one of twelve expert respondents emphasized technical knowledge of fasteners. All twelve expert's however, alluded to some form of social interaction with vendor and or customer not necessarily based on friendship alone. Novices defined expertise in terms of technical knowledge and friendship or good relations with customers. The major difference was in the pattern of the social interaction. Let me illustrate

with a few protocols:

Figure 15

Novice Description Of An Expert In Telephone Sales

N: Its a mixture of personality and techni cal knowledge. Talk well and relate to people and needs . Must have a good memory.

N: Be charming and nice to the client. Persuade them to give you an order. Agree with the specifications and delivery time. Talk about other than technical things, i.e. plans for the week-end.

N: An expert sales person will not loose an order but at the same time try to make money on it. They must also know what they are talking about.

N: I don't have technical knowledge yet but I know who to ask or where to go.

N: It's important to know the materials and the pricing, but unless you have a good relationship with the people you deal with, it doesn't make any difference.

Figure 16

Expert Description Of Experts In Telephone Sales.

E: It's being able to size up a situation and a person on the phone. In other words, you must know how to take a situation and milk it in a sense. Know how to ask a person whether it's a bid or a buy without turning them off. So a good salesman has to take 50 calls and throw out 40 without hurting somebody. There is a sublayer beyond just being charming or aggressive. Expertise is having business acumen. For example if you want to find out from a customer what he has been paying for an item, you may want to seem like you are doing him a favor. You can say: "Do you want a

target to meet so we can save you some money?" He may say " no" because nobody so far has quoted him on this item. That gives us some information. Or he may say,: 'I've been getting .40 or. 50 cents each; that is another piece of information. Or he may not want to tell you anything and that, too, tells you something about the customer. Any way, it gives you a piece of information, but it is a subtle way of asking. A novice will usually be blunt and say: "What price do you need?" In fact that's like hitting somebody over the head with something.

E:It's being able to size up a situation.It's the art of getting underneath the initial conversation. The art of extracting information and then doing something about it to modify the situation to your advantage. As opposed to just going ahead and attacking the task without extracting important information.

E:Having people pegged. Like, you know that with some people you can get away with any price. There is a buying pattern not only in the type of material they buy but how they buy it. If someone is stupid enough to say I have an order to place and gives you an order number -grab it -that's the accounts you dream about.
I also have a customer that I made from a $30,000 account into a $150,000 account be cause nobody knows what the stuff is and where to buy it. So he's locked in. You have a captive buyer. You see, every company has their own secret sources and you also develop your own. The third type is knowing who your competition is and knowing the buyer won't go out to a fourth person if there are three unless all three no- quote him. Maybe you don't want that to happen, especially if you're number one out of the three.

E: What to say appropriately. Getting out of tight situations gracefully. Know your product line. It's communication,it's how you communicate with your customers. Follow up. Keep commitments. Friendly relationships often give you greater freedom to negotiate

like asking them if the price is right or guiding you. But you also have to know what you're selling.

E: Flexible, open minded, always soft sell. I feel that if you are pushy, people run the other way.

E: You have to know how to talk and what to say and be able to get away with lying when you lie. I do it with delinquent deliveries -it's common knowledge and the common excuses are the best ones.

E: Knowing how to negotiate in the middle. Say first the customer wants the item. Then as a middle person be able to go to the vendor, negotiate with him and go back to the customer and renegotiate. To be able to be one moment a supplier and the next moment customer. Wear two hats.

E: Be persistent, but only to a point. You can generally tell that point by the response on the other end. Technical knowledge is not enough.

E: Ninety percent of this business can be learned the first two years. The other 10% takes you the next 20 years. Product line is not the most important

Some of the themes that emerge from these responses indicate that the major expert/novice difference in the social character of the worker's world centers around the patterns of their relationships. From their descriptions, novices endeavor primarily to have a superficial, friendly relationship with their customers. Experts' responses, on the other hand, suggest that they have many different levels of simultaneous relations in their work world. For example,

they delve deeper into the psyche of their customers, and their apparent friendships often function as instruments to outsmart their customers or achieve some kind of advantage over them. These responses, which reflect the daily flow of interactions and communication, together with those described previously, suggest that experts generally develop deeper, more intricate and dynamic relationships with their customers and suppliers than do novices. These private relationships often have a sentient component and are not solely bound up with sharing technical information. In other words, not all information culled from these informal exchanges is explicit or ever documented. Many of the personal contacts are private and oral in nature and frequently its features are reminiscent of oral cultures and craft work (Ong, 1982).

In sum, these verbal descriptions suggest that the companies investigated are complex and replete with conflicting interests between the outside work world and within organizational members. These interviews were honest and very revealing, in spite of the fact that customarily, once the outside investigator enters the picture, organizational secrets are often withheld, as the company tries to present its best face.

CHAPTER 8

AN ACTIVITY PERSPECTIVE OF THE SORTING TASK

There are no known empirical studies of sorting interpreted within an activity framework. In this section I will employ an activity framework as an alternate interpretation to examine the findings in which participants exhibited a reverse trend or which could not be accounted for by current cognitive theories.

The three major points previously noted that I will address now are: 1) why such different sorting approaches were taken by the two groups; 2) why experts exhibited such unstable representation of this domain; and finally 3) why novices performed closer to the officially accepted mode for the Fastener industry.

Order-Bound vs. Inventory-Bound Explanations of sorting.

One explanation for the expert/ novice differences in sorting explanations was that workers understood the instructions differently based on different goals in the experiment. On the one hand, novices read: " Sort those items that go together," (the usual instructions) whereas, on the other hand, experts interpreted the instruction as: "Sort those items that go together for an order." This

suggests that novice subjects viewed the sorting task from a sorting perspective and a screw as an object to be sorted into the inventory. Experts viewed a screw in the context of filling an order; that is, not as an object but more as an entity that may serve a particular function embedded in a larger and more complex system of relations. Since novices in their work activity drew extensively on the inventory for information about product items, the inventory in the sorting task helped to organize their classification activity and structure their knowledge. Experienced workers were more efficient in respect to " getting the job done" (their use of time) than novices and had developed modes of classification which incorporated, and were structured, by different aspects of the task which in turn structured their actions. Based on an activity approach, this suggests that novices and experts were performing very different tasks, i.e., sorting according to the characteristics of the item (inventory or item- bound) or sorting based on taking an order (order-bound).

An alternate explanation for this finding was that novices followed the instruction less accurately than experts since they did not "sort for an order."

Even though novice and expert workers both carry the label of telephone sales engineer, novice telephone sales clerks perform essentially very different work. Typically, novices carry out more routinized clerical work and get help

from a more experienced worker on the more complex tasks. Experts in telephone sales, however, are not limited to the purely technical knowledge of order-taking and order-filling, but their technical knowledge is embedded in the much wider, richer, yet less specified physical and interpersonal world of the office. This may have been reflected in their sorting approaches and explanations.

This further suggests that novices were "bound" to the surface structure and therefore were unable to reorganize for function. This could account for why they ignored "sort for an order" in the instructions.

Why Experts Show such Unstable Representation of this Knowledge Domain.

An explanation for the apparent difficulty that experts had in producing two consecutive identical sorts is suggested by the following the course of their sorting patterns. Analysis of the sorting protocol of experts S. provides a good example. Expert S. changed his grouping principles several times without ever reaching a criterion trial. He first grouped all the special items. He subsequently decided that it would be easier to price these items if they were grouped according to material. On the last sort he decided that some of the items needed to be made from scratch, changing his mode of classification for the third time. When asked why he changed his groupings so often, he replied: "We

do this all the time. That's what our job is about. We take and fill orders and are constantly learning and changing in the process." Here the actions were organized as they appeared in the actual business practice.

On further analysis, Expert S. organized the product items on a "least effort principle" similar to that found among product assembly workers in Scribner's (1984) dairy study and this suggests an explanation for the so-called 'reverse directionality finding.' The effort saving principle refers to "the psychological reorganization of work tasks to reduce the number of physical and mental steps required for the accomplishment and/or to simplify steps that cannot be eliminated" (Scribner, 1984, p.39).

Expert S. strove for greater economy and ease with each trial. On the first trial, he reduced the number of calls to suppliers by dividing the items readily available in stock and those items that had to be ordered from the outside. On the second trial, he grouped the items according to type of material. This enabled him to check stock quickly because the inventory is organized by material as the primary category. Expert S. was also able to avoid making multiple calls to suppliers since many specialize in specific materials. On the third trial, Expert S. selected from those items that had to be ordered the ones that needed to be made by a small, specialized group of machine shops again avoiding making multiple calls.

The above three trials suggest that the directionality of the experts' sorting process was toward greater economy of motion and ease and that the sorting task was functionally organized in respect to "getting the job done." This explanation suggests that the structural relationship to the elements of the experimental sorting task change when presented to individuals who process this domain in different ways and connect this classification task with real life processes.

Why Novices Performed Closer to the Officially Accepted Mode for the Fastener Industry.

Novices' sorting patterns were closer to the normative standard (sorted like the owner) and closer to how the task has been used traditionally from an information- processing perspective compared to experts. One possible explanation could be that the goal of the company and the participants' personal goals were the same and that he/she wanted to perform accurately on this task. An alternate explanation for the expert/novice difference in sorting patterns is that because it very much resembles what novices do in their daily work lives, it had functional significance for them. As a result of the routinized nature of the work performed by novices in this field, it is possible to characterize their sorting behavior according to only one set of actions and operations, i.e., those linked to the physical aspects of the material to be sorted.

Experts, on the other hand, structured the task more according to their work activity - taking and filling orders. Expert telephone sales workers must buy from the right vendors, they are expected to know whether the item is standard or special, and they must work fast because customers are always in a hurry. Their work activity therefore accounted for why they functionally reorganized the sorting task in a variety of different ways (different approaches) compared to novices. This interpretation is very consistent with an activity- oriented approach to culturally developed forms of knowledge.

The Structure of the Sorting Activity with Regard to Levels.

Examination of the sorting process from the perspective of different levels of analysis provides support for the idea that novices were performing different tasks from experts. Table 25 presents the expert/ novice change for each level.

Table 25

Activity Perspective of Sorting

	Novice	Expert
Level 1 - Activity	Classification	Order- filling activity component.
Level 2 - Action	Sorting actions i.e.items that go together.	Order- taking actions i.e.group to buy etc.
Level 3 - Operations	Clerical skills i.e. filing cards.	Sorting operations i.e. items that go together.

For the novice, sorting functioned as an inventory activity employing concrete information in performing goal-directed sorting actions. It was an activity in its own right. The sorting actions in their work (checking stock and afterwards replacing inventory cards) based on the physical features of the items also served as a goal in itself.

While classification may be logically prior to the actual filling of an order, results suggest that classification for experts may not have operated as an isolated skill but was embedded in a larger activity system. Experts were actually placing upon classification another system which had very little to do with the concrete characteristics of the items whether consistently or inconsistently used of the set to be sorted. They were superimposing an embeddedness characteristic of their business practices upon sorting

where the particular nature of the item was of less importance than the way they transacted their business. Their goal directed- actions were no longer centered around the physical or surface characteristics of the object but were order - taking actions, that is, components within a broader system that defined them. Thus, the goal directed actions of novices for them became transformed into operations or means of attaining their goal and the various sorting approaches were the goal directed actions of their order-filling activity. The differences in the larger goal-motive systems that define the structure of activities such as -inventorizing or order filling were therefore reflected in differences of these workers' goals and the organization of their actions and operations.

In sum, while information- processing focuses on the structure and organization of knowledge, these findings suggest that classification within an activity framework is closely linked to the concrete social practices or practical job tasks in which it functions. Analysis of the qualitative and quantitative results and observational data provides support for the notion that novices sorted the materials the way they check and file cards back into the inventory and that these were closely linked to the surface characteristics of the items. In contracts, experts did not separate this task from the practice of filling orders. Their sorting

approaches suggest that for them classification was a dynamic process complexly interrelated with their business practices. What was interpreted within information processing theory as a static but unstable knowledge representation can be viewed from an activity perspective as a dynamic and changing functional sorting process within a larger system of work relations.

Was there directionality? It very much depends on the theoretical position one holds in interpreting these findings. From an information- processing perspective which holds that there is one 'ideal' standard of development based on material and accuracy, these findings are difficult to explain. From a functional developmental standard where the individual is never separated from his/her activity, the experts' performance can be viewed as exhibiting a more developed state.

CHAPTER 9

Activity Approach To the Job of Telephone Sales.

My review of the literature and experience in the field led me to look beyond the current formalist and information processing models toward a broader framework, enabling me to show multiple, complex, social and material relations germane to the present investigation. Within an activity perspective, the worker is never separated from his/her activity. Therefore, in this study, rather than focusing on the individual psychological processes of telephone sales workers, characteristic of information processing theories, my starting point and the focus of my analysis was a socially organized work activity and the organization of the social and material actions and operations within it. In other words, cognition became only one aspect of the analysis. This perspective essentially enabled me to explain many of my findings, e.g., the less than optimal performance on the quasi-naturalistic task, the variability in prices, and the expert/novice differences in social relations. Although I retained many of Vygotsky's original ideas, much of this particular research was guided by the basic tenets of Leontiev's work.

The interpretations that follow in no way attempt to be

an exhaustive analysis of the data from an activity perspective. That task is beyond the scope of the present investigation. Rather, these interpretations are meant to show that the concept of activity can, in fact, be operationalized and the object of psychological study.

The Office World from an Activity Perspective.

Within an activity framework, the office world of the fastener industry appears not just as a collection of material objects such as catalogs, files, inventories, books and people but acquires new characteristics as a function of the specific activity of the worker into which it was drawn. From an activity theory perspective, for example, it is the sales worker who, as an agent, transforms the inventory, the files or catalogs or even other people and in the process transforms himself. In other words, by examining the practical work activity of telephone sales clerks, it enabled me to analyze the balance of the office environment from the point of view of the reciprocity between semiotic systems and mental operations.

For example, findings from the quasi-naturalistic task and post- test interviews in chapter 6, suggest that the inventory had different functional potentials and meaning for experts and novices. Novices often resorted to the inventory and other people as a means of obtaining information about an item. Experts on the other hand employed the

inventory as an important information system for negotiation and bargaining. In essence it was a question of the meaning. The inventory has no inherent meaning by itself. It served, however, as the official source and meaning for novices and the official and unofficial meaning and reference source for experts in these companies.

In sum, it was the work activity which brought the worker into functional relationship with the material and social world of the office. This approach differs markedly from expert/novice kinds of theories that discuss restructuring of knowledge, but do not address expert/novice changes in the organization of actions embedded in concrete kinds of activities from which knowledge is derived.

Expert/Novice Change In Content and Structure of Telephone Sales Activity.

My analysis, employing activity theory as a framework for studying expert/novice differences, will begin by operationalizing some of the basic constructs such as activity, motive, appropriation, sense and meaning which have rarely been fully delineated within a socially structured industrial organization. There are many difficulties stemming from this perspective because the theory so far has been open to a wide number of interpretations.

Much of the empirical research that has emerged from an activity perspective has failed to fully apply the analytic

framework specific to activity theory and only the levels related to actions and operations have been operationalized. In other words, because motives are not necessarily conscious, and must be examined by studying a practical activity, levels of analysis concerned with activity and motives so far as I know have not been addressed empirically in any direct way. Yet the basic tenets of activity theory concern the object directedness of an activity.

I chose as my unit of analysis the the level of the whole person engaged in a concrete type of activity or task, i.e., telephone sales order getting and filling . Since the choice of unit determines which data to look at and the level of explanation one employs, this unit on the level of activity was chosen because it enabled me to examine the expert/novice difference in the development of the structure and content of activity as I understand it.[1](see chapter 1)

A concrete type of activity, such as telephone order filling, as a unit of behavior and object of study, enabled me to examine what these sales clerks do in the broadest context relevant to my data. Questions were asked and data examined which in traditional psychological theories have

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1. Unfortunately, the relationship between content of concrete or object activity and activeness (Aktivitat), i.e., objects that function as motives vs. objects that function as goals or goal-motives that are conscious, was never sufficiently worked out by Leontiev. In this study, motives always refer to conscious goal-motives.

always been considered extra- psychological, irrelevant or non-existing. For Leontiev 'Activity' was the central construct, reflecting the cultural basis of cognition, as shown in his assertion:

> "human psychology is concerned with the activity of concrete individuals, which takes place either in a collective-,i.e., jointly with other people or in a situation in which the subject deals directly with the surrounding world of objects e.g., at the potters wheel or the writers desk...if we removed human activity from the system of social relationships and social life, it would not exist...the human individual's activity is a system in the system of social relations. It does not exist without these relations. (Leontiev,1981b, pp. 46-47)."

Moreover, this assertion indicated that contrary to current western theories, intellectual activity for him was not isolated from practical activity.

The unit of analysis must also be relative to the domain one is investigating. Selecting a unit of analysis on the level of goal directed actions (Scribner,1984) or tool-mediated action, (Zinchenko, 1985) in the present study would have meant reducing the whole to its "elements" rather than having components that possess the chararcteristics of the whole.

I searched out a common unit of analysis that expressed the three forms of one and the same process: external (objective), internal (cognitive) and relational (subject-subject) and erased the boundaries between these, set up

by traditional psychological theories. For example, the proportion of social and material constituents of the concrete activity in this study shifted with experience. The socio-cultural setting of the office provided the major resource for the work activity of the novice. For the expert on the other hand, work activity represented a multi-level, multipurpose phenomenon (multi-actions and social relations converging in on the structure of business activity) which generated a whole network of social actions going beyond the confines of the office setting.

In sum, the activity process evolved in a qualitatively and quantitatively different way for novices and experts around these three planes and shaped how their technical knowledge was incorporated into their total work experience.

On the first level of practical or object activity, I will discuss two findings culled from interview data and explanations given by participants in this study concerning expert/ novice differences which were outside the realm of Information Processing theories: First, the shift from mono- to multi-motivated activity and second, the transformation of the form of the social interaction from surface to multi layered social relations employing appropriation as an explanatory construct. I will then proceed to discuss some of the findings more on the level of actions and operations directly related to the quasi-naturalistic task.

Table 26 shows the three tiered novice/expert shift suggested by the data and discussed in the following sections. Also shown in Table 26, on the general level of 'Work Activity', novices were participating in what I called 'clerical sales' because the major component of their daily actions were routine and clerical in nature. Experts, on the other hand, participated in 'Work Activity' I called 'telephone sales' because their day to day actions consisted of telephone communication, i.e., wheeling and dealing, with customer and suppliers.

Table 26

The Novice/ Expert Shift From an Activity Perspective

	Novice	Expert
Work Activity	Clerical Sales	Telephone Sales
LEVEL 1		
Practical Activity 1	Order processing	Order getting and pricing
Practical Activity 2	Pricing	
Object or Goal-Motive(s)	Learn to fill orders	Make money; get promoted; be challenged; take profitable orders for the company
Objects or Goal-Motive(s)	Price according to company standards	
LEVEL 2		
Actions - Task 1	Question asking actions	Communicative actions; negotiate with suppliers and customers; Guesstimate price
Actions-Task 2	Calculate standard mark-up with pencil and paper	
Goal 1	Learn to fully specify items	Price according to each situation. Get order at highest price without losing order or customer.
Goal 2	Complete the order by quoting one price	
LEVEL 3		
Operations	Write up orders; calculate price with component costs given by co-workers; clerical skills	Ask s.g question to specify item; calculate price without external means

Note. Many motives are not conscious. Only in the case when the motive and the goal of an action coincide are they conscious. Conscious motives are referred to as goal-motives.

Level 1. From Mono to Multi- Motivated Activity.

As previously mentioned, in most empirical research carried out so far within an activity framework, only levels related to actions and operations have been studied. In the present study the importance of the actions for the worker and their place within the total structure of the work activity was examined as part of the analytic scheme. Although motives cannot be directly observed, they can be derived by analyzing other activity structures. Motives define and give impetus to activity and determine the personal sense and societal meaning that these actions have for a worker. The dynamic aspect of motives are explained by the person's underlying need(s). The motive that directs the workers' activity is simultaneously defined by a need and the object that satisfies it. Thus, in this scheme according to Leontyev (1979), it is possible to talk about motives only when a need has met its specific object[1]. Contrary to Western theories of motivation, this shifts the boundaries from inside the head to the 'objects' in the world outside and defines motives in a more concrete way. The difficulty with an analysis of motivation lies with discovering the 'object' of desire. Leontyev argued:

1.The term "object" here refers to physical aswell as conceptual and symbolic objects.

> "The paradox lies in the fact that motives are revealed to consciousness objectively only by means of analysis of activity and its dynamics. Subjectively, they appear only in their oblique expression, in the form of experiencing wishes, desires, or striving toward a goal...Recognition of motives is a secondary phenomenon arising only at the level of personality" (Leontyev, 1979, p.124).
>
> Elsewhere he wrote:
>
> "The main thing that distinguishes one activity from another lies in the difference between objects. The object of activity is its motive" (Leontyev, 1977, p.184).

Reorganization of Motive-Goals from Novice to Expert. ALthough the development of single and multiple motives has so far remained outside empirical formulation, results in the present study suggest that goal- motives may have played a central role in differentiating experts from novices in this study. For example, interview data showed that the personal goal- motive and the company agenda (motive) of novices converged on one object, i.e., doing what is best for the company. The object of activity for the novice was primarily to process orders according to company standards. Even their motive to learn was subordinated to the dominant motive of "efficient and profitable production", which conformed to that of the company (Wertsch et al., 1984). For them, personal sense and organizational meaning were not separate.

In the course of working, the work activity of experts changed and became generally more directed towards several often conflicting objects simultaneously. This shift of the work activity upward to order- bound skills, i.e., more decisions and responsibilities often associated with managerial tasks, reinforced the expert's underlying fantasy or illusion of achieving an entrepreneurial state which, however, was not borne out by their current pecuniary returns. Comments by expert telephone sales workers reflected this shift. For example, experts wanted to have their own business, make more commissions, be challenged by difficult situations, be promoted, change jobs, keep from being bored, etc. in addition to also turning out profitable orders for the company as defined by the organization. For them, the societal meaning and personal sense had become separated or what Marx called " alienated.[1]" In other words, experts were often caught in the conflicting demands between personal and company needs indicating that they had several objects and simultaneous relations to reality. This suggests that the activity components (on all levels) involved for experts were structured differently than those of novices by their organization of motives both on an individual level and as they related to the societal (company) level.

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1. This is an extension of Marx's concept of alienation.

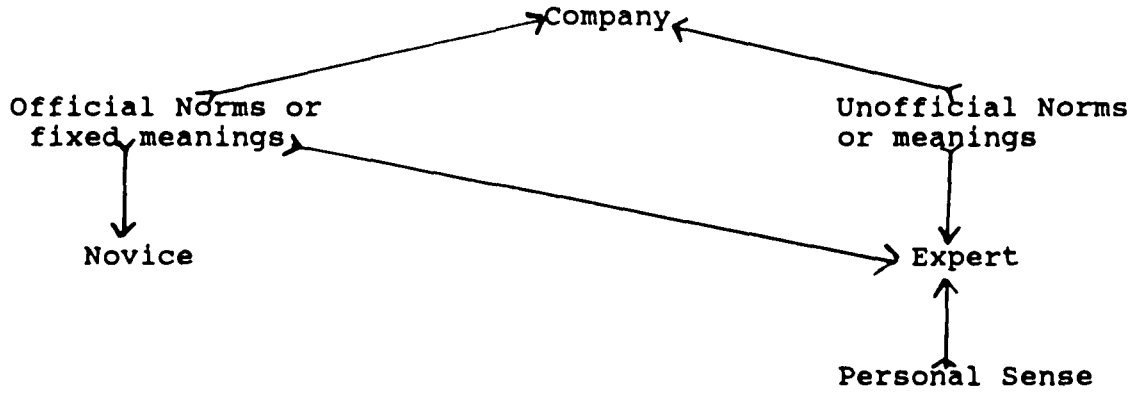
To understand expert/novice differences, the company's socio- cultural meaning, and the way goals and motives define the worker's activity and actions and their personal sense, must be taken into consideration. Figure 17 illustrates schematically the relative place of cultural meanings and personal sense of telephone sales activity for the company and the workers.

The three apparently different ideological[1] forms are essential in sustaining the business practice.

1.The term 'ideology' refers to a "level of social meaning with distinct functions, orientation and content for a social class or group (Hodge & Kress, 1988, p.3).

Figure 17

Model of Company and Novice/Expert Socio-Cultural Differences in Business Practice



Note: Official norms or meanings include the stable quality of the organization, i.e., technical knowledge; standard prices with standard mark-up; social exchanges shared by every member of the organization.

Unofficial meaning includes feeling customer out; low-balling, wheeling and dealing, etc.

Personal sense includes what the job means to the worker and the personal goal- motives that have developed from their activity, i.e, going into ones own business, getting promoted, being challenged etc.

First, for the company, telephone sales were based on multiple official and unofficial factors such as availability of the item, the quality and quantity of items required, etc. but also the wheeling and dealing with customers and suppliers.

Second, for the novice, telephone sales' goal and motive were to conform to the official norms of the company,

i.e., use a company-established mark-up in pricing; fully specify the item, etc.

Finally, telephone sales for the expert had multiple aspects. Their objects were grounded in the norms set by the organization (official and unofficial). Overriding and sometimes against this broad based system of official and unofficial meanings was posed another system, a system of individual or personal sense as opposed to the more broad based system of meanings. This personal sense kept developing for the expert and was never quite complete in its formulation. It lived in the "future of possibilities," i.e., to get promoted; start a business of my own; be more challenged, etc. For them the immediate goals and overall motives became separated - what Marx called" alienated."

In sum, novice/expert changes and reorganization of goals and motives were associated with the change in content and structure of their activity and the change and development of its objects. According to Leontiev (1979), the needs of these sales workers changed in the process of their work activity generated by a cycle of 'activity-need-activity' rather than the traditional western approaches reflected in the genetic cycle of 'need-activity-need' (Maslow, 1958). Here individual and company motives could not be studied directly. They had to be derived by examining other activity components. The dynamic aspect of motiva-

tion in this work activity was reflected by the novice/ expert transitions between these different activity components.(See Table 26)

In sum, this suggests that the transition from novice to expert leads to the differentiation of societal meaning from personal sense.

Transformation from Surface to Complex Multilayered Social Relations. Leontiev's assertion that :

> " Human individual activity is a system in the system of social relations and does not exist without these relations. The specific form in which it exists is determined by the forms and means of material, mental and social interaction created by production and realized by the activity of concrete people (1981b, p.46)."

The concept of 'appropriation' (Aneignung- taking the cultural- historical aspects of ones world into oneself and in the process being transformed and becoming part of that culture) serves in the present study as an explanatory construct for the novice/expert transformation in social relations. Appropriation can be defined as the individual's link with society and the process of incorporating societal meaning (Nielson,1986). Although Leontyev defined the process of appropriation as realizing "the main necessity and chief principle of ontogenetic evolution in man, i.e., the reproduction of the historically formed characteristics and capacities of the human species in the characteristics and

capacities of the individual, including also the capacities to understand and employ language" (Leontyev, (1981a, p.299), appropriation in this study was more narrowly defined as situation and domain specific. The limited definition, however, broadens the concept of what in traditional information processing theories has been called 'learning' to include the incorporation of social and cultural meanings ("Aneignung der gesellschaftlichen Bedeutung").

In the present study, appropriation acted as a connecting category, connecting the sales person to the larger work organization. In the course of practical activity such as telephone sales, the societal meaning of the fastener culture became gradually carried into the sales person's interpersonal relationships. This link, as well as their personal sense, characterized the expert's sales person's social being ("Gesellschafliches Sein") and relationships, and differentiated them from that of novices. For example the novice /expert shift within the organization from vertical to horizontal social relationships and more importantly the qualitative transformation of social relations with suppliers and customers (Chapter 6) reflected the process of appropriation. Leontyev's assertion that a person who appropriates the "system of linguistic meanings is as well mastering their more general ideological content,... (because) one and the same system of linguistic meanings proves

capable of expressing a different, and even opposite content (1981a, pp.258-60)." These coexisting and often hidden, implicit meanings and ideology describe the expert's social interactions.

Although this study was limited in scope, these social relationships are believed to be a more general reflection of society and of the particular kind of cultural and social organization prevalent in American business practice.

Level 2 and 3: Expert/ Novice Differences on the Level of Actions and Operations.

As shown in Table 26, with the upward movement to more order- bound skills there was a simultaneous qualitative shift downward of the expert, from the novice, to the next level in the activity structure, for some activity components.

For example, in this study, I examined the inner and outer means (forms of mediation), and their transitions. The findings suggested that the transitions from one to the other were important in demonstrating the novice/expert shift. For example novices employed external means, like asking other co-workers, to help them define the items whereas experts transformed the novice's external actions into internal operations (s.g. questions). For the novice the goal was to define the characteristics of the item and this then structured how the item was priced. The goal of

the experts, on the other hand, was to guesstimate price, and price structured their question- asking. For them the questions-asking was the means (operation) to a goal, not a goal in itself. Experts superimposed upon the question asking component of the task, just as with the sorting task, another system, which reflected an aspect of their business practice. Can I outprice a competitor? In other words, price was structured by the total business practice. Question asking, social relations, motivation and goals all contributed. Even meaning and sense condensed into the price, in the case of experts. Experts became part of the fastener culture and reflected that culture. They could afford to take a risk because they had many alternative ways of doing things available to them. For the novice, the goal was to ask all the questions. They could not take risks. Their actions were constrained and limited by their goal. Further support for this on the level of actions comes from the differential use of the inventory.

Interestingly, the patterns of the novice's social interactions were similarly constrained by their singular object and goal as reflected in their friendly but monologue-like surface relationships with customers and suppliers. On the other hand, on the level of actions, the moment to moment dialogic interaction with customers and suppliers resonated the expert's multiple objects and goals. This

once more demonstrated that the activity components involved for experts were structured differently from those of novices by the organization of their motives and goals. It also suggests that they were performing very different tasks.

What is Problem- Solving in Telephone Sales?

In addition, experts did not present one right price or solution reflecting the multiple social and material connections of the expert's activity in telephone selling. What was the goal-motive of their pricing action? As previously stated, the real issue here was what constitutes a problem and a problem solving situation in contrast to a situation that presents a multiplicity of (conflicting) goals? Having a goal of giving the one and only right price constituted a solution for the novice but not for the expert. Like in the sorting task, the single price was characteristic of the normative standards (that novices adhered to) of the fastener industry and closer to the solutions provided in the more traditional experimental problem-solving tasks. For the expert, who was operating in many realities, having the customer repeat the order, because the price was right from the supplier and at the same time make money for themselves and make money for the company was the true dilemma. The fact that experts personally ordered and edited prices depending upon the customer and situation, reflected aspects of their motivation and values. It was this difference that

shaped their business practice and was most indicative that experts and novices performed different tasks.

In sum, the proportion of social and material constituents changed from novice to expert. For the novice the socio-cultural structure of the office and the people in it provided the major resource for order- filling activity. For the expert, order- getting was a multi-level, multi-purpose phenomenon which generated a qualitative and quantitatively different interplay of actions and operations from that of novices and encompassed a whole social network of resources beyond the confines of the office setting.

Most important, however, was Leontyev's principle asserting that it is the need-objects (motives) that guide and direct activity. As these change, so does the activity and the components in it. Although motives are not always conscious if we assume that knowledge is derived from actions and actions are the source of experience, then studying the kind of actions and operations and how they were carried out here, was indicative of the participants' need-object(s) or motive(s), locus of knowledge and level of experience. As the forms of mediation changed in the course of becoming an expert, there was also a shift in the locus of knowledge and the structure of the activity components.

CHAPTER 10

CONCLUSION

Information Processing Theory vs. Activity Theory.

One of the major findings of this dissertation was that when traditional methods and explanations employing 'ideal' standards borrowed from developmental and information processing theories were applied to the knowledge domain of the fastener business, they lost some of their predictive powers. Information processing theories stress some standard measure or cognitive "ideal." In many ways information processing theories are cultural products themselves emphasizing only one aspect of reality (i.e.,thinking in school-type domains and tasks) and do not represent fully the activities in everyday life. These theories reflect the time in our cultural history which holds to the concept of an idealized human being, considered as the subject and the center of knowledge, and that there is only one way of doing things. Within this tradition psycho-physical dualism still plays a large role with respect to methodology and the interpretation of data.

One purpose of the present research was to employ the concept of activity as a methodology to see if this broader and more encompassing framework could be useful in studying

work activities in their natural setting. The choice of what was acceptable as data and more importantly how some of the data was collected and interpreted differed here from that of more orthodox studies in the field. This fundamental shift in perspective resulted in revealing certain aspects of the work activity and novice/expert differences that were not visible when examined as simply problem- solving from an information processing perspective. Within this framework, for example, there is no one ideal way of problem solving because it is the "individual in concrete activity" embedded within a social and cultural milieu that is the "functional ideal."

This dissertation provides psychologists with a look at everyday working people involved in practical activity in the business world. It was inspired by Scribner's model and analysis of practical thinking (1984b) in an industrial dairy. I would like to conclude by pointing out some similarities of Scribner's findings among dairy workers with that of telephone sales workers and how her model of practical thinking at work was extended by this dissertation. I will then follow with a general discussion of my findings.

Scribner's Model of Practical Thinking

Scribner's research involved the analysis of the uses of arithmetic performance by drivers and warehouse workers in a large diary operation. This dissertation also focused

on an industrial work setting and specific work tasks. Both studies employed activity theory as a central paradigm (1984, pp.2-4). The multimethod design of this dissertation was borrowed from research in the dairy. Employing Scribner's research strategy, I moved from observations and interviews to the experimental and quasi-naturalistic tasks and back for more questions, observations and interviews. Each method informed the other. Contrary to procedures employing information processing methods, within this framework in both studies, participants were free to perform the same task in many different ways. This yielded in- depth knowledge of the particular occupations that were examined. The aim of this dissertation, similar to that of Scribner's investigation, was to lend "some precision and rigor to the study of everyday work activities in real life situations"(1984b, p.3).

I believe that the participants' experiences found in these studies, and their similar patterns, were not unique and have deep resonance with those of a great many other white and blue- collar occupations. For example, flexibility characterized the performance of experts in both studies by demonstrating that "modes of solutions changed with experience" and knowledge. Dairy loaders began their jobs by using literal solutions to dairy orders. With experience, these solution procedures were transformed to non-literal solu-

tions. Thus, experts "freed themselves from rules, and invented flexible solution strategies" (Scribner, 1983, p.22). With the acquisition of technical knowledge, the telephone sales workers were also freed to reformulate items by sorting for function and to personally order and edit prices.

Similarly, economy of mental or physical effort characterized the experts' performance in both studies. In the dairy, drivers and warehouse experts used optimal solutions to save physical or mental effort. Telephone sales experts guesstimated or worked backwards in pricing to avoid asking all the questions or waste time on a quote which might not turn into an order.

Most important, in both studies the novice/expert shift went from the mastery of the general to the mastery of the concrete. For example, telephone sales clerks began their careers with general school-type knowledge and only much later mastered the concrete technical aspects of the fastener domain.

Extending Scribner's Model of Practical Thinking

There were two ways that the present study extended Scribner's model of practical thinking at work. First, the shift in the analytic unit and second, by the inclusion of social interaction as an object of analysis. Because of previous discussions in chapter 6, I will consider only the

first difference.

Scribner's analytic scheme involved only levels related to actions and operations and, therefore, the importance of the actions for the worker was not examined. Scribner's "guiding concept of goal directed work actions taking the form of functional systems or action units" in the present study were shifted to the next higher level, that of concrete or objective activity, i.e., concrete is synonymous with objective activity. For example, the objects of order-getting for experts were to make commissions, be challenged, get promoted, etc. In Scribner's analytic scheme (1986b), as I understand it, the action unit was a particular task or situation with a particular goal. In the present study, the task was examined as an activity directed towards needs that had found their objects. For the more experienced workers these need-objects changed, and thereby changed other activity components.

In sum, with the inclusion of the level of concrete activity, I am extending Scribner's model to a higher level which I believe reflects more fully, on a micro-level, the particular kind of social and economic organization occurring at a macro-level in American business at this point in our history.

Redefinition of Expertness: The professionalization of telephone sales.

Knowledge of fastener products, although necessary, cannot here be employed as the sole measure of expertise. The larger data base liberated the sales person and facilitated the development of expertise through the acquisition of social and cultural experience effecting an integration and structural reorganization of technical knowledge with social skills.

For example, novices usually started out as clerical workers, bringing with them the theoretical knowledge they acquired in school. The more experienced co-workers usually delegated the humdrum rote or routine aspects of telephone sales to these newcomers to get rid of the tedious details of this business. With time and experience, the technical aspects and standard procedures were mastered by the novice workers. Within traditional information processing theories these workers would now be considered experts. From an activity approach, when the technical aspects are in place, the sales worker is first then free to integrate all other aspects of the task, such as the more situation- specific realizations of business practice, i.e., bargain with suppliers, guesstimate price for customers, work backwards, underprice or 'low ball' to get a 'foot in the door', etc. (see pricing, chapter 5). Thus, the notion of expert/novice

differences was not exhausted by looking solely at qualitative and quantitative differences or the organization of knowledge , customarily associated with an information processing approach, but focused on the variations in what might be called the use of business acumen, which is a way of reproducing and instantiating the culture and meaning of business. Therefore, expertness cannot be isolated from the individual that is expert. To be an expert one must participate in a particular work activity and transform it and in the process be transformed oneself. In the present study the job of telephone sales was different for the expert and novice because the activity was different and the subject (the worker) and object (need-object) were different. The truly expert worker theoretically reproduces the culture or societal meaning in his work activities and then brings to it her/his own personal sense.

Leontyev captures this in his definition of 'meaning':

> Meaning is the generalization of reality that is crystallized and fixed in its sensuous vehicle, i.e. normally in a word or word combination. This is the ideal, mental form of the crystallization of mankind's social experience and social practice...He (man) assimilates the experience of preceding generations of people in the course of his life; that happens precisely in the form of his mastering meanings and to the extent that he assimilates them. Meaning is thus the form in which the individual man assimilates generalized and reflected human experience.
> (Leontyev, 1981a, p.226)

By societal meaning I believe is also meant the deeper, rarely examined and written about 'off the record' aspects of being an expert in the practical world revealed in this study, and I believe reflecting more generally contemporary American business practice, with its conflicting understandings and different realities.

APPENDIX A

List of Items Employed in the Sorting Task

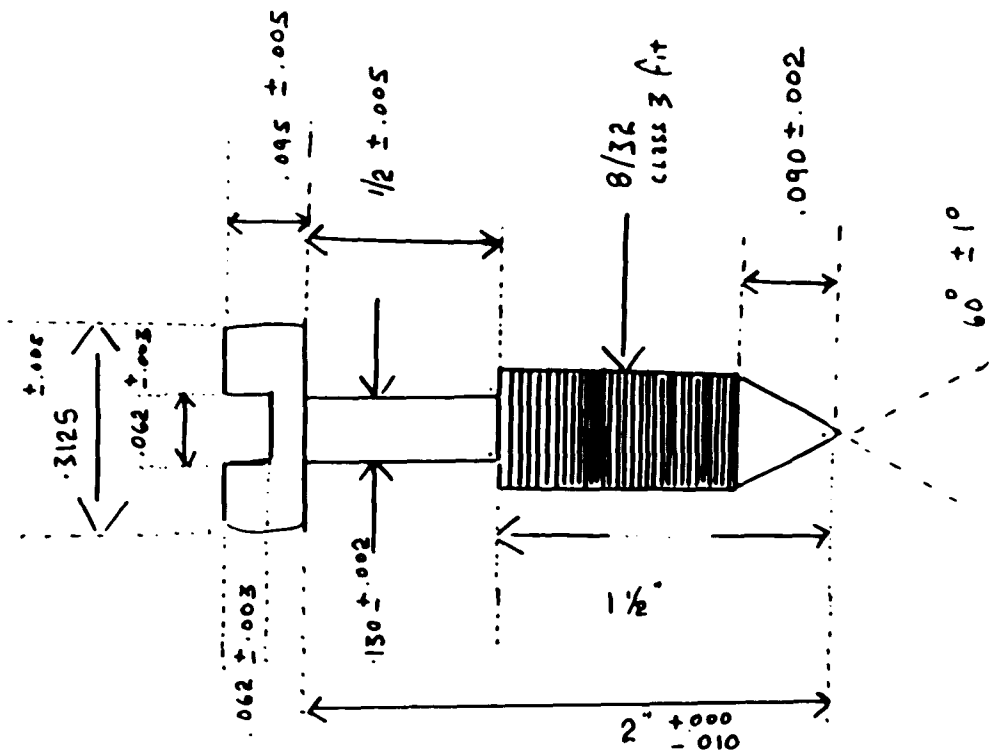
1. 8/32 Hex nut, Steel
   WAF 11/32
   Thickness 1/8
2. 8/32 Square nut, Steel
   WAF square 3/16
   Thickness 1/16
3. 8/32 Square nut, Steel
   WAF square 11/32
   Thickness 1/8
4. 8/32 Hex nut, Brass
   WAF 11/32
   Thickness 1/8
5. 8/32 Hex nut, Brass
   WAF 5/16 X7/64
6. 8/32 Hex nut, Brass
   WAF 1/4
   Thickness 3/32
7. 1/2 - 13 Slotted hex nut, Steel
   WAF 3/4
   Thickness 9/16
8. 6/32 Hex nut, Brass
   WAF 5/16
   Thickness 7/64
9. 6/32 Hex nut, Brass
   WAF 1/4
   Thickness 3/32
10. 4.40 Hex nut, Steel
    WAF 3/16
    Thickness 1/16
11. 4/40 Hex nut, Steel
    WAF 1/4
    Thickness 3/32
12. 2/56 Hex nut, Stainless steel (Type 303)
    WAF 1/8
    Thickness 1/16
13. # 4 Flat washer, Steel
14. # 10 Flat washer, Steel
15. # 10 Split lockwasher, medium series, Steel
16. # 8 Flat washer, Brass
17. # 8 Split lockwasher, silicon bronze
18. # 6 Medium split lockwasher, Phospher bronze
19. # 6 Flat washer, Brass
20. # 6 Flat washer, Steel
21. # 4 Medium split lockwasher, Steel
22. # 4 Internal lockwasher, Steel
23. 6 x 1/4 Slotted pan head type B sheet metal screw, Steel

24. 4/40 x 5/16 Binding head machine screw, Steel
25. # 10 x 1/2 Slotted pan head type B sheet metal screw, Steel

26. 6/32 x 5/16 Binding head machine screw, Brass
27. 6/32 x 1/4 Binding head machine screw, Brass
28. 4/40 x 5/16 Binding head machine screw, Brass
29. 10/32 x 1/4 Binding head machine screw, Steel
30. 4 x 1/4 Slotted pan head type B sheet metal screw, Steel
31. 3/4 - 10 x 2 Hexagon bolt, Brass
32. 3/8 - 16 x 2 Hexagon bolt, Silicon bronze
33. 1/2 - 13 x 2 Hexagon bolt, Silicon bronze
34. 1/4 - 20 x 1/2 Hexagon head capscrew, Steel
35. 1/4 - 20 x 1 Hexagon capscrew, Silicon bronze
36. 5/16 - 18 x 1 1/2 Hexagon bolt, Steel
37. 3/4 - 10 x 2 Hexagon bolt, Steel
38. 1/4 - 20 x 1 Drilled fillister head machine screw, Silicon bronze
39. 8/32 x 2 Pan head captive machine screw, Steel
40. 1/2 - 13 x 2 Shoulder screw, Brass
41. 8/36 x 1 Oval spanner head machine screw, Brass
42. 10/32 x 7/8 Thumb screw with shoulder, Steel
43. 5/16 - 18 x 1 Drilled fillister head machine screw, Steel
44. 6/32 x 3/16 Slottted flat head machine screw, Steel
45. # 6 Cup washer, Steel
46. # 6 Internal - external lockwasher, Steel
47. # 8 U- bend washer, Steel
48. 1/2" Beveled washer, Steel
49. # 8 Internal - external lockwasher, Steel
50. # 10 External countersunk washer, Steel
51. 2/56 Hex nut, Stainless steel (Type 303) WAF 3/16, Thickness 1/16
52. 1/2 - 13 Slotted hex nut, Steel WAF 7/8, Thickness 1/2
53. 1/2 -20 x 2 Carriage bolt, Steel
54. 1/4 - 20 x 1 1/8 Hex head cap screw, Brass
55. 1/2 - 13 x 3 Stripper bolt, Steel
56. 3/4 - 10 x 2 Elevator bolt, Steel
57. 3/8 - 16 x 2 Drilled hex bolt, Steel
58. 3/4 - 10 x 5 Tank bolt, Steel

Appendix B: Diagrams of the Five Fastener Items Employed in the Quasi-naturalistic Task

Item 1 — Captivated Pan HD Machine Screw



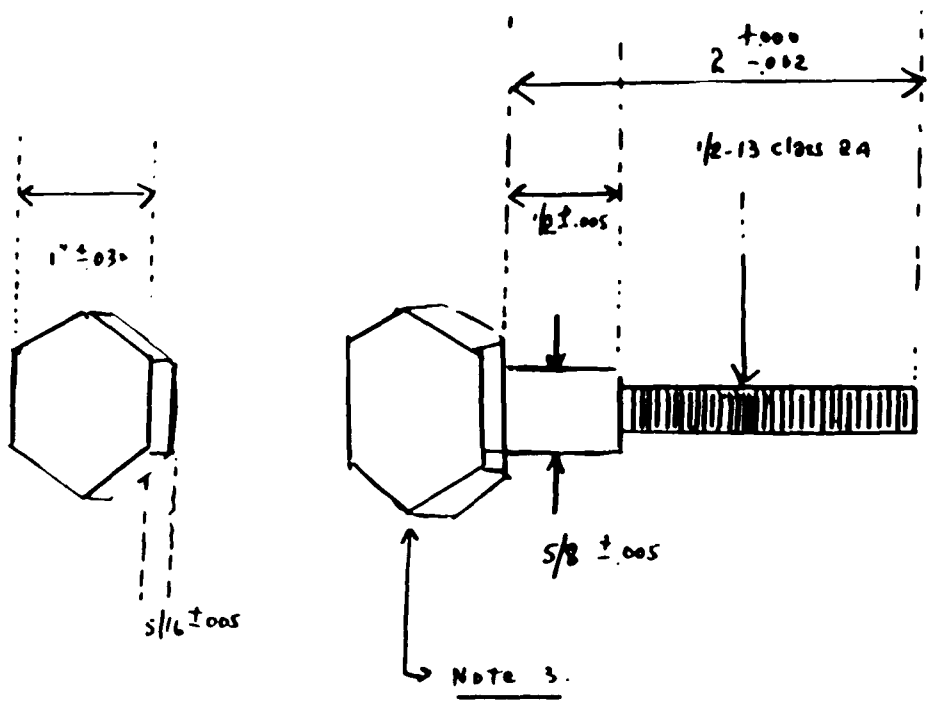
Notes

1. Class fit 3
2. Slot-sawed
3. Cone point

Material	Plate	Tolerance
1018 Steel	Zinc .002	± .005
ALT 12L14 Steel		

Item 2

Hexagon Shoulder Screw

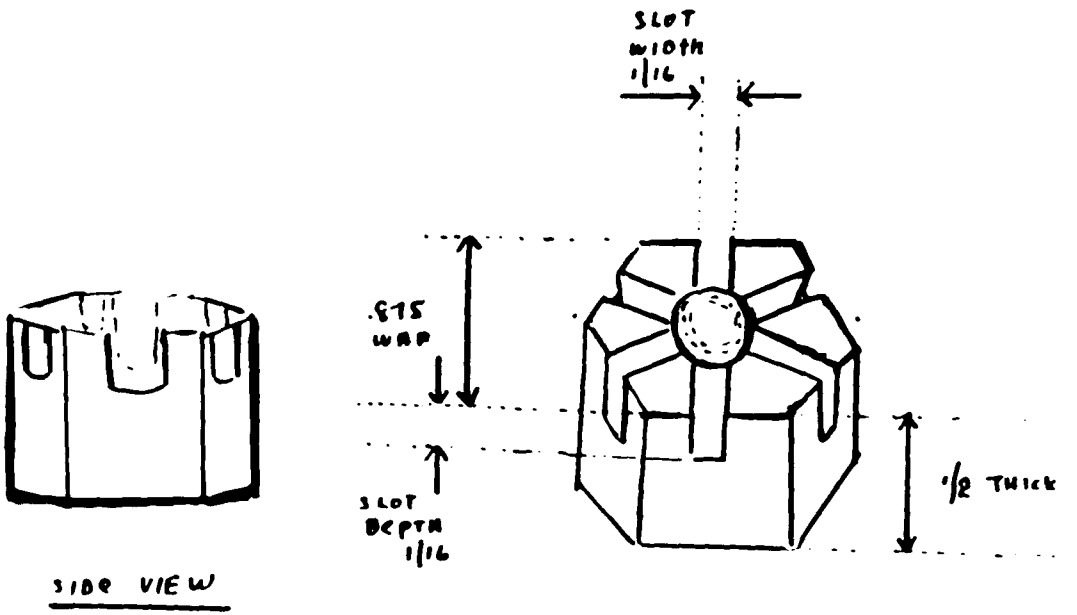


Notes

1. Head diameter 1" ± .032
   Head height 5/16 ± .005
2. Width across corners
   Hex head 1¼
3. Maximum break corners
   .005 on head only

Material	Plate	Tolerances
Brass	Bright Nickel	
Half Hard		

Item 3	Hexagon Nut-Slotted



Notes

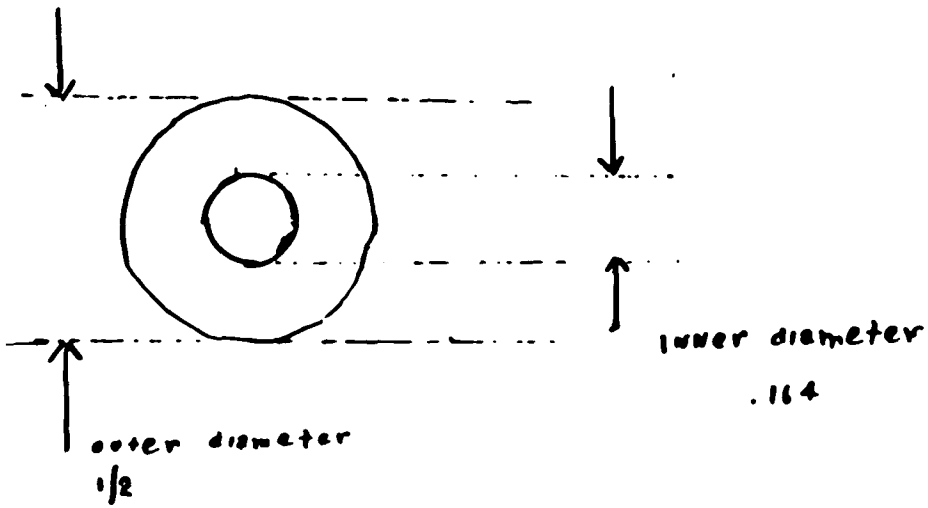
1. 1/2-13 tapped hole class 2B
2. Single chamfered
3. Double Coontersink

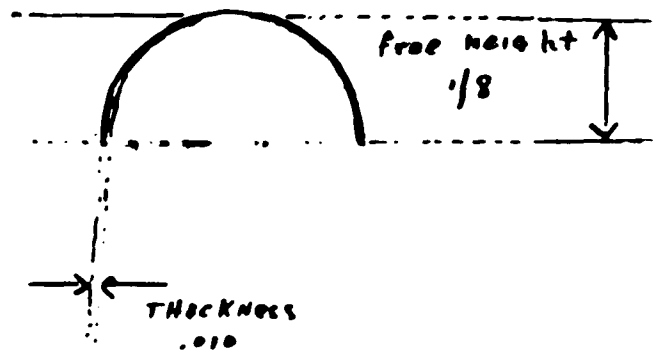
Material		Plate	Tolerance
Steel		Bright Dip Brass	± .010

Low Carbon

Item 4

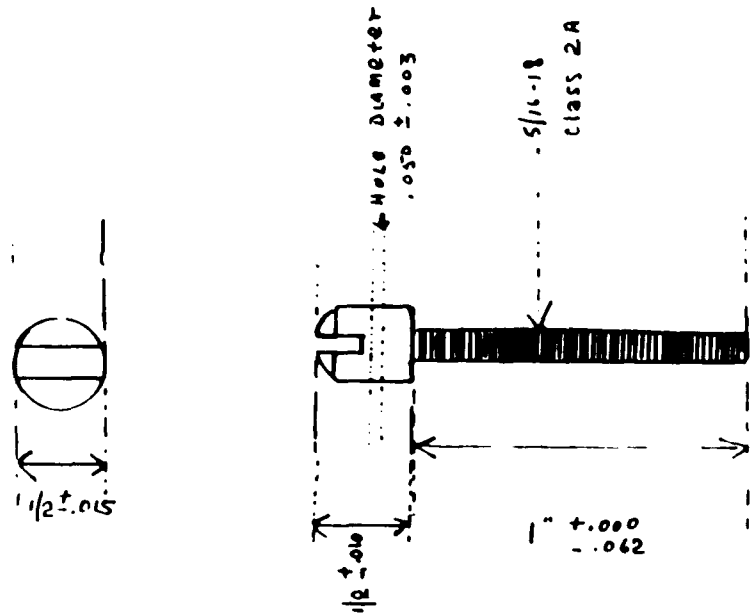
U Bend Washer





Material	Hardness	Plate	Tolerances
1065-1075 1095	RC 28-35 C scale	Black Oxide	+ .002 -
Alloy steel			

Item 5 — Drilled fillister Head Machine Screw



Notes

1. Slot width .060
   Slot depth .060
2. Center line of hole to bottom of head .060
3. Depth of slot not to break into hole

Material	Plate	Tolerance
1010 Steel	Zinc	± .005
Low Carbon		

APPENDIX C

Official Attribute Knowledge Required for Salesworker to Fill Order on the First Product Item

1000 pieces of 8/32 X 2 Pan head captive m/s,steel[a]

Attributes

1. head diameter: (std. .322-.306) .3125 +/-.005=.3175-.3075
2. head height: (std. .096-.085) .095 +/-.005
3. slotted or philips drive: slotted
4. slot width: (std. .54-.045) .062+/-.003
5. slot depth: (std. .54-.045) .062+/-.003
6. diameter of captive section .130+/-.002
7. length of captive section: 1/2" +/- .005 length
8. length of threaded section: 1 1/2"+/-.005
9. thread series and fit: class 3 fit (class 2A std.)
10. type of point: cone point
11. angle 60 degrees: +/- 1 degree
12. material: special type 1018 steel
13. plating - zinc .002

Tolerances[b]

K 14. length of captive section: +/- .005
K 15. diam. of captive section: +/- .002

Note.. Off Spec. - Receive off Spec. permission but not in keeping with 0 Defect concept

a. Cannot manufacture or modify from standard - Unless customer accepts diameter approved by quality control engineer.
   1. Class 3 is special fit (class 2A is standard fit)
   2. Head diameter is special

b. Tolerance is defined as the total permissible variation of a size; the tolerance is the difference between the limits of size.

Standard book - pg. F24.

Official Attribute Knowledge Required for Salesworker to Fill Order on the Second Product Item

100 pieces of 1/2 - 13 X 2 Shoulder Screw, Brass

Attributes

1. head style: hex head[a]
2. head diameter 1" +/- .032 (width across the hex of flats)
3. head height: 5/16" +/-.005
4. slotted or unslotted: unslotted
5. dimension from corner point to corner point: 1 1/4"
6. shoulder diameter: 5/8" +/-.005
7. shoulder length: 1/2" +/-.005
8. length of threaded section: 1 1/2"
9. thread series/fit: 1/2-13 class 2A fit
10. material: brass
11. plating: nickel

Tolerances

12. shoulder diam.: +/-.005
13. shoulder length: +/-.005
14. length under hd.: +.000 -.002

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[a] Cannot use hexagon socket head shoulder screw

Fastener Standards book - pg. G.16.

Official Attribute Knowledge Required for Salesworker to Fill Order on the Third Product Item

1000 pieces of 1/2 -13 slotted[a] hexagon nut, steel

Attributes

1. diameter of the nut (WAF: Width Across Flats): .875 (7/8") -(std: .875-.850)
2. thickness of nut: 1/2"or .500 (.510-.490) (std .504-.464]2.)
3. thread series: fit class 2B - tapped hole 1/2 - 13[b]
4. Castle or slotted: slotted
5. Number of slots: 3 (6 across)
6. width of slot: 1/16" (shallow)
7. depth of slot: 1/16"
8. double or single chamfered: double chamfered[c]
9. double or single countersunk: double countersunk[d]
10. special type of material: low carbon standard steel
11. plating: Brass

Tolerances

12. tolerances on slots : +/-.010
13. Tolerances on thickness of nut: =/-.010

---

[a] Slotting to tighten nut down to lock into something else and thereby prevent it from turning under torque pressure. Standard nut cannot be used since the tolerances exclude standard nut to be slotted. Standard thickness is less than print thickness. This calls for a thickness of .005 or .510-.490 whereas standard thickness is.504 - .464.

[b] Tapped hole is a threaded hole- class B is the pitch and fit. The letter B indicates an internal hole.

[c] Chamfering consists of removing outside corners, burrs and rough edges.

[d] Double countersunk allows mating parts to come in from either side to facilitate entrance.

Fastener Standards book - pg. D12. - Heavy Hex nuts & Heavy Hex Jam nuts.

Official Attribute Knowledge Required for Salesworker to Fill Order on the Fourth Product Item

1000 pieces of #8 U Bend washer, steel

Attributes

1. inner diameter: .164"
2. outer diameter: 1/2"
3. free height: 1/8"
4. thickness of the material: .010"
5. number of waves: one
6. special type of material: 1065, 1075, 1095 alloy steel
7. Rockwell hardness : 28-35 C scale
8. plating: black oxide

Tolerances

9. tolerances on all dimensions: +/- .002

Shakeproof catalog of the Illinois Tool and Die Co., pages 23-24.

Official Attribute Knowledge Required for Salesworker to Fill Order on the Fifth Product Item

1000 pieces of 5/16 X 1 drilled fillister hd. m/s, steel

Attributes

1. head diameter: 1/2" +.000 -.015 (std: .518-.490)
2. head height: 1/2" +/- .010 (std: .295 -.276)
3. slotted or phillips: slotted
4. slot width: .060
5. slot depth: .060
6. hole diameter: .050 +/-.003 (std: .070)
7. dimensionalize center line of head from bottom of slot: .060
8. thread series & fit: 5/16-13 class fit 2A
9. length of threaded section under hd.: 1" +.000 -.062
10. plating: zinc plating

Tolerances

11. hd. diam.: +.000 -.015
12. hd. height: +/-.010
13. hole diam.: +/-.003
14. length of screw under hd.: +.000 -.062

Note. Must manufacture specific part due to head height & hole diameter. Cannot modify standard item.

Standard book - pg. F26 - Standard Fillister head m/s
F36 - Drilled Fillister head m/s.

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