A STUDY OF SITUATED COGNITION FOR THIRD
AND FOURTH GRADE STUDENTS DOING MATH
WORD PROBLEMS

DISSERTATION

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By

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Dedicated to my Father and Mother
Charles and Mary Harley;
to my brothers and sisters,
P.J., Margaret, Colette,
Philip and Roisin;
and to my
dearest uncle Paddy
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CHAPTER I
INTRODUCTION TO THE STUDY

Origin of the problem

In its modelling of the cognitively active individual, traditional cognitive theory has not considered the significance of context and personal interpretation on the dynamic of cognition for individuals as they go about their daily business. Suchman (1990, p. viii) argues that overt activity cannot be always understood purely in terms of mental processing. Such actions, she states, are inevitably "situated actions" that become formulated as part of "the context of particular, concrete circumstances." The research of cognitive anthropologists, such as Jean Lave and Sylvia Scribner, present substantial evidence that thinking is a phenomenon intimately related to a personal definition of context. This cognitive relationship between individual and context has come to be known as "situated cognition." In their considerations of how situated cognition can be examined, Wertsch, Minick, & Arns (1984) articulate the direction that cognitive theory must take if it is to investigate cognitive activity beyond the limitations of laboratory-based studies:
A complete account of the organization of human cognitive activity, manifested in a task carried out on either the individual or the social level, must go beyond narrowly defined psychological phenomena and consider the forces that create the content in which human cognition is defined and required to operate at the level of societal and cultural organization. (p. 171)

A theory of situated cognition raises the question of how the context of the classroom as an arena of activity for students "creates the content" of what students come to learn. As societal and cultural organizations, there are abundant indications that school classrooms are not neutral arenas of activity for students (Anyon, 1981; Apple, 1982; Eisner, 1985; Friere, 1985; Giroux 1983; Goodlad, 1984; Lauder & Khan, 1988). The examination of situated cognitive activity in the classroom must therefore include an examination of the classroom as an influencing context for how students process information.

The direct and substantive influence of classroom context on the nature of cognition has been marginalized as an issue in instruction largely due to the pervading influence of functionalist social theory. The goal of a standardized classroom context for instruction would ensure that all individuals could be given equal opportunities and those who were "intellectually superior" would naturally rise to the top by virtue of their own potentiality. This conception of school-based instruction presupposed any relationship between cognition
and context as substantively inconsequential. In turn this allowed for the conclusion to be drawn that classroom instruction was free of the potential bias of "real world" particulars. School curriculum and its delivery through classroom instruction was perceived as an ideal educational arena, capable of offering the appropriate instructional conditions for making knowledge available to all students for general application in contexts beyond the classroom (Lave, 1977).

Within the study of cognitive psychology, through the psychological mechanism of learning transfer, theoretical support is given to underlying functionalist assumptions operating in the classroom. Transfer theories, and in particular general transfer theory, indicate that knowledge and skills acquired in "context neutral" circumstances of the functionalist classroom are potentially recognizable and available for general application in all contexts, and are relatively uncompromised in the course and process of time, space, and application (Singley & Anderson, 1989; Lave, 1989, p. 9). Recognizing that the research support for general transfer is weak, Singley and Anderson (p. 26) ask, "Why has general transfer in problem solving been so hard to detect?" thereby evidencing the presumption that general transfer is there to be detected in the first place. What they present in their book are studies that seek to detect general transfer by measuring instances of specific transfer.
The study of situated cognition heralds a break away from the field of conventional cognitive psychology where thinking and learning are operationalized as processes of manipulating and constructing symbolic representations of information that become mental structures for "understanding" (Ellis, 1979, p. 3). Cognition is generally defined in terms of overt, observable activity identified as "the unit" of analysis for the study of predefined, unobservable covert mental activities, such as creativity, problem solving, memorization, and so on. Such constructs become reified through experimental research designed to minimize the potential influence of "confounding" variables. Discrete skills are measured by a "dependent variable" previously defined as the measure of cognition. This measure is used, in turn, to substantiate assumptions of cognitive processing as learning occurs.

The adoption of such investigative procedures assumes and supports generalizability of research findings beyond the lab and into the classroom, where the process of "thought in practice" is explained in terms of stability and continuity of cognition across settings. Such explanations, however, have been found to be unsatisfactory for several reasons. The "one model fits all" approach fails to explain why individuals working within the same contextual circumstances do not think in the same way. Nor does it explain differences in cognition for the same individual in different activities, such as in
problem solving. As early as 1932 Sir Frederic Bartlett (1954) argued that it is questionable that laboratory activities can shed much light on how people think when the experimental environment is so different from the "real world" thinking experiences the researcher is hoping to understand.

The psychologist, whether he uses experimental methods or not, is dealing, not simply with reactions, but with human beings. Consequently the experimenter must consider the everyday behavior of the ordinary individual, as well as render an account of the responses of his subjects within a laboratory. (p. 12)

Bartlett proposed that the observation of "real world" thinking activities should take place, if not in the "real world," at least in more situationally sensitive environments (Lave, 1989, p. 11). John Dewey (1933), an American contemporary of Bartlett, presented a similar argument that cognition must have a broader working definition than that recognized within laboratory experimentation. He argued that:

If thought had nothing to do with real conditions and if it did not move logically from these conditions to the thought of ends to be reached, we should never invent, or plan, or know how to get out of any trouble or predicament. (p. 79)

Cziko (1989) questions the validity of a quantitative, experimental, positivist approach to educational research. Basing his arguments on research into individual differences, chaos theory, the
evolutionary nature of learning and development, consciousness and free will, Cziko argues that human behavior is inherently complex and by its very nature unpredictable if not indeterminate. Bruner (1986, p. 9) refers to the psychologist's laboratory-centered approach as a "top-down" method whereby the psychologist begins from theory-driven inquiry. In so doing, Bruner cautions, the danger is ever-present of being so intent on finding support for a hypothesis that the results are "insensitive to the contexts in which they were dug up." The "bottom-up" approach, on the other hand, is driven by a different directive. This approach tries to examine a phenomenon holistically, not with the purpose of proving or disproving a theory, but of exploring the world in which the phenomenon occurs in the hope of better understanding the nature of its occurrence. This is not to deny theory as a powerful tool for inquiry, but rather to recognize that the constraints on activity used to create theoretical models inevitably distance them from the systems of activity they purport to represent. Jean Lave (1989) points out:

[This] argument has been formulated as a journey from the laboratory into the everyday world . . . to move the analysis, and the theory as well, out of the laboratory and the problematic that locates investigation of cognition in that setting (only) . . . (p. 170)
**Problem Statement**

While predominant theories of instruction acknowledge the importance of activity and context for creating the appropriate conditions for learning, conditions, *per se*, are not considered to be substantively influential. For example, given that information and contingencies of reinforcement are the same, the behaviorist position assumes that the computer, as opposed to a human teacher, makes no significant difference to the substantive integrity of the information to be learned (Streibel, 1986). The mind is expected to *operate on* rather than *interact with* the learning conditions (de la Rocha, 1986), indicating that those conditions have little or no substantive impact on what is learned — beyond the goal of "efficient instruction" (Gagne', 1985, p. 17).

For purposes of classroom instruction, cognitive theories have come to be adopted in the same narrow terms, as a matter of controlling input to elicit predictable output. Indeed, designers of instruction look to the field of educational psychology to determine what needs to happen in the classroom that will "cause" learning, thereby supporting instructional design as having the power to bring about very specific learning outcomes. Instructional systems design (ISD) is built around such particulars, regarding control and predictability within the instructional enterprise as fundamental
design requirements for efficient learning (Heinich, 1985; Reigeluth & Merrill, 1978; Dick & Carey, 1985).

The theoretical underpinnings of most traditional ISD enterprises include a further assumption that knowledge can be extracted from the particulars of experience and activity can be isolated from its operational context (Heinich, 1985). Such an approach allows the designer to conclude that knowledge and activity can be made available as pre-prepared, intact units, regardless of the unique circumstances of time and context of actual use. Along with a restrictive model of the learner, this process of designing instruction presumes to impose "cognitively controlling" conditions that guide learners toward specific objective-driven learning outcomes of the kind proposed by Mager (1975). This allows for the claim to be made that there exists a technology of instruction (Heinich, 1984).

There is a growing body of literature that questions the validity of adopting descriptive theories of cognition, supported by laboratory findings, as prescriptive theories for instruction in markedly different contexts (Streibel, 1989b). The argument is being developed that thinking is as much a social phenomenon as it is an intellectual one. Researchers within the field of cognitive psychology are being challenged to go beyond experimental laboratory conditions to study the thinking individual in action, using non-experimental
methodologies (Brown, Collins & Duguid, 1989; Lave, 1989; Scribner, 1984; Suchman, 1990). Such "real world" activities are to be considered as personally constructed by individuals as they create their own sense and interpretations of time, space, context, and purpose. These factors have come to be referred to as the "situational" elements of cognition in action.

According to Cole (1979), commenting on the work of Vygotsky, the nature of a child's cognitive processing is the result of the history of his/her interactions with the social and non-social environments. From such a basis the child evolves an extensive set of specific adaptations that affect relations among objects and people encountered. Chapter two of this document identifies studies of "thinking in action" in order to discern characteristics of this phenomenon. Although current literature reflects little understanding of thinking as it relates to the moment of action, the literature indicates that activity and setting are related to what the individual considers central factors in their determinations of "situation." A personally defined sense of "situation" is increasingly being recognized as critical to the substantive nature and direction of the cognitive processing activity.

If a phenomenon of situated context-based cognition can be substantiated then current theoretical positions in the development of
good instruction (see Haertel, Walberg & Weinstein, 1983) need to be revised. By studying individuals within their unique situations, it may be possible to discern patterns which suggest a general model of a thinker in action. The focus of this study, however, is not whether there is an observable universal model that applies to all individuals in all situations, but rather, what patterns are common to particular students in particular contexts. To phrase this consideration another way, how similar are individuals as "thinkers in action," given the same particulars of context?

To date, most studies on the situated nature of cognition have been concerned with adults as they go about their daily activities. This study is concerned with the situated cognition of ten third and fourth grade students as they worked with textbook word problems in mathematics. The following served as focus questions for the research inquiry:

What do students recognize as their purpose in attending school? Is there evidence that this sense of purpose influences their activity in the classroom?

Is there evidence that students reconfigure the description of math word problems into a personalized contextual framework so as to be able to achieve the original task goals?

Would a student, presented with several structurally similar tasks, use similar strategies for accomplishing each task, given varying degrees of contextual resource support?
How does the students' determination of purpose for classroom instructional activities compare with the teachers' assessment of purpose?

Significance of the Study

Contemporary theory on how humans think has almost entirely isolated thinking as an act in itself, a pure, cerebral activity in which we are all assumed to engage. This understanding has contributed greatly to the conditions whereby laboratory and school research conclusions have been used to systematize instruction (Reigeluth, 1983; Gagne', Briggs & Wager, 1988). What is lacking is an investigation of what Geertz (1983 p. 153) has called "outdoor psychology": that is, a psychology which takes into account the "social anthropology" of cognition, the most defining feature of which is that it examines cognition in relation to the socio-cultural behavior of people involved in their everyday activities.

The significance of this study can be viewed from several perspectives. First, this study brings together available research literature with a view to developing testable theory as to how individual interpretations of a context influence meaning and activity. Secondly, this study uses "outdoor psychology" in an examination of young individuals who attend elementary school and find math word problems as a part of their routine classroom activity. In so doing
this study brings into question the assumption that school-based thinking can be examined separately from school context, and most importantly, that it can be examined separately from the situational interpretations constructed by individuals. Thirdly, in light of the results of this study, implications for the traditional ISD enterprise, as represented by the instructional design "blueprints" of designers such as Dick and Carey, Gagne', and Reigeluth are discussed. Fourthly, the results of this study are discussed in terms of how they expand the theoretical groundwork being laid in the area of situated cognition.

The Use of Qualitative Research

This study examined students as they participated in school-generated activities. The study began with intensive participant observation in the classroom as students engaged in classroom learning activities. Several of the students had already been introduced to fractions as part of their classroom work while several students had not. A "study of work" technique was then used to create interview settings where students were asked to solve math word problems. The data analyzed came from observations of the students as they proceeded through the various activities. Although the methodology section in chapter three explains this qualitative research approach in detail, some justification is provided here as to why qualitative research is the most appropriate methodological approach for a study of what is termed situated cognition.
This study is concerned with an examination of individuals thinking *in situ*, in real-time and, for them, commonplace activities. A study of situated cognition must treat each example of its occurrence as, to use the words of Garfinkel (1989, p. 9), "another first time." That is to say, while activity in action is to be considered unique, it is not to be considered apart from the historical elements that bring it into being. Unlike an experimental study which adopts the method of controlling "extraneous variables" so as to be able to draw conclusions about the influence of the variable in question, the naturalistic paradigm in which qualitative research finds its roots, is concerned with activity as it occurs, however uncontrolled (on the part of the researcher) that activity may be. A primary assumption is that any "variable" that is found to interact with the phenomenon under inquiry cannot be extraneous and must be considered as having a potential dialectic influence on the direction of activity. The interaction among variables (hereafter referred to as "situational elements"), especially when dealing with human beings, cannot be assumed to be monodirectional; that is to say, it is the interaction of situational elements that brings the "situatedness" to situated cognition. A central consideration within a study of situated cognition is that there can be no discussion of "situation" in general, but that every occurrence of "situatedness" is itself indexical.
The phenomenon of situated cognition can only be studied with the assumption that it is subject to a multiplicity of complex constructions. A contributing factor to those constructions is the situational element of the investigator as the main data gathering tool. As such, the analysis of the phenomenon includes an analysis of the researcher, together with his inevitable biases and limited powers of observation, as elements influencing what is occurring. In other words, the data collected and subsequent analysis are to be recognized as selective and subjective.

Cognition in this study is considered to be intimately context dependent. A qualitative research approach allows the researcher to describe context not as a fixed factor, but as a continuously changing phenomenon. Of importance is the understanding that changes within context are subject to unpredictable variations that dialectically influence both context and participants.

Definition of Terms

There is a paucity of terms with which phenomena relating to situated cognition can be discussed. The following definitions of terms are provided to reduce ambiguity as these terms are used in the study.
**Environment.** Environment can be considered as an individual's time and space, as well as the less tangible influences that explain an individual's position with respect to the world around him/her. It has global referents that influence an individual, either consciously or unconsciously as pre-established "givens." For example, an individual works within a framework of a twenty-four hour day, a specific geographic location, supported by a social infrastructure of values, customs, historical background, politics, and so on. For a school-aged child, environment might be identified by certain tacit assumptions, such as all children go to school, teachers have authority, every school has a principal in charge, and schools are centers for learning.

**Context.** Context exists within environment but is determined with reference to more localized, immediate referents. These referents are prescriptive in that they indicate to an individual rules and conditions that govern activity. Conditions of a context are known to an individual as exigencies of the present moment as he or she engages in activity. Through awareness of the conditions of a context, the individual defines his/her role. For example, within the grocery shopping context discussed by Lave (1989), the individual, in the role of shopping consumer, is obliged to work with the layout of the store. For a school-child in the classroom, context might be
defined as membership in a specific class group, sharing the same teacher, and engaging in more or less the same classroom activities.

**Situation/Situated.** While the descriptions of environment and context assume that there exist certain influential conditions external to the individual, "situation" is the ultimate level of recognition by which the individual determines his/her reality. Ultimately situation is the ontological perspective (disposition) that the individual brings to and uses to interpret conditions of the external, physical environment. The term "situation," as in "situated cognition," indicates that cognition is, first and foremost, uniquely individual. At this level of consideration, the individual is a constructive interlocutor and interpreter of both environment and context beyond the perceived impositions of external conditions. The parameters of the individual's determination of situation are not bound to immediate external conditions, but are linked with personal history; that is to say, an individual's situation is linked to the individual's past and recent-present life conditions, experiences and knowledge. How the individual might determine situation is also connected with a future time dimension in that it can be influenced by the individual's desire to accomplish some future objective. An individual's determination of situation is the ultimate filter for what he/she considers "real."
Situation, although ultimately internalized, nevertheless develops and operates within an influential and responsive social context. Personal definition of "situation" is, therefore, fluid, lending itself to adaptability based on "moment by moment" readings (interpretations) within environment and context.

**Dialectic.** The term dialectic identifies a reciprocal meaning-making process by which an individual extrapolates meaning from, and attributes meaning to, context. This process occurs as interaction between what the individual brings to a context as personal (knowledge) resources and the resources recognized by the individual within the context itself. Personal and contextual resources are fused to become the dialectic process, the direction of which is determined in relation to emerging goals established by the individual. The construction of "situation" for the individual occurs as the dialectic process is taking place.

**Problematizing.** Problematizing, as it is used in this study, is the perception of discrepancies or dissonance between elements of context, which become the catalyst for investigation. For example, a shopper discussed by Lave (1989) perceived discrepancies between packs of cheese and package pricing. Because the shopper needed to buy cheese, this perceived discrepancy problematized the correctness
of package pricing, which, in turn, initiated his investigation of which package was correctly priced.

**Propositions.** Propositions are relational models between and among information (Anderson, 1978; Pylyshyn, 1973). A proposition may be expressed as words or phrases, but in essence a proposition is really what an expression may assert (Pylyshyn, 1973). For example, the proposition that *the pencil is on the desk* is established by the understanding of the concepts of "pencil" and "desk," and the relationship of one to the other.

Propositions have a second major characteristic: they are either true or false, supported or unsupported (Anderson, 1978; Pylyshyn, 1973). To become a proposition, information must be structured within testable relationships. Regardless of how such relationships are conceptualized, propositional thinking has two main elements: the generation of testable relationships between and among elements, and the verification process for testing the "truths" about those relationships.

**Organization of Chapters**

The first chapter presents the background and focus of the study. The central focus questions for the study are presented, together with a rationale for the methodology being used.
The second chapter, the review of literature, examines how other educators and researchers have addressed questions related to those identified in this study. Although the literature cited may not be directly related to students in school, it does address cognition and instruction for groups of individuals, as they operate in other contexts. The intent is to synthesize relevant literature in order to come to a deeper understanding of the phenomenon of situated cognition, while also identifying activities that characterize how people are "thinking in action." Finally this chapter gives direction to the investigation of situated cognition with respect to elementary school students.

The intention of the third chapter is to describe the methodological approach for this study. This chapter clarifies the assumptions underlying the naturalistic paradigm, thereby justifying its adoption. This chapter also describes the specifics of this study in terms of how it was conducted and the rigors that were established in order to substantiate credibility for the results.

The fourth chapter presents the field data by examining the significant themes and characteristics that became evident as the data were examined. This chapter presents a description of the study site and the participants of the study. Thereafter data are organized in
relation to the focus questions of the study. Finally conclusions that
can be derived from the data are discussed.

The fifth and final chapter reviews the conclusions derived
from the data in chapter four with respect to their general
implications. In particular this chapter relates the findings from
chapter four to the previously cited studies in an attempt to confirm,
develop, or reject the findings of other researchers. Chapter five also
indicates potential implications of the research findings for
Instructional Systems Design.
CHAPTER II
REVIEW OF RELATED LITERATURE

The first objective of this chapter is to provide an account of research related to situated cognition. This account will provide a general perspective for the present study by indicating the major findings and implications of other studies. The second objective is to identify particular features of situated cognition identified in other studies that can be used to bring focus to the data gathering in the field and the analysis component of this study.

SITUATED COGNITION AND THE REALITY OF CONTEXT

A theory of situated cognition is an explanation of our thinking as we perceive, interpret, and act upon the reality we construct. Implicit in this explanation is that how thinking occurs must be examined with consideration for the influences of the individual's determination of his/her reality within a structured environment and the particulars of setting (Lave 1989, p. 151). The concept of situated cognition invites certain assumptions to be made about whether reality of context is individually created, or whether it is an absolute
condition of the physical world we live in, independent of what we as individuals bring to it.

The theory of situated cognition is, first and foremost, based on the assumption that each individual is unique in and of him/herself. While identification of context as an influencing factor in the nature of cognition presupposes that there exist certain realities external to the individual that he/she either works with or rejects, "situation" is the level of awareness by which the individual determines his/her moment-by-moment reality. The intimate and inextricable nature of an individual's sense of reality is described by Natanson (1973):

My biographical situation defines the way in which I locate the arena of action, interpret its possibilities, and engage its challenges. Even the determination of what the individual can modify or not modify is affected by his unique [interpretation of] situation. The funded experience of a life, . . . is the condition for the subsequent interpretation of all new events and activities. "The" world becomes transposed into "my" world in accordance with the relevant elements of my biographical situation. Thus the individual as an actor in the social world defines the reality he encounters. (p. xxviii)

A similar understanding of individual interpretation is presented by John Dewey (1933):

Thinking is specific, in that different things suggest their own appropriate meanings, tell their own unique stories, and do this in very different ways with different persons. (p. 46)
The specificity of thought referred to by Dewey is both specific to circumstances and (potentially) unique to the thinker. For instance, it is safe to say that everyone has experienced the extemporaneous recollection of memories as a result of a smell, a taste, or an event. In this Proustian sense the specificity of our thoughts can never be duplicated because of their complexity, their spontaneity, and the fact that no two individuals can possibly have the same history through which recollection becomes possible. And yet the situatedness of cognition, although ultimately personalized, nevertheless develops and operates within the influential and responsive conditions of context.

The ongoing nature of situated cognition supports the realization that most thinking and learning in most settings can be a communal activity in the sense that it is a sharing of an individual sense of (developing) context, recognized as viable by the mutual agreement on the part of participant actors. Schoggen (1989) defines this as a reciprocity among individuals and context:

The individual persons within a bounded unit of the ecological environment differ from one another in psychological attributes (needs, goals, perceptions); their behavior in the same environment will, therefore, display some individual differences. However, because . . . the inhabitants of the same ecological unit are subject to inputs and forces characteristic of
that particular ecological unit, its inhabitants will exhibit a stable overall extra-individual pattern of behavior. (p. 13)

Schoggen uses the term "extra-individual" to refer to contextual conditions that present the individual with a "structured arena" through which participation is partially determined by factors other than the uniqueness of the individual's particular situational definition. Richard Rorty (1989) argued for such a communally constructed determination of context definition thus:

A liberal society is one which is content to call "true" whatever the upshot of such [contextual] encounters turns out to be. That is why a liberal society is badly served by an attempt to supply it with "philosophical foundations." For the attempt to supply such foundations presupposes a natural order of topics and arguments which is prior to, and overrides the results of, encounters between old and new vocabularies [understanding]. (p. 52)

Rorty is arguing for an understanding of structured arenas as a fluid concept, subject to change in response to the defining activity of participants. In essence what creates communal understanding in a context has to do with the indexical links that are established through the collaboration of individuals and their ability to come to sufficiently similar interpretive conclusions. The process of knowledge acquisition, therefore, is not one whereby individuals make their knowledge their own independently of other (contextual) conditions, but one in which they make it their own in a community
of others who recognize and share a sense of belonging within a context (Bruner, 1986, p. 127).

Mental processes, (how we think, and what we think about) are the result of the history of our interactions within contexts. Contexts serve to validate knowledge as relevant to and worthy of acceptance by virtue of the fact that an individual can operate effectively within them. In doing so we evolve an extensive set of specific adaptations that organize relations among objects, people, and situations that we encounter (Cole, 1979). Lave (1989) supports this conclusion as she describes the relationship of shoppers to the supermarket context:

Part of what makes personal navigation of the arena feasible is . . . the structured nature of shopper's expectations about the process of shopping and what they will buy. The setting of grocery-shopping activity is one way of conceptualizing relations between these two kinds of structure. It may be thought of as one locus of articulation between persons-acting and the structured arena. (p. 152)

Situated cognition explains how we think by recognizing that thinking occurs through personal constructions of what "things" mean. Construction of meaning does not occur in a cerebral vacuum. Rather it occurs with a recognition and sensitivity for what such "things" have come to mean for others in other contextual circumstances. Situated cognition, nevertheless, is ultimately an interpretive cognitive processing of information through which a personal
construction of what is real takes place and this processing ultimately becomes the determinant of the "structured arena."

Cognition

Cognition refers to the activity of the mind as we think and has come to be understood as an abstract process of symbol system generation and manipulation. Through this process we conceptualize (translate)

\footnote{This is analogous to the computer environment. While we might input elements of the external environment as English language codes, for the computer to be able to work with such information it has to "translate" these codes into the binary coding with which it operates. According to the theory, human beings, are involved in a similar translation process whereby we do not take raw data from the environment "as is." Rather we translate that data into a symbolic form which allows us to operate with it.}

our environment into symbolic mental representations, and we use this symbolizing to organize and "make sense of" (process) our environment. This understanding of cognition involves the creation of internal symbolic representations in response to external information. It also involves the internal processing of those symbols towards the creation and organization of new knowledge by establishing interrelationships. In essence, cognition is an "in head" activity, conceptualized in terms of the creation of meaningful environmental abstractions through the development of symbol systems and organized mental schema.

This description does little to explain the dynamic of thought. What is the nature of the activity of the thought process as it
happens? What is it people do when they are engaged in creating cognitive structures? How do cognitive structures become modified in the light of experience, or as Suchman (1989) puts it, in response to "moment by moment contingencies?" The dynamic of thought as the individual meets with experience is perhaps the key to a theory of situated cognition. Such a dynamic can be assumed to take place with as much regularity as breathing.

Cognition and situational relationships

The study of situated cognition examines the relationship between knowledge and context. A sense of context influences how we situate our thinking because we relate how we think, and what we think about, to the context in which it takes place. Sylvia Scribner (1984) argued that in Western philosophy, theoretical and practical thinking have been opposed to each other as different forms of thought. The classroom can be understood as the laboratory setting where students experiment with (theoretical) knowledge devoid of substantive situational definition. This dichotomy teaches students to fragment knowledge into discrete disciplines rather than leading them to integrate and synthesize actively across disciplines, including the "discipline" of working with knowledge in practice (Eisner 1985, p. 78).
A study by Scribner and Cole (1981) of the Vai people in Liberia found that literacy outside of formal schooling was not associated with the same cognitive skills as literacy with formal schooling. It was concluded in this study that "literacy, as well as schooling, had identifiable cognitive consequences" (p. 251) such that students perceived how to think about information in school differently from the way to think about apparently similar information elsewhere. Although literacy competence was considered important both within school and as a social concern outside school, the way it was thought about, the researchers argued, was influenced by where the individuals did their thinking. In short, students were recognizing a dichotomy between 'school literacy' and 'home literacy' and established a sense of context-appropriacy for how and where this knowledge was to be used.

Jean Lave (1987), when studying the thinking process of shoppers in a U.S. supermarket, made similar observations. She concluded that participants make sense of information through context, and subsequently determine actions in relation to situationally determined goals. She argues that to comprehend the nature of arithmetic activity as a whole requires a contextualized understanding of its role within an activity. The shoppers in Lave's study demonstrated in their actions that the math used while shopping was not a skill set apart from the shopping activity itself.
Their ability and methods for using mathematics to solve problems was inextricably related to a situational understanding of the role that mathematics was to be given. In this study shoppers were found to be "proficient mathematicians" in the context of a supermarket where they were generators of the problem definition. In contrast, they were significantly less proficient when asked to apply the same kinds of reasoning in a paper and pencil activity in which the definition of the problem was delivered to them, and where contextual supports were unavailable to them. Clearly these people were not mathematically unknowledgeable, but they appeared to be situationally dependent for how they understood and applied their mathematical ability.

An ethnography of cognition

Geertz (1983, p. 152) considers knowledge, individual, context, and interaction as definitional elements central to an understanding of cognition. Lave (1988) describes the study of these elements and their interaction as the development of "an ethnography of cognition" by which she means an enterprise that seeks to understand "everyday" people's thinking as they make their way through their "everyday" lives. Taylor's (1971) discussion of the relationship between knowledge and personal understanding considers some of the key requirements for knowledge to become "cognitively situated" for the learner:
Our conviction that (an) account makes sense is contingent on our reading of action and situation. But these readings cannot be explained or justified except by reference to other such readings and their relation to the whole . . . Ultimately, a good explanation is one which makes sense of the behavior; but then to appreciate a good explanation, one has to agree on what makes good sense; what makes good sense is a function of one's readings and these in turn are based on the kind of sense one understands. (p. 88)

As Taylor refers to "readings," we can understand them to mean interpretations and conclusions from which an individual derives knowledge and understanding. Taylor points out the complex interaction between what we already know and what we come to know as we construct meaning throughout our "everyday" lives. He further points out the complexity of any one entity (person or machine) trying to convey to an individual a sense of meaning which reflects exactly, or even closely, the intent of the deliverer. Streibel (1986) points out that we cannot assume meaning for learners based upon our understanding of how we think that they are thinking. Ultimately meaning can only be established by and not for the learner. Streibel (1989) argues that this "meaning-making" can only be understood as "an essential historicity that could never be made fully explicit in action although it could be made explicit before or after the fact as imaginative projections or rational reconstructions."
Situated cognition assumes complexity as an inherent condition of cognitive processing. To be properly understood it must, therefore, be recognized as the personalized domain of an individual situating their knowledge in relation to the communicative resources of context (Suchman, 1990, p. 68). How "everyday" people determine meaning as they situate their thinking inevitably involves a process of evaluation and synthesis. The recognition of knowledge and the and decision process as to how the knowledge is deemed pertinent within a context is a central concern for situated cognition and activity.

Cognition and Situational Experience

Contributions of Lucy Suchman. As a researcher at Xerox PARC (Palo Alto Research Center), Lucy Suchman focused on how novices (as opposed to experts) worked with Xerox machines that had built-in help and diagnostic programs. Her investigation centered around the instructional validity of generic, preplanned troubleshooting procedures that had been programmed into the copying machines. She found that as pairs of novices worked together the preplanned interaction between machine and user did not occur in a manner that had been anticipated in the design of the diagnostic program guide. The prescriptive guiding procedure of the machine became redefined as the participants engaged in real-time troubleshooting experiences. The users instigated their own sense-
making and directionality for how they undertook to diagnose and solve the problem of operating the machine.

Of importance when considering Suchman's (1987) study is that what the individuals were presented with by way of troubleshooting information was neither wrong nor procedurally inadequate. It can be assumed that all the "nuggets" of information were made available for the individuals to work with and that the instructions were clearly and adequately presented. The central concern is the assumption on the part of the machine designers that the availability of this diagnostic information would instigate its adoption by the users as the exclusive resource for sense making within the troubleshooting activity.

Suchman found that within the context of the problem moment in which those "nuggets" of information were planned by the program designers to be most salient, the users worked with personal strategies which they constantly modified on a "moment by moment" basis. Procedural troubleshooting information that had been programmed into the machine was redefined, and indeed re-understood, when the individuals found themselves involved in the actual troubleshooting activity.
Suchman explains this phenomenon by claiming that the users' determination of their situation, and not the preplanned strategies presented by the machine, became the final determinant of how to understand the "nuggets" of information. Procedural information presented by the machine program became contextually related with other sources of information (noise, smell, ongoing discussion) as part of an ongoing activity.

Users did not consider the machine's program definitive, or even the most central resource, for troubleshooting the machine. In the process of troubleshooting, the users were not executors of the machine's instructions on what to do to fix the machine but rather guided themselves, referencing the machine's solution directives as a resource only. Information made available through the machine program became situationally defined for the users through the support of working with the machine; "nuggets" of information became understood interactively in terms of their observable consequences, and actions became grounded in the logic of the immediate situations.

A theory of situated cognition recognizes that experiences are substantively integral for learner understanding in the process of "meaning making." The work of Suchman brings into question whether procedural plans, extrapolated from the kinds of
contextually embedded experiences which make them meaningful, can be assumed to have substantive integrity for the learner. Substantive integrity would require that such information and planned sense-making will initiate the same kind of sense-making for the learner whenever he/she finds him/herself participating in those particular, or similar experiences.

Suchman argues that a context is inherently influential for how we think, and that each context is, in and of itself, generative of how it can be thought about. Consequently, separating information from a particular contextual base must change how such information can be understood. In effect, the information becomes interpreted as something different. When presented to novices, such as those mentioned earlier, who have little or no experience of particular information in a substantively meaningful context, the intended significance of the information can become lost. Suchman (1990) concludes from her study that:

the contingence of action on a complex world of objects, artifacts, and other actors, located in space and time, is no longer treated as an extraneous problem with which the individual actor must contend, but rather is seen as the essential resource that makes knowledge possible and gives action its sense." (p. 179)
Learners create (tacitly or otherwise) a personalized sense of situation that guides a decision process as to what is meaningful and how it is to be understood and incorporated into what is already known. If knowledge is to become substantively meaningful to the individual, (instructional) attention must be directed to the individual's propensity for situating the information in response to the conditions of the actual events in which they find themselves.

**Contributions of Jean Lave.** The work of Lave (1988) provides further evidence for the claim that the learner engages in "situational meaning-making" and acts upon this understanding to create plans of action. Lave's ethnographic studies in schools indicated that, although a teacher had engaged in teaching a specific algorithmic problem solving strategy in a math class, students' perceptions of the problem(s) were conceptualized with reference to contexts larger than the restrictive parameters of the math problem statements and teacher expectations of how to answer the questions. For the students, the problem definition also included getting the right answer to satisfy the teacher's requirements, and at the same time having the teacher perceive that their strategies were in keeping with those proposed by the teacher. Lave reports that as a result of this contextually specific redefinition of the problem, students engaged in a variety of problem-solving strategies that went far beyond the direct application of arithmetic algorithms as anticipated
by the teacher. That this occurred in the classroom indicates that: 1) the students adapted their problem solving strategies using a multiplicity of resources available to them in the classroom; and 2) the teacher, and indeed the planned instructional activity, did not recognize these "other" classroom resources as meaningful or relevant for the students as they solved the text problems.

A theory of contextually sensitive cognitive processing would explain this phenomenon in terms of the students' activity not being restricted to a rigid information-application model, as had been anticipated by the classroom teacher. The problem information given by the text book was not removed from the other classroom contextual factors in which it was presented. Context was indeed a contributory factor for how the students thought about the text initiated problem, redefined it, and determined the best solution strategy. The problem for the students was not, it seems, the acquisition of substantive knowledge and skills for use beyond the classroom, but rather the attainment of more immediate objectives, namely to please the teacher and, presumably, earn a good grade. This contextually sensitive cognitive dynamic is what a theory of situated cognition attempts to identify and explain.

A theory of situated cognition proposes that context cannot be considered irrelevant to thinking and extrapolation of meaning.
Therefore, the creation of "robust" knowledge that is recognized as having worth beyond the classroom needs to occur within contextual experiences that are substantively meaningful, and that allow learners to become situated as an active negotiator within that context. Indeed, as Lave's (1988) study indicates, students in the classroom are inevitably active negotiators in an instructional context because an instructional context, like any other, becomes inevitably situated.

The concern, so far, has been to examine claims that situated cognition is indeed a consideration in the study of how individuals think in action as they explore context to inform, support, and guide their processing of information. Traditional cognitive psychology has proved inadequate for this task (Lave, 1989, chap. 1). The studies by Suchman and Lave indicate that individuals do not limit cognition to the levels of abstraction presumed by conventional cognitive psychology. Instead, these studies force us to expand our explanation of cognition, vigorously considering the context of cognition. These studies indicate that context influences cognition both in terms of what is understood, and how information can be used through application. The question remains, however, as to how the moment by moment activity can be understood and modelled.
A DYNAMIC OF COGNITION

Situated cognition is concerned with the dynamics of reciprocating thought and action. Central to this dynamic is the idea that interpretive understanding within the specifics of context influences how we perceive, how we conceptualize, and how we make informed constructs of external stimuli as they relate to what we already understand. The following sections bring together present theory and research in order to construct a theoretical base for understanding the relationship that is established between mind and the conditions of external context.

Mental modeling

Greeno (1991) tries to explain the process of creating our cognitive arena in terms of mental modelling. He argues that understanding is established through the construction of mental models that provide us with cognitive situations in which we can "interact with mental objects that represent objects, properties, and relations and that behave in ways that simulate the objects, properties, and relations that our models represent" (p. 200). Mental models are constructed to provide mediating referents for things that may or may not be physically present but can be substantiated and made cognitively real through their mental representation.
An example of such mental representation is the navigation by Micronesian seamen (Hutchins, 1983). As he navigates his boat, the seaman keeps track of his position with reference to islands that serve as landmarks but are not necessarily visible. Indeed, in some cases, the "landmark" islands do not physically exist. In so doing the seaman works with a geography of the seascape that must be created in his mind because it does not in fact exist in the physical geography of the terrain itself. Within this mental representation the seaman integrates information from wind direction and speed, the speed of waves, the location of stars, and so on. This seascape in the mind of the seaman is a constructed arena of cognition in which decisions on how to navigate his vessel are made. The situated cognition for the seamen becomes realized through the cognitive reality of his mental model that incorporates his understanding of, and sensitivity to, the region's geography, wave patterns, and weather influences, as well as the stars and his destination. By virtue of the fact that the seaman integrates such components together to determine the appropriate navigational course, and by virtue of the fact that the model is constantly updated based on moment-by-moment changes in conditions, indicates that such mental modelling is a dynamic, situated process.

The functionality of any mental model is most likely to be related to the quality and sophistication of the model itself and the
determination or motivation of the individual to continue "running" the model until a satisfactory solution is "generated." Such a model, of course, would have the potential of being enhanced and reformulated with the recognition and integration of new information. The mental modelling of the Micronesian navigator was deeply, but not exclusively, rooted in the circumstances of the physical world, and the subtleties of conditional changes served to provide important information to the process of navigation. An understanding of situated cognition invites inquiry as to how an individual comes to recognize particular information within a context so that it can be used to inform the mental modelling — that is the situated operational plain — for thought. The theory of "object affordance" serves to inform such an investigation.

Object affordance

Gibson's (1979) "theory of affordances" uses the term affordance to identify the potential for components of a context to contribute to cognitive interaction (p. 129). In relation to situated cognition, affordances allow individuals to identify information through the recognition of relationships among objects or contextual conditions. For example, a wrench has the affordance of being used to tighten or loosen nuts, but it also has the affordance of being used to hit a nail into a wall. The affordance of using the wrench to tighten the nut most likely occurs when there is a nut to be tightened, while
the affordance of using the wrench as a hammer is (most likely) when there is a nail sticking out of the wall and a more appropriate tool is not readily available. In a similar vein Lave (1989) points out that the act of identifying a problem changes dialectically the salience of setting characteristics (p. 159) and thereby the potential and direction of affordance recognition.

At the heart of his theory of affordances is an economy of perception whereby "those features of a thing are noticed which distinguish it from other things that it is not — but not all the features that distinguish it from everything that is not" (p. 135). Gibson also points out:

Psychologists carry out elegant experiments in the laboratory to find out how and how well these qualities are discriminated. The psychologists assume that objects are composed of their qualities. But I now suggest that what we perceive when we look at objects are their affordances, not their qualities. We can discriminate the dimensions of difference if required to do so in an experiment, but what the object affords us is what we normally pay attention to. (p. 134)

Accordingly, affordance recognition has to be understood as a contextually sensitive activity for determining what will (most likely) be paid attention to and subsequently whether an affordance will be perceived.
The ability to recognize affordances is also related to the individual's ability to attend and learn from contextual information. For example, in an experiment by Gibson and Walk (1960), crawling infants would not walk over a visual cliff of sturdy plate glass and, although some would pat the glass with their hands, they misperceived the affordance of a transparent surface for support. Although haptic information was available to specify an adequate surface for support, the infants relied on the optical information. By implication, the creation of viable and sufficiently sophisticated mental models depends on our ability to interact within a context in a manner that can contribute to, and promote, cognitive perceptions of contextual affordances.

Considering situated cognition in terms of mental modelling of contextual affordance further posits cognition as a dynamic phenomenon. To understand this dynamic demands that the investigation look to the dialectic nature of the individual involved in the process of meaning-making. Piaget's theorizing of assimilation and accommodation serves as a good starting point.

Assimilation and accommodation

Piaget describes a child's meaning-making as a process of relating what is known and what is under consideration with the goal of reducing perceived "cognitive disequilibrium" (Navarick, 1979, p.
236). Lave (1989) describes this kind of activity as the cognitive
dialectic whereby the "central aspects of activity include its self-
generative and open character, whose structuring grows
(dialectically) out of conflict" (p. 145). For example, young children
often come to understand "bird" as a working categorization for
"anything that flies." Such a child, when confronted with an airplane,
is liable to find upon closer scrutiny discrepancies in the
categorization label as it relates to this new object. The child is
involved not only in testing what s/he knows as "bird" with respect to
this new item (plane), but is also (potentially) having to make
immediate modifications to the bird concept to include a "plane."
S/he can, however, make the choice of abandoning the attempt to
incorporate "plane" into the "bird" concept, declaring it more
satisfactory to establish new "plane" and "bird" concepts, as
subconcepts to "anything that flies." In terms of "mental modelling"
the child might be said to be trying to integrate the new information
into the bird model that the present conceptualization of bird may or
may not support. It then becomes a question for the child of
modifying that original model or defining a new model, such as, a
mechanical flying thing.

A similar phenomenon is described by Lave (1989) when she
says: "Persons-acting are free to transform, solve or resolve a
problem, or abandon it in favor of other options . . . they own their
own problems" (p. 156). Lave indicates an important corollary that, just as an individual owns his/her problem(s) as he/she thinks situationally, so too does the individual own his/her own solution(s) as they engage in self-generative contextual structuring. Lave (1989, p. 159), in her study of shoppers in a supermarket, points out that as shoppers navigated through the supermarket, it is likely that they assigned rich content and shape (structure) to simplify the shopping task; that is, they brought with them to the shopping experience a predetermined model of the concept of "supermarket" together with their own objectives; these became integrated into a modelling of "this week's family shopping."

These shoppers evidenced intelligent action, defined by Scribner (1984) as "thinking that serves to organize and make more economical the operational components of tasks" (p. 26). The "intelligent action" of shoppers can be understood in the same terms as the example of the Micronesian seamen. Shoppers were cognitively appreciative of where they had gone in the store and where they were going, and yet the particulars of circumstances (for example, standing beside the sauce shelves) became compositional factors that modified the particulars of their shopping expedition. They accommodated change in the particulars of their shopping task (fortuitously noticing and deciding to buy sale items, for example)
without losing sight of their sense of the overall task, which was to do
the shopping.

How they negotiated the particulars of their situated actions can
be explained through the working of a mental model that
incorporated the main features of the problem moment, allowing
their interaction to be "cognitively simulated" within the model. This
can be better understood by consideration of a "doing the shopping"
model that could very well involve components such as the following:

I am standing in front of the sauce section. It is on special. My
family uses sauce. It has been a while since I bought sauce. I
recollect that the sauce bottle was nearly empty the last time I
saw it. I am going to buy hamburgers for tonight's dinner. My
family likes sauce on their hamburgers. We might run out. Do I
have enough money? Do I have a sauce coupon with me? Are
there any specials on the kind of sauce my family likes? I must
decide on what to buy now so that I do not have to return to
this aisle before I leave the store.

The model presents situated features (sauce, family, burgers, etc.) not
as discrete elements per se, but as contiguous and inter-influential
factors through which the issue of buying sauce becomes identified
and the nature of the (complex) problem becomes defined.

The invention of strategy

In Lave's study shoppers demonstrated an ability to invent
problem resolution strategies using the physical resources of the
supermarket. These strategies varied in degrees of sophistication and were used systematically, from the least to the most sophisticated necessary for bringing about an acceptable problem resolution. For example, one shopper, having detected an error in the pricing of a pack of cheese, recognized the affordances of other packages as a resource for the creation of a contextually specific solution strategy. He searched through the cheese bin for a package weighing the same amount and inferred from the differences in their price that his suspicion of error was correct. By comparing other sized packages and their pricing he was able to deduce which of the same weight packs was in fact mispriced. The shopper, alternatively, might have begun a process of mentally dividing weight into price and comparing the result with the price per pound printed on the label. In examples such as this, for the shopper the more demanding problem resolution was the use of mathematics; for the child and the plane, discussed earlier, the more demanding resolution strategy might be the establishing of new conceptual categories.

Scribner (1984, p. 21) describes the recognition and adoption of resolution strategies as conforming to a "Law of mental effort." In her study of dairy plant workers, she reports that mental work would be expended to save physical work. Bearing in mind that the physical work of the assembly workers was substantially more demanding than picking up lightweight packs of cheese, it is hardly surprising
that mental work might be chosen as the most efficient strategy in terms of effort investment. Additionally Scribner found that more sophisticated problem strategies were invoked when previous strategies proved to be inadequate or inefficient. In particular, the preloaders were found to adapt base ten arithmetic to base eight in order to accommodate the circumstances of products packaged in cases of eight.

The central point to be understood from these instances is that strategy choices were being made, and that in these instances the choices were determined by decisions based upon the criteria of economy of effort. Such activities suggest, in Piaget's terms, that the choices of assimilation and accommodation can be extended to explain, at least in part, how adults engage in their own meaning-making, taking actual occurrences as the starting point for cognitive analysis.

The invention of strategy appears to be an on-the-spot creation of understanding through which a problem becomes identified, affordances recognized, and the process towards solution instigated. The Piagetian description of the dynamic between the initial intention to assimilate (to adapt the environment to what is already understood) and the forced necessity to accommodate (adapting cognitive process to the demands of the environment) can be
developed further if they are considered in terms of a dialectic process of problematizing and creating testable propositions.

**Problematizing and task formulation**

Problematizing can be understood as the recognition of discrepancy between what an individual already understands and new information that is being recognized. The recognition of such discrepancies acts as a "cognitive trigger" that initiates the thinking process. In terms of mental modelling, problematizing is the result of attempting to incorporate new information into an already established mental model that alerts the individual to a lack of "good fit." With the shoppers in the supermarket, Lave (1989) found that "problems take on meaning as conflicting possibilities for activity, or troubles with ongoing activity, that snag or interrupt the process of shopping" (p. 156). In such instances, the individual is left with the decision as to whether it is an inadequacy with the pre-established personal mental model or whether the particular information under consideration is in error. For example, a shopper, having looked at the price on the first cheese pack, problematized the marked price with the amount of cheese in the pack. The shopper must have worked with a pre-established model for what cheese was worth in relation to how much that particular package should have cost. According to Lave's (1989, p. 154) description of the incident the shopper began to look for evidence to support the proposition that he
was correct and the price on the package was wrong. In other words, the shopper had confidence that his modelling of how cheese was priced was correct and that the discrepancy did not merit a change in his mental model but rather an investigation to uncover the error in that particular cheese pack's price.

Problematizing, however, is not confirmation that a relationship really does exist. It is the creation of a tentative proposal by the individual that the potential exists for a relationship to be considered and that further investigation is warranted. How the problematizing activity shapes the strategy for inquiry is dialectically bound to the individual's recognition of resources within the situation and the affordances that are deemed to be relevant.

Laboratory-based research into cognition and problem-solving discounts (and even ignores) the process of formulating the task and forming the goal(s) which are often the responsibilities of people in everyday contextual settings. Newman, Griffin, & Cole (1984) address this issue:

"Because a [problem] task in cognitive psychology is a goal plus constraints on reaching that goal presented by the researcher to the subject, the researcher does a lot of work to formulate a clear task. In everyday situations people do not always have the "advantage" of this kind of help; they often have to figure out what the available resources are as well as to solve the problem once it is formulated. In everyday situations people
are confronted with the "whole" task, not just the solution part." (p. 176)

Both the shoppers in the Lave (1989) study and the preloaders in the Scribner (1984) study indicated that problematizing is a characteristic of the process of cognition and activity. Scribner and Lave argued that the way we problematize within activity, however, has a dynamic that is both complex and intimately related to a personal determination of how the context is to become situated within the deliberative activity of the individual. Relationships between situated elements in a cognitive arena emerge as propositions for further consideration by the individual.

**Propositional thinking**

Support for the notion that situated cognition is driven by a generative process of propositions can be found in the work of Suchman (1987) with the Xerox employees, and in Lave's (1988) study of shoppers. In both cases, individuals create propositional plans based upon their moment-by-moment interpretations of the problem context.

For the Xerox employees in Suchman's (1988) study the information and procedural system presented to them by the duplicating machine was not the same as, or even sufficiently acceptable for them as, a "meaning-making" machine. Their thinking
in action obliged them to bring to the problem their own selective (situated) conceptualization and verification schema and it was this that ultimately directed their decisions with respect to the appropriate line of action to be taken.

Lave (1989) described such problem solving activity as "dilemma handling." Dilemma, in this instance, is the discrepancy perceived by the individual between what "is" and what they anticipate could or ought to be. Situated cognition research has come to suggest that a common response strategy to this condition can be understood as a "gap closing" activity between goals and the kind of action(s) necessary to realize those goals. Thus, the problem resolution process is not a rigid, linear, solution-strategy enterprise, but is an activity that allows for a more flexible, circular, working-towards strategy for solution.

In situated activity the main strategy in dilemma handling is generating propositional relationships in situations to a point that the individual decides is sufficiently precise. The "data gathering" that occurs as an individual works towards clarifying the salient affordances of a situation influences not only an individual's ability to identify useful relationships, but also influences the determination as to whether an endeavor is sufficiently important to warrant any further attention. This is a generative process of comparing the
The current state of knowledge of the problem with the current definition of a solution. Lave (1989) describes the phenomenon thus:

Settings, persons-acting, and activity intersect in the construction and playing out of what might be called expectations rather than goals. They may be thought of as potential resolution shapes embodied in experienced activity in setting. Expectations, dialectically constituted in gap-closing processes, enable activity while they change in the course of activity, backward and forward in time at the same time. (p. 185)

An equally important characteristic of a situated cognition dynamic is the manner in which problem and solution are not dichotomized in the process of propositionalizing. Lave (1989) identifies this phenomenon as she describes one lady’s description of problem solving in the supermarket:

It appears that the problem was defined by the answer at the same time an answer developed during the problem, and they both took form in action in a particular, culturally structured setting, the supermarket. (p. 2)

Dewey (1933) earlier recognized this phenomenon by pointing out that "the nature of the problem fixes the end of thought, and the end controls the process of thinking" (p. 15). Confronted with a perceived "gap," the individual situates cognitive processing by using the contextual resources to (at least initially) propositionalize the relationships between present state and desired state (expectations).
These propositions support tentative resolutions that estimate what kind of, and how much, activity must be undertaken by the individual for resolution to occur. Partial conclusions emerge during the course of reflection and action, described by Dewey (1933) as "temporary stopping places, landings of past thought that are also stations of departure for subsequent thought" (p. 75). The creation of a propositional relationship has the primary function of exploiting dialectic circumstances through which the individual can work on simplifying problems into "mind-sized chunks" thereby allowing for the activity of "testable inquiry." One example of such an activity is found in Lave's (1989) supermarket study:

The arithmetic procedures used by the shopper followed a pattern. She started with a probable resolution, but inspection of the evidence and comparison with the expected conclusion led her to reject it. "No, I'm sorry," was her acknowledgment that the initial solution was in error. Pulled up short by the weight information from the package, she recalculated and obtained a new conclusion. This pattern is an example of gap-closing movement between the expected shape of the resolution and the information and calculation devices at hand . . ." (p. 163)

**Proposition testing and verification**

The creation of testable propositions within situated activity can be described as constant hypothesis generating and testing. This is a generative process within a situated cognition dynamic whereby the individual is actively engaged in acquiring and substantiating
information. The creation of knowledge in this sense can be defined as working towards a position of "justified, true belief" (Strike, 1975). This new, situationally supported, knowledge can then be used to develop further informed propositions.

Parallels can be drawn from the work of Strike (1975) as he describes the dynamic of verification within "discovery learning." The generative process of creating testable propositions (hypotheses) in situated activity has personal verification as a central element. The verification process is a determination that a conclusion is warranted based on the available evidence as it relates to a propositional hypothesis. To this extent the dynamic of situated cognition can be better explained as an iterative discovery process. Lave (1989) gives support to such a claim in the light of her study of supermarket shoppers:

The end product of supermarket calculation is so accurate for two reasons. First, dialectical processes of problem solving make powerful monitoring possible because of the juxtaposition of problem, solution, and checking activities. Second, . . . . If the process of the problem generation is under the control of the problem solver, the solution shape is generated at the same time . . . . (p. 92)

From what has been said earlier, the dynamic of situated cognition can be understood as beginning with a proposition, leading to the generation of hypothesis, leading to conclusion based on
verification, ultimately leading to new knowledge and understanding. This is diagrammatically represented in Figure 1:

![Diagram of Cognition Dynamic](image)

Figure 1. Situated Cognition Dynamic.

Propositioning -hypothesis testing- verification are indicated as the core of situated cognition, and are being used to describe the thinking that goes on within the mental model. The individual can be seen as the selector of what "counts" within the process with respect to both personal knowledge and contextual information. Note that the
identification of new knowledge is not perceived as an end in itself but serves to modify the situated modelling of context by the addition of new information. The new knowledge established can be described as the "temporary stopping places" and "stations of departure" referred to by Dewey because it represents a concluding point of new understanding from which further understanding can be built.

This description of cognition as an ongoing activity is supported through Lave's (1989) observations of shoppers' decision-making as a "gap closing" activity. Decision solutions were created more as a gradual process than as a spontaneous event. The cognitively active individual is alert to moment-by-moment changes in context conditions in relation to his/her own ongoing development of understanding. This modelling of the situated thought dynamic demonstrates that thought is not separate from context, but looks to the context to "embellish" the process. Dewey (1933) points out that such "intellectual organization originates and for a time grows as an accompaniment of the organization of the means required to realize an end; inferences are constantly tested by results achieved; futile and scattering methods tend to be discounted; orderly arrangements have a premium put upon them" (p. 49).
Thinking with situations

The supermarket context influenced the way the individuals in Lave's (1989, chap. 7) study could think "with" mathematics as they calculated best-buy items in the store. But most important to an understanding of how people think "with" information is the acknowledgement that they are capable of thinking, and do think, "with" information from diverse sources considered by the individual as situationally relevant.

A theory of situated cognition recognizes that we can think "with" many bodies of knowledge at the same time as we define what is situationally relevant and what needs to be given the most attention with respect to our intentions within a context. Lave (1989, p. 120) argues that an individual's determination of situation is integral to the process of cognition because it elicits from us schemas of information which are drawn upon to direct ongoing cognitive activity. Within the context of shopping, the shoppers may not have considered their sense of context to be "activity prescriptive," but it clearly influenced what they deemed their task at that moment. The task, however, was open to modification based on situationally generated relationships of information. These relationships take the form of both "intra" and "inter" relationships.
"Intra" relationships can be described as the convergent activities in which the shopper compared prices between similar products: "Okay, 25 cents off any size flavor of Kraft Barbecue Sauce, including the new Sweet and Sour" (Lave, 1989, p. 166). Such "intra" relationships are characterized primarily by the impact of immediate contextual referents.

"Inter" relationships can be described as the divergent activities in which the shopper takes a wider frame of reference to think "with" information not generated specifically by this immediate context but relating to the activity that the shopper is engaged in. For example, a shopper said: "Heinz has a special [on ketchup] . . . And I was going to make spare ribs one night this week, which I didn't mention to you [the researcher], but that was in my mind now that she [the daughter] mentions the sauce" (Lave, 1989, p. 166). The shopper was thinking "with" more than one resource for information to guide her activity. The sauce, her future intentions, the price, flavor, the brand name, and the researcher all influence how the shopper thought; her cognition became "situated" as she thought "with" (at least) all those bodies of information which became part of the propositionalizing of situation for her, and the establishing of relationships among elements.
In the dairy plant study by Scribner (1984), preloaders who, in the context of their job, had learned that the most efficient way to count crate contents was to modify their school-learned base ten algorithms with a base eight system, were able to adapt their mathematical strategies in other ways to solve a simulated paper and pencil problem. In the same study, college students, having little experience in adapting their arithmetic skills in the light of situational particulars, were unable to change their algorithmic strategies to accommodate the situation they encountered and instead continued to use inefficient approaches to the problem solution. It could be reasonably concluded that the preloaders had learned from practice within the process of situating mathematics with "real life" problems that mathematics was not about the application of rigid algorithms, but was a conceptual tool to be modified as and when necessary. One might speculate further that the "preloaders" had become proficient in thinking "with" situational information as they learned the "intellectual freedom" that existed within situations in contrast to the confinement of pre-specified algorithmic applications as is conventional in school-based instruction in mathematics.

The discussion thus far has been directed towards bringing together some of the current research on situated cognition in order to 1) establish situated cognition as a theoretical understanding for how individuals think in action; and 2) describe common elements
that allow for the description of a dynamic for situated cognition. It can be concluded at this point that situated cognition involves an apparently eclectic mental activity, which is nonetheless clearly organized in a personal and systematic manner. Lave's (1988) study begins to examine how students situate activity in response to the conditions of classroom instruction. The case can now be made that situating activity is inevitable as the student comes to determine roles and goals in the classroom context. This chapter now turns to the nature of classroom activity through which students situate classroom tasks, and how it influences their cognition as they engage in "meaning-making."

CLASSROOM INSTRUCTION AND SITUATED COGNITION

Classroom curriculum and instruction

In general terms, schooling as evidenced in classroom curriculum and instruction posits individual performance as the dominant mode of activity. Furthermore, competence and skill on the part of students tend to be measured in terms of "pure thought" activities defined by what students can do without the immediate support of books, manipulatives, and other external resources (Resnick, 1987). Both teachers and students know what is expected of them because they know how mastery of classroom instruction is to be measured. In such a system the potential scope for teacher or student flexibility in curriculum decision-making narrows because
the specified objectives resulting from adherence to school or district-wide goals predefine what is to be known and the acceptable levels of individual performance (Eisner, 1985, p. 129).

Given that variations in how people think are related to the circumstances in which thinking occurs, the pre-planned definition of classroom instruction as an arena of activity is prone to under-representing experiences that represent the diverse situations that individuals face outside the classroom. The juxtaposition of this observation with what has already been discussed for how individuals situate their thinking raises the question about the validity of school instructional activities for developing robust knowledge and skills that individuals can use outside the classroom.

Students often fail to realize consistency of problem elements when they are presented in different contextual structures, which is partly why understanding transfer is central to decisions about what is taught in the classroom. Butterfield and Nelson (1989) discuss the implications of common elements theory and how it impacts on an individual's ability to transfer knowledge skills and understanding from one area to another. They suggest that educators have tried to "locate" problems in knowledge domains. As a result the study of problem solving has been separated from an analysis of the contexts
in which the problems occur. Bruner (1966) argues that formal schooling:

... is removed from the immediate context of socially relevant action. This very disengagement makes learning an act in itself and makes it possible to embed it in a context of language and symbolic activity ... Words are the major invitations to form concepts rather than the action. (p. 62)

A theory of situated cognition indicates that the isomorphism between school problems as presented through, for example, word problems, and the reality of problem situations in real life breaks down largely because of the low level of "generative involvement" on the part of the student. The dialectic interaction that goes on between individual and contextual circumstances, such as a shopper in a grocery store, is seldom considered when students are asked to solve text-initiated problems (Greeno, 1991). In so doing, the social dimensions of cognition fail to be represented.

Drawing from the work of Vygotsky, cognitive development is understood as the "appropriation" of socioculturally evolved means of mediation and modes of activity. The core of cognition as thinking processes, is deeply rooted in cultural activity: the grocery store, the work place, the school, and so on. Cole (1979) describes this phenomenon:
The child's mental processes are the result of the history of his/her interactions with the social and nonsocial environment, on the basis of which he/she has evolved a large set of specific adaptations that operationalize relations among objects (including people) that the child encounters. (p. 5)

Unlike Piaget who claimed that cognitive development is primarily subject to neurological maturity, Vygotsky argued that cognitive development should not be conceived of as merely individual, independent, or inner but as the result of experiential support that nurtures and guides our ability to think. There must, therefore, be recognition of what the child achieves in cooperative activity by imitation, pointing to the direction of development (Simon, 1987).

Situated instruction

In support of a theory of situated cognition, Brown, Collins & Duguid (1989) argue that "situations coproduce knowledge" through activity. Furthermore, the activity in which knowledge is learned and deployed is neither separate from learning and cognition, nor is it neutral. Situated instruction, therefore, becomes partly defined through recognition that the process of being instructed in the classroom is in itself a rich source of information for the learner. Learning and enculturation go hand in hand and it is this phenomenological aspect of learning that a student needs to access in preparation for when they go beyond the learning situation to the "real world" in which the learning is expected to be applicable.
The role of the instructor within situated activity can be considered as supportive rather than directive of learning. Greenfield (1984) refers to this as instructional "scaffolding," sensitive to the "zone of proximal development" of the learner. Unlike Skinnerian shaping, the proposed instructional experience is not broken down into manageable parts, but is kept constant while simplifying the learner's role as much as necessary for it to be manageable by the learner. The learner works with the culture of the experience in toto through the supportive guidance of the instructor. The entry level for instructor guidance is inversely responsive to the learner's experience; as learner competence increases, instructor intervention decreases.

From the student's point of view a central consideration for situating instructional activity is the recognition of "situational intent." That is to say, an individual's determination of situation brings to the fore certain expectations that guide purposeful action. This acts like an advanced organizer (Ausubel, 1968, p. 137) except that it occurs not just in preparation for the instructional activity but occurs throughout the activity in response to changes in situated conditions. For example, the behavior of shoppers indicated their "situational intent" to make appropriate purchases and the behavior of the dairy plant workers indicated their "situational intent" to count
the cartons as efficiently as possible. Each guided their activity in relation to their situational intent definition.

Brown, Collins & Duguid (1989) point out that students are often being asked to use knowledge tools (Whitehead, 1929) without a sense of adopting the broader culture of tool use. The culture of a knowledge tool is recognized through a sense of appropriacy for the type of activity in which the knowledge tool is to be used. For example, the culture of mathematics can be recognized through the activity of people solving problems using math that results in "real" consequences, as opposed to them being simply paper and pencil exercises that meet a grading requirement. As students situate their thinking, the cultural context for activity is recognized as extremely relevant to how they situate their understanding.

**Authentic activity**

Brown, Collins & Duguid (1989) use the term authentic activity to describe instruction that unifies the culture of a knowledge domain with the experience of situated activity. Greenfield (1984) argues that, in schools, instruction is insufficiently "whole task oriented" and that what is needed is for the learner to be involved in activity that is whole task defined. Authentic activity within instruction is understood as learning activity that promotes student engagement as generatively determined from within the activity, rather than a
prescribed requisite from the preplanned instruction. Wertsch, Minick, & Arns (1984) point out that for whole task activity:

To specify the nature of an activity is not to specify the particular means-ends relationships that it involves but simply to identify the socioculturally defined milieu in which it occurs. (p. 155)

Authentic activity in the classroom can be understood, therefore, as creating opportunity for the learner to discover resources that can be used to define and support individual and social tasks. Therein authentic activity becomes a matter of developing activity that is rooted in the culture of knowledge tools and their relevance. Situated learning can then be understood as developing the ability to look for, recognize, evaluate, and use those resources productively.

Wertsch et al. (1984) argue that school based activity is often "inauthentic" because what is at stake is less consequential. That is to say, school-based instructional activities tend to emphasize independent functioning where errors are expected, while those in real-life most often emphasize error-free performance because errors involve "real" consequences. They go on to say that with the development of formal schooling as a social institution and the dominant locus of learning activity in a society, the culture for learning and instruction becomes the culture of schools, set apart
from the society in general. The activity of schooling becomes self-determining rather than being sensitive to, and embedded within, other social systems of activity. Greeno (1991) voices his concern for the often inauthentic nature of formal schooling:

Learning also occurs as individuals interact with texts and work on symbolic problems, but reliance only on individual interactions with printed or computational material misses a social learning that is probably crucial for a large number of students. (p. 201)

A cognitive apprenticeship model

Brown, Collins and Duguid (1989) propose situating authentic instruction for students through a cognitive apprenticeship model. An apprenticeship model involves supporting students' instructional activities through guided independence. A study by Rogoff and Gardner (1984) on the degree of adult instructional supervision found that "scaffolding" within contextually generative, coproduced activity was effective in guiding the transfer of knowledge and skills from more familiar contexts, thereby aiding the learner to make connections within the context of the immediate activity. Rogoff and Gardner (1984) explained the dynamic of teacher-student interaction where the activity of "scaffolding" takes place:

Both the learner and the teacher are actively involved in such instruction. . . . The instruction occurs in the interaction between novice and expert, who together structure their communication so that the novice is brought into the expert's more mature
understanding of the problem. They jointly manage the transfer of responsibility for the task so that the novice is participating at a comfortable yet challenging level in the problem's solution. The expert revises the scaffolding for the learning as the novice's capabilities develop, adjusting the support for the novice's performance to a level just beyond that which the novice could independently manage. (p. 116)

Such an approach to classroom instruction supports the concept of learner empowerment (Streibel, 1986) through its assumptions of a negotiated interaction between student and teacher. A core consideration is the creation of a learning environment which fosters a learner's sense of personal intellectual enterprise whereby they are able to bring to the instructional activity their own ontological definition, rather than having to work strictly within the ontological definition imposed by an external agent (Hymes, 1980). The role of the learner within authentic, situated activity is one whereby they are encouraged to recognize that they themselves are intentional agents creating their situated experience within a culture of activity, as opposed to being simply external observers or incidental actors.

This raises questions for the rather common didactic position taken by teachers who understand their role as knowledge mediator in terms of "I know what you will come to know" (Rogoff & Gardner, 1984, p. 105; Sirotnik, 1983; Johnsen & Taylor, 1990). Such a position assumes that within the instructional activity knowledge is absolute and that the ontology of the experience is teacher-defined. The role
of the learner is to decode the knowledge of the expert teacher and then adopt the same coding for themselves because the instruction climate fosters an 'understanding' that there is only one way of knowing — the teacher's way. The crux of the concern, in terms of the absence of situated experiential learning, is that the knowledge is likely to be perceived by the student as the domain of the teacher or text book, rather than the domain of the experience for which that knowledge is supposed to be germane.

Streibel (1986) describes the teacher as a "central agent in a dialectical community of learning and one who forms a triadic relationship with the learner and the subject matter" (p. 140). This is diagramatically represented in Figure 2:

![Triadic Instructional Relationship](image)

Figure 2. Triadic Instructional Relationship.
While this two-directional triangular relationship model begins to identify the important elements of an apprenticeship model that contribute to a situated instructional experience. However, it needs to be developed further to incorporate the influence of the learner as a central agent, together with context as yet another central agent, collaborating dialectically in the construction of the situated instructional experience.

The modelling of a situated instructional enterprise has to have (at least) four major elements: teacher, student, context, and coproduced intention of outcomes. Intention can be considered as the deliberative identification of purpose, tacit or otherwise, resulting from collective negotiation among the first three elements. This understanding becomes the collective purpose of the situation and is central to the initiation and direction of activity. This relationship model is represented in Figure 3:
The intersection of teacher, student, and instructional context is more than a determination of intended outcomes. It also identifies the point at which consideration is given by the student towards situating activity within their own mechanisms for "meaning-making."

Effective situated instruction requires the teacher to guide the learner, through common involvement, in the generative definition and direction of the activity. In terms of a "zone of proximal development," the teacher must be sensitive to the moment by moment contingencies of students responding to their own sense of
situation. What is more difficult to model is the potential for coproduced intention of outcomes to change as renegotiation takes place throughout activity.

Chapter summary and conclusions

This chapter has presented a descriptive account of research that informs the development of a theory of situated cognition. The chapter described and gave examples of several major factors recognized as characteristic of the phenomenon:

- cognition is a process and must be recognized as such.
- cognition is ultimately a personal act but can be shared in a community through negotiated agreement.
- the act of thinking is not separate from the conditions of context or the individual's sense of purpose therein.

Several studies indicated that what characterizes thinking in the main is not the homogeneity of thought from individual to individual, but the diversity of thought resulting from meaning generated by the unique thinker as an "in action" information processing activity. This most succinctly identifies the "situatedness" of situated cognition.

This chapter also examined some of the implications of a theory of situated cognition on classroom instruction. A recognition of the student as a situated thinker necessitates consideration of how the context of activity influences the student's meaning-making. Situated
instructional activity has to be measured against the criteria of "authentic activity." The instructional interaction between student and teacher is defined with reference to an apprenticeship model where the teacher as expert in the culture of a knowledge domain supports student activity as he/she works within that culture. Goals within instructional activity are coproduced through the immediacy of the authentic activity and the level of participation.

The field-based research reviewed in the chapter is predominantly based on investigations into the activities of adults. The discussion on situated cognition in relation to classroom instruction is presented with the underlying assumption that students in a classroom setting are indeed situated thinkers. While the research presented in this chapter supports such a conclusion, it also highlights a need to investigate the situated nature of school-based instruction from the standpoint of the participating student. Chapters three and four describe such a study that took place in an elementary school. The study focused on the activities of third and fourth grade students as they described their understanding of school and text initiated math word problems.
CHAPTER III
METHODOLOGY

As discussed in chapter one, qualitative research is the appropriate methodological approach for the current study. The study involves an emergent design in response to the data as it became available (see Lincoln & Guba, 1985, p. 210). This chapter describes how the study was conducted and the considerations that became necessary, given the "emergent" nature of the design.

Qualitative approach

This research was guided by the intent to answer the original focus questions of the study. According to Bogdan and Biklen (1982), however, "While people conducting qualitative research may develop a focus as they collect data, they do not approach the research with specific questions to answer or hypotheses to test" (p. 2). Nevertheless, the methodology to be used came from a qualitative research tradition, itself rooted in an interpretivist paradigm.

It was an important consideration in this study of situated cognition that the investigation centered around process rather than
product (Suchman, 1990, p. 111). While product was not considered irrelevant, it was the process of cognition attributed to observable behavior that became the focus of attention for the researcher. The goal was to study process as it unfolded within observable contextual conditions. Interpretations and suppositions were constructed based on observations, interviews, and other sources of information that allowed the researcher a "view" into the dynamic of rich context and complex situated activity.

The study used approaches to thinking and activity developed by White and Seigel (1984, p. 254) who advocated that the study of thinking should be concerned with the relationship between culture and cognition. For the purposes of this study, the term "culture," as used by White and Seigel, was understood as meaning "environment" (see definitions). They argued that some ways of thinking are socially created and that consideration of this social influence allows for a richer understanding of how people think. Secondly, they proposed that a more context-specific analysis can be undertaken through the use of "transforming experiments," in which students are shifted to differing context conditions and their adapting activities observed. Within the transforming experiments of this study, participants found the same task, or "tracer" elements (Newman, Griffin & Cole, 1984, p. 176), under different conditions. This allowed for a specifically context-sensitive analysis of the "tracer."
The term "experiment," as used here, is not to be understood in the context of the scientific method, whereby variables are identified a priori in order to establish controls. The use of the word "experiment" serves to highlight the artificial activity of creating circumstances that would not ordinarily develop in the course of regular classroom activity. In this case students were asked to take time away from their regular classroom activities to solve math word problems in an interview setting.

**Study site**

This study was conducted in an elementary school in Columbus, Ohio. This site was chosen for several reasons. First, through preliminary visits to the school and conversations with the principal and the four teachers involved in the study, they agreed to allow the study to be conducted during the school day and with their students. Secondly, the teachers and students were accustomed to having "visitors" to the school and the researcher's presence there quickly became familiar to them. Thirdly, the students were very friendly so a comfortable rapport was established easily between researcher and the students in general. Finally, and most importantly, the teachers were willing to release students from regular classroom activities so that interviews could be conducted.
Participants

The target participants for this study were third and fourth grade students in the school. The classroom teacher selected fifteen students in response to the researcher's request for a balanced group of boys and girls from all three math ability groups. Fifteen students were chosen initially because this seemed a large enough pool from which ten students could be selected for further phases on the study. A final selection of ten students was made by the researcher because ten proved to offer a sufficient distribution between boys and girls and among ability groupings. Students were asked to cooperate with the researcher although it was made clear to students that they were under no obligation to participate. As it happened, the students appeared eager to be selected.

"Stratified purposeful sampling" (Bogdan & Biklen, 1982, p. 67) was used to select the students for the study. Ten students were chosen by the researcher from the initial fifteen interviewed to facilitate the acquisition of data for a developing theory of situated cognition (see Bogdan & Biklen, 1982, p. 67; Patton, 1990, p. 174). There were two main criteria upon which the selection of the ten students was based:

- Students had to have proficiency in verbal communication skills that allowed them to describe feelings and actions to the researcher.
- Students had to represent the three math ability groupings for grades three and four.
Scribner and Cole (1981, p. 251) used the data from their study of the Vai people to argue against using school competencies as a measure of general competence and skill in other contexts. The rationale for choosing "mixed ability" students, therefore, is to move this study away from looking at ability, as reflected in performance of regular classroom activities, towards recognizing situated cognitive activity in everyone. In short, no assumptions were made that students who performed better during classroom instruction were going to be more efficient at organizing their sense of situation. It was, however, of interest to see if any differentiating patterns emerged.

Classroom teachers were also part of the subject pool. They were interviewed to assess their understandings of school-based education and their perceptions of their own students as they engaged in classroom-defined instructional activities.

**Data collection**

Data collection was prolonged and persistent: prolonged in that it took place over several months; persistent in that the study focused on particular individuals as they participated in the transforming experiments.
Data collection was done by the researcher through on-site observation, general discussion with members of the school community, and formal interviews with selected participants. "Thick description" (Geertz, 1973, p. 6) was considered necessary in order to understand the social culture of the school and the classroom. Thick description in this study considered how the school day was organized, the social mix of the school population, the school's educational philosophy, and the manner in which students and teachers interacted as they went about their school day.

This study was an investigation into how students determined meaning from their context-embedded experiences and their sense of situation. Data gathering, therefore, focused on eliciting from the students their sense of personal meaning-making. While interpretation on the part of the researcher was inevitable as the researcher himself "made-meaning" from what was observed, the intention was to capture, as accurately as possible, students' perspectives in the data gathered. The present author was both researcher and interviewer and the data were collected by means of field notes, a research diary, and both audio and video recordings.

The classroom math text book provided the math word problems for the transforming experiments (see Appendix B). Questions marked with an asterisk in Appendix B were chosen directly from the Addison-Wesley Mathematics series (vols. III, IV, &
V) used by the students in their lessons. The remaining questions were based on textbook questions, but were enhanced in order to present unusual or extreme conditions within the problems. For example, the last question was changed from asking about two pound chickens to asking about twenty pound chickens. The questions were chosen to deal with fractions that were considered by both the researcher and the teachers as "everyday fractions". Most of the questions chosen asked students to work with halves and quarters. Several less common fractions (eights, tenths, sixteenths) were also included in the question selection to examine whether or not common usage made a difference in how students used them.

During the first three days in the school, the researcher was an observer, seated in various locations around the room. This early non-interventionist role was useful as it allowed the researcher the opportunity to observe, take notes, and familiarize himself with the conventions of daily classroom activity.

In the following weeks, the researcher functioned as a participant observer, helping students with their work, especially those students who were having difficulty and would otherwise have had to wait until the classroom teacher was free. This allowed the researcher an opportunity to familiarize himself with the students in anticipation of selecting particular students for "persistent" study at a later stage.
As the daily school schedule left little time for interviews to be conducted during the day, each teacher was interviewed in her respective home on weekends. The principal of the school was interviewed in her office. Interviews and transforming experiments with students took place in various locations around the school with only one student at a time. Students were excused from their regular classroom routine at times that were convenient to both teacher and student. There was never any predetermined sequence in who was to be interviewed. The students were escorted to the interview site by the researcher. Each meeting began with general conversation relating to daily concerns (health, weather, school events, etc.). This served to relax the students.

At the beginning of each session, students were given a general description of what they were going to be asked to do. It was pointed out to the students that their answers would be confidential and therefore they should speak as freely and honestly as they could. Interview questions had been prepared beforehand and these served to guide the course of the interview. Interview questions were developed in consultation with the researcher's advisor. A general principle adhered to in the design of the questions was that they were to be open-ended. That is to say they were phrased in such a way as to invite the students to express their own thoughts and opinions regarding the topic in question.
Unlike a "friendly" conversation, the verbal interaction between subjects and researcher had a business-like manner. Spradley (1979, p. 67) identifies four common characteristics of an ethnographic interview that aptly describe the dynamic of the interviews in this study. First, throughout the interview turn taking was not an even exchange between interviewer and the participant. The interviews could be characterized as a question and answer interaction, with the interviewer asking almost all of the questions and the participant primarily responding with answers. To this extent the conversations were controlled by the interviewer. Secondly, the interviewer would often repeat what had been said by the participant in the form of a question for the purposes of verification, or to encourage him/her to expand on what had already been said. Thirdly, whenever a reticence to speak and express thoughts was detected, the interviewer gave encouragement by expressing interest in what was being said, and perhaps pointing out that those responses provided information that the interviewer did not already have. This helped to reassure participants that what they were saying was considered interesting and important. Fourthly, in place of the normal practice of giving short answers, the interviewer encouraged the participants to expand on what they were saying.
Data analysis

Meaning and understanding were as situated for the researcher as they were for the participants. The interpretive process for the researcher can be seen as involving three approaches (McCutcheon, 1981):

1) the forming of patterns by accounting for the affiliation of separate phenomena to one another;
2) the interpretation of the social meaning of events through "thick description";
3) and the relating of particulars of the setting to external considerations, such as theories from social sciences and education, philosophy, and history.

Data analysis, however, was not a discrete step in the design. Rather it was an ongoing activity throughout the data gathering process, having direct dialectical implications for the emergent design. The activity of taking field notes was in itself a data analysis activity (see Spradley, 1980, p. 69). The researcher was constantly having to identify and explain in the text what was happening in the classroom and during interviews.

The process of transcribing interviews proved a rich resource for data analysis. The fact that the interviews were transcribed line-by-line allowed for a more considered appraisal of what was being said. In fact, many things were understood during transcribing that
were completely missed or misunderstood during the actual interviews (see Spradley, 1980, p. 67).

As interviews were transcribed, the researcher made note of particular events for more detailed examination. Having transcribed the interviews, the researcher read through them many times to identify themes and distinctive events that served to organize the data as a whole. Each interview was then read with the purpose of finding exemplars of a particular theme or event.

Although the focus questions was established before the data collection began, the data analysis was not explicitly controlled by a need to answer those questions. The questions served as a starting point for the analysis and the data itself served to direct how it could be organized. To make the analysis and presentation of the data more manageable, focus questions were broken down and answered through the use of subquestions. In the course of looking for and analyzing particular features in the data, other features came to light and acted as catalysts for further investigation.

During the time data were gathered and analyzed, and particularly during phase five (described below), the researcher was involved in further literature research related to the study of situated cognition. New ideas presented by other authors served to focus the
researcher's attention on features of the data that had been previously overlooked or under-appreciated.

**Phase one of the study**

The objective of phase one was to gain understanding of the normative practices common to the classroom and school operations (see Lincoln and Guba, 1985, p. 301). This phase alerted the researcher to unanticipated considerations, and guided the researcher in determining the most efficient logistics and strategy for conducting interviews in subsequent phases. Phase one began with two weeks of observation in the classroom. The researcher visited the school all day, three days a week. During this time the researcher observed classroom routine and helped both students and teacher, using the opportunity to get to know both groups better so as to facilitate the selection of participants. This was also a time for establishing trust between researcher and participants thereby increasing the likelihood that participants would be more candid and open informants during the study (Lincoln & Guba, 1985, p. 256). The school principal was interviewed in order to clarify and develop general observations made by the researcher. She also presented general data about the school that could not be immediately observed in the school itself.

Phase one had a second objective. In order to prepare for the "transforming experiments" (to be discussed later), the researcher
had to ascertain the kinds of instructional activities that went on in the classroom. As had been anticipated, based on information from preliminary visits to the school, students were found to be studying fractions as part of their classroom course of study, albeit at different levels of sophistication. Fractions were chosen as an appropriate content area because they represented a knowledge domain that, it was assumed, young people worked with informally as they shared time, space, and materials with others. Support for this assumption was obtained through discussions with the students and teachers. A third objective of phase one was to select student participants to continue with the interview phases of the study.

**Phase two**

This phase began the formal interviews. Fifteen students were selected from phase one, in collaboration with the main contact teacher. Interview questions (see appendix A) were selected to gather data describing students' understanding of the particulars of their "environment." In particular, questions for this interview were designed with particular attention to eliciting from the students their perceptions of school and the role of school in their lives. The central focus of the interviews was to determine if students felt it was necessary to come to school and why. Students were also asked to describe how they valued the subjects that they studied in school and what use they made of them, both now and as preparation for the future.
Students were given permission to leave their regular classroom activities to go with the researcher for these interviews. They accompanied the researcher to a central library area in the open-plan classroom where a tape recorder, table and two chairs had been set up (see Figure 4).

![Diagram of open-plan classroom area]

Figure 4. Open-Plan Classroom Area.

Although there was background noise from general classroom activity, this did not interrupt the flow of the interview. In order to cause a minimum of disruption to classroom activity, two interviews were conducted per day.
Based on students' communication skills and their general ease in talking with the researcher, phase two was used to select the most suitable students for subsequent interviews.

**Phase three**

Phase three began the first of the transforming experiments. This phase involved ten of the fifteen students interviewed in phase two. Students were escorted by the researcher to a store room where a table, two chairs, a video camera and tape recorder were set up (see Figure 5).

![Diagram](image)

**Figure 5.** Transforming Experiments Setting.

The students were given a printed copy of thirteen math word problems (Appendix B). Together, the questions presented to the students had the following characteristics:

- they purported to be solvable through the use of fractions.
they asked students to consider the circumstances of a hypothetical context. 
- some of the contextual circumstances were unlikely or impossible.

The students read or had the questions read to them and were asked to solve the problem and to explain how they did so. Students were also asked to explain how "real" they thought each problem was and to comment on whether this was important to them. Appendix C lists some of the major focus questions presented to the students during the interviews.

Not all students were asked all the questions. It became apparent to the interviewer during the interviews that asking students to do questions that were too difficult for them was likely to cause some anxiety. In order to create and sustain an atmosphere of openness and discussion, students were reminded throughout the interview that this was not a test and that the interviewer was interested in what they thought of the questions and how they would go about trying to answer them.

Students' answers were recorded on audio and video tape for later transcription. Particular observations and thoughts by the interviewer were written into his field notes either during or just after each interview. In order to lessen anxiety on the part of the students, they were invited to see themselves on the video monitor.
screen as their recording was played back to them. All the students enjoyed this activity.

Phase four

Phase four involved the second of the transforming experiments. These interviews took place in the store room under similar conditions to phase three. In this phase a more limited selection of the questions already presented to the students in phase three was presented (see Appendix D). Most of the students had been exposed to these questions before; however, this time the students not only were given the questions but also were presented with objects related to the questions. For example, one question involved grapefruits, so grapefruits were available during the interview.

Students were asked to solve the problems and were invited to use the objects in front of them in any manner they considered suitable for that task. As they engaged in their problem-solving activities, students were asked to explain their actions and rationale to the interviewer. Particular observations and thoughts by the interviewer were written into his field notes either during or just after each interview.

Phase five

Although data analysis was an ongoing activity throughout earlier phases of the study, phase five is particularly distinctive in
that it involved an analysis of the data collected up to that point as they related to the original focus questions of the study.

**Phase six**

Phase six involved interviewing the teachers of the students who participated in the earlier phases of the study. Guiding questions for these interviews (see Appendix E) were drawn from data obtained from the students. These data were analyzed for similarities and differences in the teachers' perceptions of their role as instructors. A central objective was to determine if the teachers considered students' learning in the classroom a situated phenomenon. Interviews were audio recorded and later transcribed; field notes were also taken.

**Phase seven**

This phase was concerned with establishing reliability and validity for the study data. Clarification and further data were sought whenever necessary. Study data and interpretations were given the appropriate revisions allowing for study conclusions to be made.
Figure 6. Study Time Line.
Schedule for the study

The study took place over a period of seven months, from spring until autumn, 1991. The first three months involved visits to the school for three full days per week. This was soon supplemented by transcribed interviews. Transcription and analyses of data were ongoing features of the study. Intensive data analysis of students' interviews was done over the months of June, July and August. As there was insufficient time to interview teachers before the summer break, teacher interviews were conducted during the first few weeks of the autumn school term. The final two months of the study were spent analyzing the teachers' interviews and conducting checking procedures on the data. Figure 6 is a time line for how the study was conducted.

Validity

The term "validity" is borrowed from the vocabulary of quantitative research. Lincoln and Guba (1985, p. 294) define the term "validity" with respect to qualitative research as "truth value" or "credibility." The question of validity brings to the forefront two major concerns: 1) how authentic and representative are the researcher's descriptions for rendering the complex interactions of participants' activity?; and 2) to what extent do the biases of the researcher influence interpretations and conclusions from the data? It is acknowledged from the outset that data gathering and interpretation are decision-laden processes, and that the decisions are
made, at least initially, by the researcher. The effort to establish validity in this study can be seen, therefore, as a search for "truth value," so that what is reported in terms of evidence and conclusions can be substantiated and defended with reference to the research-site data sources. While omissions and oversights must be accepted as one of the "perils" of any research enterprise, validity as in "truth value," is concerned with accountability for those limitations. Such inherent "flaws" in a study must be accounted for so that what is understood as a report of activity can be substantiated as representative of the activity, despite the absence of certain unexamined dimensions.

Triangulation, the practice of supporting conclusions or assumptions based on several data sources (Lincoln & Guba, 1985, p. 305), was established to support the authenticity of the researcher's descriptions, and to support the interpreted conclusions that were derived from the data.

Data authenticity was supported through audio and video recordings, transcriptions, field notes and teacher member-checks. While it would have been desirable for authenticity to be checked through member-checks with students, this proved impractical as some students did not return to the school after the summer vacation and others moved into other classroom groups.
Interpretations and conclusions from research data were supported by several sources. Observational data relating to thick description of the school and the school community was confirmed by comparing the teachers' and the principal's responses to questions specific to the observed information and conclusions. Whenever possible, interpretations drawn from interviews and transforming experiments were supported by referencing specific statements of the participants.

Although member checks with student participants were not performed, teacher interviews served as a checking process for conclusions made from student data. While teachers were given a brief explanation of the study during phase one, little attention was paid to explaining the intent of the student interviews or what transpired during them. Nevertheless, teachers validated the researcher's findings from the student data by describing student activity and perceptions in ways that often mirrored the findings of the researcher. Particular instances of this substantiation are described in the data presentation.

Reliability for interpretations and conclusions drawn from teacher interviews and general data about the school itself was established through a group discussion with the teachers and the principal. Also, in order to substantiate claims rooted in data, an audit trail was established. As this is research emanating from a
doctoral dissertation requirement, the auditor of record is the student advisor.
CHAPTER IV

PRESENTATION OF THE STUDY DATA

The data presented in this chapter are taken from interviews with students and teachers as well as the researcher's observations during the spring term in an elementary school. The school will be referred to as Park Elementary. Given that this study is an investigation of the situated activities of particular people working within particular circumstances, the data presentation begins with a description of the study site and the study participants.

A description of the study site is important for understanding the school climate and the resources into which daily classroom activity had to fit. The descriptions of the study participants allow for a general understanding of the background circumstances of the participants, and how these students were grouped within class and school structure for the purposes of school learning. This area of data presentation and analysis is based on observational and ethnographic data.
Thereafter, presentation of the data is guided by the four focus questions of the study. The first question was designed to examine how students in the classroom situated their thinking in relation to their interpretive understanding of the relevance of school based activities; this can be considered the "environment" level. The second and third focus questions were designed to examine students' cognition as they engaged in specific math word problem activities. The fourth question was designed to examine the data from the first three in relation to how the students' teachers conceptualized students' situating of classroom instruction.

**Study questions**

The environmental level was examined through the first focus question:

What do students recognize as their purpose in attending school? Is there evidence that this sense of purpose influences their activity in the classroom?

In the interests of manageability and clarity this question is broken down into the following subquestions:

What do students believe to be the purpose of being at school? How do students define their role as students in the classroom? How do students define purpose and goals for the activities that they undertake in the classroom?

The examination of context and students' participation in math activity are examined through the second focus question:
Is there evidence that students reconfigure the description of math word problems into a personalized contextual framework so as to be able to achieve the original task goals?

This question is broken down into the following subquestions:

Do students recognize context resources to support their performance during math word problem activities? What is the nature of the interpretive cues through which students contextualize the description of math word problems? Do students reconfigure math word problem contexts (as described by the word problems) beyond the conditions of the problem statement?

The students' "in-action" math activity is examined through the filter of the following focus question:

Would a student, presented with several structurally similar tasks, use similar strategies for accomplishing each task, given varying degrees of contextual resource support?

This question is broken down into the following subquestions:

Do students work to recognize and select context support cues as they try to perform math word problems? How does the presence of support cues influence strategies for solving word problems?

The fourth focus question, designed to allow comparison between students' and teachers' perceptions, asks:

How does the students' determination of purpose for classroom instructional activities compare with the teachers' assessment of purpose?

This question is broken down into the following subquestions:

How do teacher's perceive the functions of classroom instructional activities within the lives of the students?
What do the teachers perceive as the learning value of students working through math word problems?

Overall these focus questions were selected to guide the inquiry into eliciting the students' reasoning for why they came to school, what their sense of purpose was in being there, and how they constructed meaning and relevance as they engaged in specific activity. With respect to situated activity, the study looked to how students' "pre-plans" for activity compared with their "in-action" strategies and/or their "post-action" reconstructive explanations for what they had just done.

Figure 7 is a conceptual model of how the data for the first three questions is to be presented. It can be seen that while situated activity is the central focus of the study, it is examined within the broader socio-cultural world of the student.

![Data Presentation Model](image)
The fourth focus question is distinct from the first three in that it was designed to examine how the teachers of the specific students in the study conceptualized their own role as educators, and how they perceived the impact of classroom activities on the cognitive development, that is to say, learning of their students.

School site and facilities

Park Elementary is an alternative public school located on the north east side of Columbus, Ohio. As part of a desegregation plan, parents can have their child's name placed into a city-wide lottery for a place at Linden Park and/or other alternative schools in the city. Each alternative school in Columbus is characterized by a particular educational approach and philosophy with respect to how learning takes place for students.

The building has two levels. The first floor houses the principal's office, the main office, the gymnasium and stage, the music and video rooms. The majority of the ground floor space is used as an open-plan learning center with the library in the center of the room allowing ready access should there be need of it during classtime. The second floor consists mainly of teaching areas, with a teachers' lounge at the top of the stairs.
The school is carpeted throughout, with central air conditioning that is considered a luxury in older elementary schools in Columbus. There is a play area around the school which is not fenced in, allowing the students to make use of the extensive grass covered sports field that is adjacent to the school. Students frequently use this area.

Each teacher has access to general resources in a central store room. Each teacher also has three computers with further access to computers in a computer laboratory that has sixteen computers. A shared art area is available that has a sink and a workbench, used for potentially messy art projects and for cleaning the cages of the school's resident menagerie.

School population

The school has a population of four hundred children from grades K-5, with sixteen teachers. There are approximately twenty five students to each class. The teachers are supported by five teacher-aides, one secretary, and two custodians, and of course, the school principal. A large pool of volunteer parents is readily available to the school when extra help is needed. For example, on one occasion the school had a "sleep over" where students who had earned the privilege could sleep in the school overnight. Over twenty five parents volunteered to organize game activities and stay with the children overnight. So, while the school student population draws
from a non-local student population, the school does have a substantial sense of school community.

The student population draws students from a broad range of socio-economic backgrounds. Most of the students, however, come from low to average income families. Despite that fact that 42% of the students get free school meals and 40% of the students come from one parent families, they appeared well nourished and attired when they came to school with durable, practical clothing that was clean and in good condition.

School program

Park Elementary is described as an "alternative school" because of its Individually Guided Education (IGE) approach to student instruction. The school's philosophy tailors learning to the students' specific needs and abilities. The design of each program, however, has to meet with city, state, and federal legal requirements and so the general curriculum corresponds to the Columbus Graded Course of Study.

The teaching is collective through the use of a team approach. Each team of teachers, together with the students within particular grades (for example grades three and four) come together to form a "Learning Community." There are several Learning Communities in
the school, all of which take their names from astronomic planet configurations. The Learning Community from which the majority of the data for this study were gathered is called "Betelgeuse," (grades three and four).

Each teacher-team works together to agree on the structure and schedule of the classes for the students within their Learning Community. Through the team approach, teachers work together to decide on the most appropriate class section for each student within each subject area. For example, there are high, intermediate, low and remedial groupings for mathematics and English. Also students are allowed to enroll themselves with the homeroom teacher of their choice.

Students are pre-assessed for ability level in each core subject area, such as reading and math. Class groupings for reading, writing, and math are established based on these results. It is a normal state of affairs for a student who is technically in third grade to be working together with a student who is technically in fourth grade, both doing the same level of work. For example, Michael who is technically in third grade is in the high math group, together with fourth grade students. That group, by Easter time, was working on the math book designed for fifth grade. Students come together in their home-room groupings for subjects such as music, P.E., life skills, and science.
The success of the team approach was recognized by the staff to be due largely to mutual agreement by the teachers that they could teach better that way. Teachers met regularly to discuss students' progress. When appropriate, students were moved to higher or lower sections throughout the school year. Pupil progress reports were sent to parents every nine weeks. The reports emphasize not just whether a child had mastered knowledge and skills within a certain content area, but particular attention was also given to a student's effort and work habits. Reports are structured as "criterion referenced" with the criterion being the performance of the individual in relation to individually tailored school and learning-group expectations for that particular student.

**Daily schedule**

The instructional day began at 9:00 a.m. when students could enter the building. Students went to their home rooms where attendance, lunch money, and other administrative business for the day was taken care of. After the pledge of allegiance and the schools code of personal conduct were recited (Appendix G), students proceeded to their first class of the day. Classes continued until 10:30 a.m. when there was a recess for fifteen minutes. Class continued until lunch time at 12 noon. Afternoon classes began at 1:00 for the afternoon session. School was dismissed at 3:30 with a recess for
fifteen minutes at 2:00. Appendix H gives a breakdown a the school week for 1990-1991. Despite the preplanned scheduling for the students' activities, teachers evidenced a great deal of flexibility in order to exploit unanticipated opportunities. For example, regular instructional activities were postponed in order that the students should have the opportunity to hear a presentation about the researcher who was a foreign student from Scotland.

School organization

The school is designed as an open plan learning environment. Class groups are not divided by partitions or any kind of barrier designed to shut out the activities of the adjacent group. In fact the Betelgeuse Learning Community work alongside the Sagittarian Learning Community, even though the "Saggies" (as they were called) were predominantly fifth grade students.

The school has a rich array of in-class projects. For instance, the Saggies have a menagerie which is open for all the students to see. This group has a makeshift greenhouse heated by lamps where they experiment in growing plants. These are all part of the experiential learning that goes on within the groups. Earlier in the spring they hatched three chicken eggs. Children in the group take care of the animals and you can hear the chickens "cheeping" all day throughout the classroom area. Betelgeuse have a hamster as a pet within each
home base area. Students are given the responsibility for taking care of the animals and making sure that their cages are kept clean.

The general atmosphere of the building was one of organized activity. Walls and poster-boards were decorated with material indicating the theme of the Learning Community's general activities within a specific topic area. For example, in May the students in Betelgeuse were studying industry and commerce. The walls were decorated with posters and students' work reflecting that topic. As topic areas change, so too did the wall displays.

Children are often moving from area to area and this usually generates the excited commotion that one might expect. The dulcet tones of young children could be heard whenever the peripatetic music teacher was at the school. The music teacher organized a concert for the spring term based on the contemporary theme of "save our earth," to which teachers, parents and visitors were cordially invited.

Cries of excitement are commonplace from the school gymnasium, together with the thumping of dozens of little feet as the peripatetic gym teacher orchestrates her classes through a variety of energetic, and judging from the noises, very enjoyable physical activities. The general office has no shortage of traffic. Some are
there to deliver messages, some are there to receive messages. Some are there to receive solace and comfort from the "slings and arrows" of being a young child; cuts, bruises, headaches, chills, fevers, pains and aches — whether real or imagined! Fortunately the school has a nurse that comes in several times per week.

The school makes use of the resources of the broader community. During the months of April and May, Betelgeuse invited a docent who had retired from the Columbus Symphony Orchestra. This gentleman presented the students with four half-hour presentations about the instruments of the orchestra and how they influenced the sounds that the orchestra could make. The students were then bussed to the Ohio Theatre in Columbus to hear the orchestra perform. One child, was particularly unimpressed with their first numbers; he had failed, to appreciate that the tuning of the instruments before the concert began was not really being offered as part of orchestra's musical repertoire.

The Betelgeuse Learning Community

The term "Learning Community," is not used as a superficial label in this school; learning is about learning together. Students work with teachers, teachers work with students, and students work with students. Although students are ability-grouped within subject areas, the constant flow of students moving and working with others
serve to bring students together in all sorts of cooperative ways. For example, students all participate in the same field trips, such as a visit to the Center Of Science and Industry (COSI), in the center of Columbus. Another example is that students who are in high and low sections for math, can be found working together in the same group during a science lesson.

In the open plan configuration of the classroom space it is particularly important to be considerate towards other groups in the vicinity in terms of noise levels and general behavior. Through consistent policies applied by the teacher-team, students are taught to respect each other and realize the consequences of their behavior, particularly as it affects others in the Community. This respectful behavior ranges from keeping the outside doors closed in order to keep the air cool inside, to helping a student who is having difficulty with schoolwork.

The Betelgeuse team of teachers

A strength of the Betelgeuse Learning Community, and indeed all the Learning Communities at Linden Park, lies in the detailed, cohesive planning done by the team of teachers responsible for that Community. Their planning is comprehensive in that it dealt with all aspects of each day's instruction, as well as the long term planning and guidance for each student. Within official guidelines, the teachers
decide among themselves what to teach and when. What is more, at the end of each instructional unit, evaluations are done to determine how successful their teaching has been, what needs to be changed, and what that change is to look like. They all take responsibility for creating and evaluating instructional materials whenever the materials of a unit are found to be unsatisfactory.

A particular strength of the Learning Community team approach is its facilitation of the Individually Guided Education philosophy of the school. Each teacher within the team works with every student within that Learning Community. Every student is known by every teacher, not just by name, but personally. Teachers come together on a regular basis to discuss the progress of each student. A student profile is developed through the input of each of the teachers and decisions as to what can be done to serve a student's best interests are made as a teacher-group decision. Teachers ask for the support of the principal and parents whenever they feel it necessary.

Policies for Learning Community management are made by the teacher-team. This involves, for example, the creation and administration of the Care Club reward system for good conduct, and how students move around as they change class groups during the day. A key goal of the Learning Community is that the teachers have
consistent behavior expectations with respect to all of the students, both in terms of a student's self discipline and a student's application and effort towards class instruction.

**Teacher and student profiles**

All of the teachers share a belief in Linden Park as a quality school because of its IGE philosophy. They believe that they can teach better as a team and, most important of all, the team approach gives the students a better education. The grouping of students across grades is commented upon by all as a major strength in facilitating the Learning Community's individual approach. More detailed descriptions of the teachers in the study are given in Appendix K.

The students in the Betelgeuse Learning Community are approximately fifty percent boys and fifty percent girls. Forty six percent of the students are African American, fifty percent are Caucasian, and four percent are Asian. Generally speaking, they appear to be happy about coming to school and engage in classroom activities with enthusiasm. More detailed descriptions of the students in the study are given in Appendix L.
What do students recognize as their purpose in attending school? Is there evidence that this sense of purpose influences their activity in the classroom?

1) What did students believe to be the purpose of being at school?

The common assumption that everyone should go to school has many justifications, such as school gives you the necessary skills and knowledge to function in society. Most of this reasoning, however, is generated from a top down, adult perspective. The following data examined going to school as a purposeful activity from the students' point of view, contributing to the students' contextual definition of classroom activity.

School

Students explained their coming to school in socio-cultural terms. That is to say, the students articulated reasons for coming to school that reflected values and norms that find their roots and importance beyond the school, in the families and communities from which the students came. Such findings are not unique and can be supported by more detailed studies into the sociological connections between school and community (see Anyon, 1981; and Willis, 1981). For the purposes of this study these socio-cultural factors served to identify what is being called the environmental influences on students' cognition.
While outsiders such as parents and the researcher might view schooling as a single coherent event in the day or life of a student, for the students school was a very dynamic, differentiated series of occurrences that can only be explained in phenomenological terms. For the student going to school was going to Monday's school, Tuesday's school, and so on. Each day was described by students as different events. For example, Thea pointed out that she preferred Mondays and Thursdays because "we have all our special things on Mondays" and on Thursdays "we just get to do anything we want" (j18). Indeed each subject area generated its own "package" of expectations, hopes and concerns in ways that varied from student to student. For example, some students liked "reading" in class, others did not. In short, school was a place in which students were guided through a multiplicity of activities, each one separate but connected by the fact that they took place during the school day and in the school building.

School as education leading to employability

Many of the students explained the importance of coming to school in terms of receiving an "education." The term education, however, was explained in several different ways. For the majority, like Steven, an education was to do with learning "about different subjects, and you know how to do them in your head and you can get
a good job" (m18). The significance of this and similar responses became apparent when consideration was given to what students defined as their goals within the routine of the classroom experience. With the notable exception of Michael who said, "Nearly, almost every week I come across something I've almost never done and I can learn more about it," students explained the goals of school instruction as mastering school work because to be good at school work is an investment in job opportunities. This sentiment of becoming employable was echoed by nine of the initial thirteen student interviewees; it is described by Anyon (1981) as characteristic of middle class students' recognition of how "school knowledge" impacts on their lives.

Despite students explanations of school preparation for future employability, students found themselves having to modify this connection when they were asked to relate their position with respect to individual subject areas. For example, when asked why he should be doing music John responded, "If I want to be in a singing band it helps me sing better" (k91). However, John also argued that even if he wasn't going to make his career in music he should be expected to do music because of his belief that it was worthwhile in itself. The valuing of subjects for their own sake was a recurring theme among the students, irrespective of how the subject contributed towards the end goals of employability. When asked why they should study
something even though they did not intend to make a career of it, students replied, "Just to learn about it" (b92), "Because there will still be a little bit of science in your life" (e104). Mary replied that she simply liked to sing and particularly liked the songs that they sing in their music class (g98).

Education is what is done in school

For these students, there was very little general awareness of a relationship between what they were doing at school and how it impacted on their lives at present. Lawrence, for example, did not consider basketball as education because "basketball is really a sport and you don't really learn a lot about sports in school" (c56).

Lawrence, however, played basketball almost every recess. Another student, Steven, went as far as to point out that while learning about other things might be interesting in themselves, such as baseball card collecting, the work done in class is real education for what you do in life (m82). It could be concluded that basketball and collecting cards were not considered education by students such as Lawrence and Steven because they were not part of their formal school schedule and also because of the absence of teacher or text book support and direction.
2) How do students define their role as students in the classroom?

The distinction between how adults might define students' roles in the classroom and how in fact students defined their own roles is the focus of analysis in relation to this question. The students' role is examined as social interaction because the classroom is assumed to be more than just a place where students learn the planned curriculum. It is at least as much, a place where students learn the lessons of classroom socialization.

General structure as guide

For many of the students the concept of classroom structure and procedure was a key definitional aspect of classroom activity. As noted earlier, the students were accustomed to an orderly procedure for each day's agenda. Although the students had a varied day as they moved from teacher to teacher and subject to subject, the students learned, the routines of how to go about their daily instructional activities. There were standard procedures for how and when to move from area to area, how and when to line up and drink from the water fountain, how and when to sit as a group, how and when to go back to their tables, and so on. Students demonstrated by their behavior a clear understanding of their roles within each of these activities.
The role of the math student

The students perceived themselves as students in the classroom "doing math" as they "learn about story problems" (kk294). The students recognized the working context of the classroom in terms of staying in your seat, being on task, proceeding through the problems as quickly as possible with no mistakes, and, among other constraints and expectations, working within the time allotted for math during that particular day. In the event that the scenario presented by a math problem did serve to contextualize the mathematics, it did not generate a conscious working context for the student that was apart from other elements of classroom activity.

Multiple roles

Students were seen to be involved in a variety of roles that depended on who they were with, the time of day, and the type of activity in which they were engaged. Their roles were very changeable and this seemed to have occurred in direct response to the contextual circumstances prevailing. When the teacher was instructing, students were listeners. They adopted this role, it can be argued, because it was a contextual expectation of them that they recognized. When involved in group work, such as a science experiment, students adopted different roles; some were leaders, some were helpers, some where note-takers, and others were passive observers.
It was clear that role definition for students in the classroom was not fixed. Students perceived their role orientation, in part, in response to the people they were with and their recognition of the central activity. In general students described their role in the classroom in terms of end goals; namely, as people who had come to learn. They did explicate their roles as learners by the fact that they generally guided their activity towards the accomplishment of teacher initiated tasks such as book exercises, worksheets, and tests.

Nevertheless, the frequency of "off task" activities suggested that students engaged in several central activities at the same time, with one activity being given more prominence than another at specific points in time. For example, students regularly talked to partners, looked out of the window, observed other students, or talked to the researcher. However, when asked, "what are you doing," students inevitably responded by ignoring these "other" activities in their response and answering by describing what they thought they were supposed to be doing. This suggested that students understood their only legitimate role at that moment as "learner" and the only legitimate way to demonstrate that was to explain only "on task" activity.
An example of role changing can be seen in Eron who points out that he likes math, "Because I am kinda good at it. Whenever somebody has trouble with it I can go over and help them" (c32). Although not considered as one of the best in his middle math group, Eron indicated that he recognized his role as teacher for other students. In fact when involved in "on task" activities Eron, like most of the students most of the time, did work collaboratively with other students who were sitting beside him.

Eron, like the other students, seemed to accommodate moving from one role to another with great ease. Students sat in groups (see Appendix I) adopting roles therein, but assuming that their work was to be presented as an individual enterprise each student ended up providing individual work upon which their grade was to be judged. So, although they may have moved in and out of roles, the recognition of their role as individual and individually accountable students was predominant and the most influential.

3) How did students define purpose and goals for the activities they undertook in the classroom?

For the students in this study, the goals in doing mathematics were defined in relation to classroom-context considerations. Students recognized that the consequences of finding problem solutions made no impact on characters or circumstances within the
problems. Consequences for the students were classroom related such that success allowed a student to move on to the next section of problems. This was further reinforced for the students by the classroom system for evaluating success. Successful solutions were subject to a verification process of comparing answers with the already established answers in the text books, or, alternatively, by having answers verified by the teacher. Even when students compared their answers with those of their classmates, the ultimate criterion of correctness was still recognized as teacher or text book defined. In short, mathematics, as presented through word problems, had little to do with a word problem definition *per se*, but was intimately linked to a problem that became constructed by students through their understanding of classroom context.

**Math as a routinized activity**

While the researcher's interview questions and observations inquired about school activity in general, much of the questioning focused on students' perceived value in doing math in school and how it supported their activities outside of school. Most of the students interviewed enjoyed math, but they painted a bland picture of what goes on in the math class. One student, Vicky, when asked, "What do you do in math," responded, "Mostly I take tests and when I don't pass my tests I do work" (b14). For Michael, who could be described as academically ambitious, the most noteworthy thing for him in
math was how quickly he could master the text book problems, so that he could move on to the next book in the math series. Most students, in one way or another, described math as doing "addition, subtraction, multiplication, division and word problems" (m60).

Math beyond the classroom

When presented with the general question of how math helps you outside of school, students tended to answer by referring to algorithmic procedures such as addition and multiplication; math in general was explained in terms of algorithms. In marked contrast, when given a specific scenario wherein the student was being asked to go to the grocery store for some provisions for the family dinner, every student but one indicated that math in that situation was important "so people won't try to cheat you out of your money" (f46). What is noteworthy in the students' responses is that they give little indication of personally valuing math as a general concept or skill that merited study in and of itself as a potential, even employment related, resource. However, the discussion of math within specific conditions, such as the store, elicited responses that described math in very specific objective-oriented terms, such as the example above.

Summary

The common definitional theme for school was that it was about getting an education and employment. Beyond this, students each
had their own personally constructed justifications for doing school work. Some, such as Mary, simply enjoyed it. In other cases reasons were much more attributable to specific considerations from outside of the school. Vicky valued math because her father was an accountant, Eron valued music because his mother was a musician, and Lawrence valued physical education because he wanted to be a basketball player and "because you need leg muscles to run down the court and stuff" (c32).

While students may have explained school in broad, future-oriented terms, there was little evidence that such terms were immediately influential when the students were involved in specific classroom activities. It seems that although students had awareness of societal expectations for the school-going student, generally speaking, students did not look to such considerations as they created a point of "cognitive focus" to guide them through the demands of specific daily activities in the classroom. With respect to all the students that were interviewed it can be said that they took their schoolwork seriously and were generally conscientious in their attempts to do well. Their conscientiousness, however, was more motivated by a desire to achieve immediate context goals than by the long term goals of future employment.
The data indicated that students' orientations towards classroom activity were primarily guided by *their* sense of belonging to *their* classroom community. As members of this social community their participation was motivated by the rewards intrinsic to the context, such as peer acceptance, teacher attention and praise, and the satisfaction in being able to do the tasks that had been set out by the teacher and/or text book. Extrinsic motivators such as getting a good job were real but not immediately compelling.

**Relation to cognition**

Lucy Suchman (1990) discussed the situatedness of cognition in relation to predeveloped plans and the execution of those plans. The basic tenet of her conclusions was that while we may make plans, plans do not necessarily translate as specific action statements. The students in this study explained their purposes for being at school in somewhat the same manner. They rationalized school as part of a life plan where school work was recognized as providing the bedrock upon which their employment futures were to be built. But this plan did not translate as action statements for how to go about being a student in the classroom.

School as a preparatory institution for life was an imposed plan on the students. As far as can be discerned, the students in this study acquiesced on this "education" plan for themselves and as such it
became definitionally significant. But while the plan, detailed through curriculum, had laid out a course for the students, it was clear that students were constantly modifying the plan in a manner similar to how the Trukese navigators navigated their way across the oceans (Hutchins, 1983). The students’ articulated a broad understanding for why they were in school, but they worked within the more immediate specifics of the context of their own particular school and class group. This then became further refined towards the more immediate specifics of the class activity and teacher expectancies. At other moments further refinement occurred as in the example of Eron teaching his friends how to do their math. This became for Eron another refinement for cognitive focus.

Of central importance is that the students could be cognizant of all these considerations, being able to relate and differentiate them all at the same time, and yet skillfully move in and out of working contexts with great ease and contextual sensitivity, without losing sight of what was being recognized as the most important contextual priority. Using Eron as an example, his arena(s) of cognitive focus is represented in Figure 8:
Figure 8. Eron's Arena of Cognitive Focus.

Such refinement of contextual particulars became definitional for the cognitive focus adopted by the students. Students adopted roles that became defined and refined in response to the exigencies of the context which they were recognizing as pertinent. What was important in terms of situated cognition was that they could selectively differentiate one working context from another and that each one substantiated different ways of thinking about ostensibly the same math material.
In terms of the first focus question, students evidenced an awareness of broad 'environment' considerations as they situated their school centered activity. Although they were clearly able to incorporate such considerations as they explained their sense of purpose as students in the classroom, they nevertheless adopted a cognitive focus that prioritized certain considerations over others. The pressing conditions of the classroom context became substantially influential for how they channelled the direction of their thinking.

From the observational and interview data examined thus far it can be stated that, even though students may have been aware of a "social plan" that defined schooling, they recognized the context of the classroom as an information resource to help guide their daily activities. Although students recognized that what happened in school related to considerations outside of school, they selected the school context as the working context, that is, the context of cognitive focus. It can be concluded, therefore, that school and the classroom are not cognitively neutral arenas for learning, and students are constantly involved in fluid movement from one cognitive priority to the next.
Is there evidence that students reconfigure the description of math word problems into a personalized contextual framework so as to be able to achieve the original task goals?

1. Did students recognize context resources to support their performance during math word problem activities?

**Algorithms**

Students found most of their math word problems in their math text books, although some came from worksheets. Several of the students described word problems as if they were a genre of math that stood alongside addition, subtraction, and so on. By explaining their task as making problems out of the words, students were describing a twofold activity: firstly students had to "learn how read the problems" (kk296) as a presentation mode for math; secondly they had to extrapolate the nature of the computations that were involved. For the students their objectives were very clear — read the question to find the algorithm, the numbers that needed to be used, and decide how to organize those numbers within the algorithm in order to come up with the correct answer. Reusser (1988) refers to this as the grammar of problem texts that serve to "signal paths and goals pointing to the solution pattern and putting the student on the right track" (p. 310). In other words for the students the exercise of how to think about the grapefruit problem was more or less the same as doing the wrench problem because neither the grapefruit nor the wrench themselves were considered important elements in the
question. Students preparation for solving math word problems need not have gone any further than bringing to mind their understanding of the "operational grammar" for this form of math word problems.

The importance for the students of finding the algorithm was quite consistent across the students interviewed. Having read the question and having been asked what was the question asking you to do, the students frequently responded by indicating their understanding of "right track" as finding the type of algorithm involved. Lawrence, in response to the question, 'What is the question asking you to do,' responded unhesitatingly, "Math" (cc18). Vicky was more explicit in her analysis of her activity:

R: So when you were looking at that question, what was the first thing you looked for?
S: I read the problem and I had to see whether to add or subtract. And then if I found out that I had to subtract, I looked for what I had to subtract. (bb106)

There was no indication by the students that the solutions to the word problems had any other internal dimensions beyond the numeric solutions. That is to say, the recognition of the numeric solution was never explained in terms of their significance for people, places, events or concerns mentioned in the problem text. Indeed, when questioned about this, students indicated the opposite to be the case.
The context of text

Overwhelmingly, students gave negligible consideration to the circumstances described in the word problems. With respect to the credibility of the problems the students thought all such textual embellishments were irrelevancies — as far as 'doing math' was concerned. In short, the problem context for the students was not the context described by the problem. Word problem contexts, as described through the text, became eclipsed within the larger more immediate context of student-in-classroom activity. The students were not working within the contexts of the word problem text (see Figure 9), but the word problem texts were being worked into the contexts of students which was the classroom context (see Figure 10).

Figure 9. Context of Word Problem Text

Figure 10. Word Problem Within Classroom Context.
Notice that, unlike Figure 9, Figure 10 assumes no consideration for the classroom as a working context. A disregard for the text context is presented quite explicitly by Steven when discussing the important components of the May family hamburger question (see Appendix B):

R: So, how many children are there?
S: Well, if they each ate one of them there would be four. If they each ate two of them there would be two.
R: Does it matter?
S: No.
R: Why not?
S: Mm. It could be grown ups, it could be midgets, it could be anything. It could be babies. It just depends on how many there are and how many hamburgers they ate. Or whatever they ate. (mm188)

Clearly Steven wasted little time considering the circumstances of the May family or their activity. His answer to this question indicated that his concern was with the numbers: "The children ate four hamburgers because half of eight is four" (mm180).
2) What is the nature of the interpretive cues through which students contextualize the rubric of math word problems?

The reality of a word problem

As previously discussed, when students were presented with word problems during math time, the major assumption guiding their activity was that they had to translate particular components described within the word problem into a math equation; that is to "mathematize." However, the type of mathematization that is stimulated by math word problems is particular to math word problems in a classroom context — because where else are problems presented in this manner? Students come to math word problems with very specific preconceptions for what this type of problem solving demands. Reusser (1988) explains some of these preconceptions thus:

... there is a presentational structure or setting, the tacit structure of the pragmatic or situational context that can provide quite significant hints to the solution of a specific task, and that also shapes the student's textbook-problem solving behavior. An important piece of this "context-knowledge" of even very young students concerning textbook math problems is that the problems must always make sense, that they are always solvable, that they work out neatly, that they do not contain irrelevant numerical information... (p. 310)

It can be concluded therefore, that the presentational format of the word problems is recognized by students as providing contextual
guiding cues through which students become informed in how to work out their solution. To this extent the whole problem solving episode can be explained as algorithmic because it involves a predefined sequence of events that are followed in order to obtain a solution and this strategy can be repeated so long as the word problems are presented in the same familiar format.

Students, however, did not always "read" the word problem format in the same way. When asked why the problems were presented to them in textual, narrative form as opposed to numbers, students' responses indicated considerations that can be understood as more extraneous than substantive to the content of the questions. For example, one student, Thea, described the word problem format as presenting the question in a "cartoonly way. It is like a cartoon but it is not a cartoon. It is a math problem put in with a cartoon" (jj270). Another student, Vicky, indicated the helpful nature of the word problem format for Isabel spending her pennies by saying that it helped "me picture the people and it helps me think better" (bb272). However when questioned about the possibility of John's four mile walk to school she replied, "Usually people don't walk four miles to school. That would be too far away" (bb114). Vicky contested the reality of such a scenario but treated such considerations as unimportant to the question "'cause it [the question] is imaginary." This is not to deny that the word problem format did
help Vicky "think better" but it also indicates that the circumstances of the word problems were substantively unimportant for her.

Other students took the opposite viewpoint and described the word problem format as existing to "make it harder" and to "try and trick you" (ee369; gg253). What was hard, or even challenging for these students, was that the textual component of word problems obscured the math. It was not the problem within the text scenario that was "harder" but the extra effort that was necessary for identifying and extrapolating the arithmetic that was to be used to come up with the correct numerical solution.

Students, like Vicky, who found that descriptive detail could make the problems more interesting, made no reference to such details as substantive elements of the problem or problem solution. Details such as John walking four miles to school, and the twenty pound chickens exemplified students' disregard for the factual support of the problems being presented to them. Michael described the textual support within word problems thus:

R: Why do you think they present the questions to you with those little stories?
S: So that. Well. Sometimes I used to think. I still think this. It's just to give you extra information that keeps your mind busy and you can't get the correct, straight answer. But I never pay attention to it.
R: Never pay attention to what?
S: To the extra information they give me.
R: So when you are doing these questions, what is important for you?
S: The questions and the amounts.
R: When you say the questions, what do you mean?
S: Like, what was the total weight . . . how far does she have to go . . . how much more is used. (aa242)

Students consistently demonstrated a disregard for descriptive detail. It seemed that the students "suspended disbelief" in order to do their math. For example, students could give an acceptable approximation of the size of both a two pound and a twenty pound chicken. They could then proceed to give a mathematically correct answer relating to these items, even though they openly acknowledged the impossibility of having a twenty pound chicken. When faced with inconsistencies, students still proceeded to mathematize problems despite the impossibility of the event giving rise to the math problem. In these instances, for them, the question was about math — not chickens. Math information was what they looked for and math information was what they worked with. If considered at all, any other information was, at best, an afterthought.

The potential for context selection

The students could think about the circumstances within the word problems if they wanted, but they chose not to. Students, for example, could personify characters based on the information in the problem. Several students, when asked by the interviewer, described
Isabel, the subject of question seven, (see Appendix B) as a young child and justified their description by pointing out that it was because she had so little money to spend in the store, a subtle observation deemed substantively irrelevant to the problem because that information did not contribute to the answer.

Students did not consider personal, qualitative considerations as relevant to the task of doing "this kind of math." If they thought of problems as "real world" contexts the questions became overly, and unnecessarily complicated in terms of the students' goal of finding the correct numeric solution. Some students, such as Steven and Thea, seemed quite bothered that they should even be asked, by the interviewer about circumstantial factors within the problem when those factors did nothing to qualify or modify the correctness of their answer. In fact, it would be fair to say, that most of the students considered being asked about the characters in the problem as an attempt by the interviewer to trick them. This is not the same thing, of course, as saying that the students were engaged in decontextualized activity.
3) Do students reconfigure math word problem contexts (as described by the word problems) beyond the conditions of the problem statement?

**Students' choice of working context**

There can be no such thing as decontextualized cognition, however unapparent the working context of the individual may be to the external observer. However different the interviews may have been from the regular classroom conditions, the students were acutely aware of "doing math." The students were clearly recognized the position of the interviewer as question-asker. They undoubtedly saw their roles as question-answerer. Although it was pointed out to each student several times during each interview not to worry about being right or wrong but to do their best, the quality of their responses were inevitably subjected to the assessment of the interviewer and students responded by presenting answers to the interviewer for verification of correctness. These were (at least) a few of the conditions recognized by the students as the substantive elements of their working context.

Students learned an expectation of detail in their responses that was being asked of them by the interviewer; considerations that would not have been evoked by the word problems themselves nor, it would seem, have been considered as the students worked through the problems in their regular classroom setting. As the interviews
progressed students learned to anticipate detail questions and often offered answers even before the questions were asked. In short, as interview questions directed them to give more qualitative considerations to their answers, the students began to think of the word problems more qualitatively in anticipation that these considerations might be asked for. They learned that in the context of the interview, qualitative personal considerations were to count as relevant and important — if for no other reason than they were being asked for by the interviewer. That being the case, the students still did not consider qualitative considerations as substantively relevant to the word problems but substantively relevant to the context in which they were doing the word problems — the interview context.

Summary

Students recognized word problems as part of the activity of doing math in the classroom and they developed very specific expectations as to the object of the exercise. It is clear that students were involved in a focused process of reading the problems using very selective criteria for extrapolating the important elements within the problem in order to reach the intended goals of the task.

Students were involved in problem solving. The problem, however, was not one defined explicitly by the word problem scenario itself but was one that centered around the students'
understanding of the external expectations of "how to do word problems," as well as the expectations of others who were going to be judging the quality of their performance. Therein, students recognized the teacher or interviewer as the ultimate arbiter of correctness.

Students' definition of problem, therefore, was contextualized by the exigencies of classroom and/or interview performance and the word problems were considered merely as a means to that end, and not an end in themselves. This became the working context and is the one that students paid attention to.

Relation to cognition

Students were involved in a process of interpretation and decision making. It is clear that they came to the activity of solving word problems with already established expectations for what was involved. This then became their initial point of "cognitive focus." But it was also clear that students quickly recognized differences between doing word problems on their own and doing them as part of an ongoing discussion with the interviewer.

Under regular classroom circumstances, that is to say, working individually to calculate the correct answer, the students read word problems with the intent of discerning the algorithmic math structure.
of the problem so as to calculate the numeric solution. The situated nature of such activity for the students did not look to particular circumstances within the problem text as offering significant elements with which to negotiate. Their thinking, it can be said, was not situated within the scenario of the word problem as a working context. Rather it became situated with respect to the broader "real" context of doing classroom work and the numeric solution then became a goal among other classroom goals. At the most fundamental level the problem became situated in the minds of the students as their problem which was the problem in doing math word problems (generally because they were instructed to do so by the teacher).

Under the circumstances of the interview, a major factor defining the situated nature of students' activity is the manner in which they incorporated the influence of the interviewer as a main element in their "cognitive focussing" activity. Having realized that the word problems were going to be examined as more than delivery systems for practice in algorithms, the students thought differently about them. Students became cognizant of, and attuned to a working context that involved the word problems in relation to the interviewer and they responded by providing the kinds of considerations that they judged to be germane to the conditions of that context. The students read the word problems with an eye for detail beyond the numbers, while also including considerations that
must have been personally determined because they were never made explicit from the immediate context.

This change in behavior on the part of the students can be recognized as situated because it evidenced recognition of the exigencies of the interview context and interpreted the description of the math word problem in such a way that they no longer considered it as a classroom math problem but tried to interpret it in the manner they thought was being asked for by the interviewer. Furthermore, it can be recognized as situated by virtue of the evidence that students individually recognized, selected, and negotiated with information in particularly unique ways thus indicating a personally determined structure for framing the context of the problem situation and the context of operation for solving the problem.
Would a student, presented with several structurally similar tasks, use similar strategies for accomplishing each task, given varying degrees of contextual resource support?

Phase four of this study asked students to respond to a selection of math word problem questions that were designed to elicit the use of fractions for their solution (see Appendix D). These same questions had been presented to the students several weeks previously during phase two of the study. However, in contrast to this previous experience with the questions, the questions were presented to students together with objects that related to those questions. For example, the question about choosing the correct wrench size was supported by wrenches physically present for the students to work with.

As will be evidenced by the following data, students' general approaches to problems followed a rather consistent general pattern that is identified by the following three characteristics. Firstly students attempted to mathematize problems and solve them by direct use of algorithmic math knowledge; this will be referred to as "math constructed solutions," or "algorithmic solutions." Secondly they used objects to generate what will referred to as "object constructed solutions" to either solve the problems or as a verification strategy for their initial math constructed solutions. Thirdly their acceptance of a satisfactory solution looked to their "object
constructed solutions" as the most reliable source for confirmation of correctness, but several of the students reverted back to describing solution strategies as if they had been exclusively solved and verified as formal algorithmic arithmetic.

1) Do students work to recognize and select context support cues as they try to perform math word problems?

A support cue is any resource that has a recognized affordance and is subsequently introduced as part of a strategy designed to lead to a problem resolution.

Objects to think with

The term "objects to think with" is taken from the work of Seymour Papert. Such objects become resources that are adopted because of their recognized potential for advancing understanding and the discovery of problem solutions. This recognition Papert refers to as an "invention" on the part of the individual of the relationship among "cultural presence, embedded knowledge, and personal identification" (Papert, 1980, p. 11).

The presence of "objects to think with" had several distinctive features in terms of how they were worked into the students' solutions to problems. Students initially showed a reluctance to recognize the objects as "thinking tools" until they were invited to do
so by the interviewer. A particular example of this was when Latisha 
was asked to share the thirty two baseball cards among four 
[fictitious] people. She counted out loud in groups of five as if she 
were dealing to each person and yet she made no attempt to use the 
cards themselves despite the fact that she had already handled them 
to count how many cards were in the pack. Latisha demonstrated a 
"hands-on" strategy but made no indication to presume to use the 
cards as resources towards the solution (c1153). She acted as if she 
felt she weren't supposed to physically manipulate the cards to solve 
the distribution problem and yet it seemed that she incorporated the 
cards into her thinking and was in fact using them as objects to think 
with, even though she was not physically working with them.

Another example of negotiating an "in head" response, by 
disregarding the opportunity to work physically with immediate 
available resources is shown by Mary:

R: Split that pack of cards into four quarters.
S: Four quarters? Do you mean four people?
R: Yes.
S: (pause)
R: Are you trying to work it out in your head?
S: (nods yes)
R: What other way can you do it? Are you able to work it out in your head?
S: (nods yes) (ggg 187)
It can be conjectured that the students were working on the premise that math word problems were "in head" problems, especially as in this situation the students were not given any traditional writing materials with which to work out the problem. Students did not acknowledge the use of objects as legitimate resources in their word problem solving activities most likely because their past experiences of math word problems did not incorporate such features to be used. Another explanation would be that if students had, themselves, already defined what they were being asked to do as an "in head" activity, which seems to have been the case, then although they knew that the objects would have been helpful they deliberately chose not to incorporate them into their solution strategies.

In the cases of both Latisha and Mary, the use of fractions was not purely algorithmic although technically it could have been. Both students chose to 'translate' their task into a formulation of their own. Latisha distributed the cards among four fictitious people as if she were dealing cards in a card game and she counted them out in fives. Mary made a similar, but more transparent translation when she rephrased the question as four people, not four quarters. By calculating within such imaginary objects these students created "objects" that helped them mentally organize and bring their own order to the context to create their individualized solution strategies.
**Object knowledge**

The extent to which students used available objects within "in head" solutions strategies is difficult to discern. It is reasonable to assume, however, that even though they did not manipulate them, some use was made of objects depending on the questions asked and the types of objects involved. For example, it was not necessary to manipulate the grapefruits to know that there were six, but the same cannot be said for knowing how many baseball cards were in the pack. The extent to which students were inclined to use objects became apparent when they realized that such resources were being presented by the interviewer as legitimate "tools" in their problem solving enterprise.

Students took note of information features in the objects themselves and worked with the information in direct proportion to how pertinent it promised to be for generating problem solutions or explanations. This approach was described by Wertsch (1984, p. 9) as representing an object as an "object-to-be-used-as-I-see-fit." Students, for example, paid particular attention to the fact that the markings on the measuring cup could be used to make accurate quantity measures but made no references to color, or the material that it was made of. Color and material offered no affordance towards the problem that was being negotiated.
Students also related object information to other information. For example, all but one student recognized that the number 91 on the baseball cards most likely meant the year. For card collectors such as John, this was obvious; for non collectors, such as Mary, this was deduced:

R: For example, what is that number (91) telling you?  
S: I don't know.  
R: You see it on all the cards (showing other cards). Does that give you any clues as to what that number might be telling you? What do you think that 91 means?  
S: The date.  
R: Why did you change your mind?  
S: Because it is 91.  
R: What made you decide that it wasn't the card number?  
S: Because it is 1991. (ggg227)

A further example of relating different sources of information together at the same time is given by Steven:

R: Here's a measuring cup and Bran and Flour. How would arithmetic and numbers help you do the kinds of things you would do with these materials?  
S: Well, it would help you do the microwave directions. So if you want four servings you'd need one and one third cup. (Reading from the box) That is one of these (using measuring cup) and up to there (pointing to one third of a cup measure). And then you'd need four of these. And then you'd go get a tablespoon of salt. You could really not do that because that says optional, so you might not use it. (mmm48)
Steven related the objects with the process of baking and his understanding of the process of following directions. From the observation of activity and from the students' explanation of how they came to their answers, there is clear evidence that students were actively engaged in physically organizing objects to facilitate solutions. More explicitly, Latisha gives a rather complicated explanation for how she used the position of the hamburger buns, piled in a 2*2*4 configuration, to check her answer:

R: How many hamburgers did they [the children] eat?  
S: Four  
R: How do you know?  
S: Because when I first took them out they were like this. (refers to the way the buns piled up when she slid them out of the packing) Now if I they eat half of the top one and eat half of the bottom one, that's a whole one. And then I put them all on top you can just say one each. One, two, three, four. (ccc201)

This kind of object organizing behavior was as prevalent for boys as girls, irrespective of the math section that they belonged to. Steven and Michael, probably the most math proficient students interviewed, organized the physical attributes of the wrenches, from largest to smallest, to decide the size order (mmm78, aaa66). Steven, rather than counting out eight buns from the pack, noticed that it was a twelve bun pack. He held four buns inside the pack and tipped out the rest knowing that he would be tipping out eight. In this example,
as with others, the organization of the relevant objects made either initial solutions or checking activities more efficient and easier. Benita, a student from the lowest math section, physically broke the two pizzas into the appropriate sections indicating that by being able to organize the pizzas into discrete halves she could work out how many pieces in each half — and she did. (III321)

Perhaps the most subtle example of how organizational behavior was used to reach an answer was when John and Latisha were asked to divide the cards into four equal piles. Important information was being recognized not just by the number of piles or the number of cards in each pile, but also within the process of distributing the cards. They both noted that as the cards were distributed, the "dealer" did not get the last card if he also got the first. This recognition and understanding of organizational sequence allowed them to conclude that all four piles of cards should have had an equal amount. (kkk333, ccc167)

It is important to note that in some cases students who were unable to work out a solution using math knowledge could work out a solution using object knowledge. This was particularly true for students who were in the middle or low math sections and had been given very little or no formal training in fractions. There are several examples of this of which the following from Eron is one:
R: They both ate half of their pizzas. How many more pieces did
Robert eat than Kikko?
S: Two.
R: Use that pizza to check your answer.
S: (pause) One more. (eee358)

Math knowledge

Students, on several occasions, worked with numbers as "raw
numbers", thereby failing to recognize both the "evidence of objects"
and the quantifiable phenomena that the numbers represented.
Throughout the interviews there were several occasions when
students' errors seemed to be the product of haphazard quesswork.
When asked to explain their responses, however, it became clear that
the students did engage in a thinking-through process using their
best judgement for selecting salient features in the problems to come
to a supportable conclusion. A particularly striking example of this
was with reference to the question about the appropriate sized
wrench for the nut (see Appendix J for an idea of the proportional
size differences between the wrenches). Students were asked to
work with the wrenches in front of them. Several students choose
the 13/16 inch wrench as being the next highest size from 5/8 inch
(as opposed to the third choice of 3/4 inch). The most salient
information feature for these students was not the numbers as
represented as fractions but the whole numbers themselves. In
short, as explained by Vicky, "thirteen and sixteen (13/16) are higher
than three and four \((3/4)\)" (bb82). This information justified her accepting the 13/16th inch wrench as the next biggest wrench.

Of particular significance is that students who were involved in this type of information selection process, consistently ignored "object information" and as a result generated errors that they failed to recognize until the validity of their conclusions were tested. Similar instances of disassociating numbers from what they represented, even though the objects were physically present, were given by John, Eron and Vicky when they were asked which of two identically sized pizzas was the bigger. These students reasoned that the pizza with the greater number of slices was the bigger Pizza. It seems that the students were rather rigidly involved in defining the pizza quantitatively with little to no consideration of visible qualitative considerations, such as the geometrical similarity between the two. Perhaps they defined the pizza in terms of the number of people that could be served (six or eight) rather than the amount each person would get.

**Correct "wrong" answers**

There is evidence that some students were recognizing and working with units of measurement different from the typical expectation of the questions and text book math. Some students framed questions in an accurate but unconventional manner. Eron,
for example, when asked how many cards Javier would have left if he gave away one quarter of his (32) cards responded:

S: Seventy five left.
R: He has only got thirty two to start with. How can he give away a quarter and end up with seventy five?
S: Oh.
R: What were you thinking there?
S: I was thinking of twenty five percent of these. (eee310)

In terms of percentage Eron was correct, although he did not work with the specifics of the question that was being asked. His response demonstrates the point that the same problem can be represented and defined in different ways. This is further evidenced in how students worked with the grapefruit question, with and without the grapefruits.

In interview two, while the grapefruit question asked how many grapefruits had to be bought, John, Eron, Lawrence, and Thea (students in the lower sections) conceptualized the problem not in terms of whole grapefruits, but in terms of half grapefruits. Their reasoning would seem to be that if each person was getting a half a grapefruit, then it was the half grapefruits that were the most important feature and that was what was to be counted. Eron offered the most striking explanation: "Ten . . . Because if you get two people that is one whole grapefruit . . . I kept counting up until I got to ten"
(ee22). In other words, Eron was unshakably proposing that what was being bought was ten halves rather than five whole grapefruits.

It is significant that in terms of the amount of halves that would ultimately have to be bought to serve the nine customers, these students were correct in their thinking. However, in terms of the whole question their answer would be deemed incorrect because their focus was on the customers needs not the purchasing needs of the restaurant owner. Their responses evidenced an interpretive construction of the question that would be considered markedly at odds from a more conventionally mathematical construction. Although they failed to solve the problem in terms of the conventional mathematical solution, their solution would have been very precise had the problem been "real."

For interview three, where the students had the grapefruits in front of them, these same students, with the exception of Thea, gave the answer as "five," indicating a focus on the number of whole grapefruits that had to be bought. Both John and Eron gave the answer immediately while Lawrence said six initially (the same number of grapefruits on the table in front of him), but changed his number to five. In both interviews Thea concluded with the same answer (nine grapefruits) as in the previous interview, suggesting that she still conceptualized the question as asking how many halves.
Despite the availability of the grapefruits in front of her Thea could still not work within the framework of conventional math using grapefruits but she undoubtedly had her correct answer as is evidenced in the following discussion:

S: You have to buy eight and a half.
R: No. How many grapefruits are there? (pointing to one whole grapefruit)
S: Two.
R: Oh I see. I understand where you are now. There's two there. I understand exactly what you are saying now. Let's just say. You don't go to the shop and say give me two grapefruits, do you? What would you say?
S: Can I have two grapefruits or two slices of grapefruit.
R: Now, if you say to me two I would give you two grapefruits. Is that what you want?
S: Yes.
R: But when you go to the shop to buy for nine people, how many things do you want?
S: (takes aside four grapefruits) And a half of this one. (Pointing to a whole grapefruit) (jjj44)

While the other students were able to rethink their answers in response to a question about whole grapefruits, Thea still framed the question as centering around the number of half grapefruits that had to be purchased. Significantly the correctness of her answer only became apparent when she physically took aside and explained the appropriate number of grapefruits needed.
Summary

It seems evident that for the students their sense of context was largely defined as a doing-math-word-problems-in-school context. Such a context had experientially defined conditions whereby the students concerned themselves with demonstrating their skills in math. This would explain their initial reluctance to work physically with objects that had been made available to them and were substantively related to the questions being asked.

Their eventual use of objects demonstrated that students did involve themselves in the recognition of features in the objects that were considered supportive of the task of obtaining the correct answer. Of fundamental significance is the fact that the students demonstrated a variety of methods with which to use the objects. And while their methods may have been different, they were nevertheless constructive in the sense that they allowed students other ways of negotiating with contextual supports towards the correct answer; or, as described in chapter two, they evidenced intelligent action (Scribner, 1984, p. 26).

Perhaps the most significant finding was when students were producing answers that were wrong when compared with the text book, but were validated by the students as equally correct when they were asked to explain how they had come to their answer. This
raises the caveat that the presence of the objects, such as the
grapefruits, as a contextual support can not be assumed to be
sufficiently representative of the circumstances of going to a store to
make such a purchase. The specifics for why some students worked
with the questions in such different ways is important because it gets
to the heart of the question of the situatedness of students' thinking.

Cognition implications

The concept of "support cues" presupposed a recognition by
each student of associations between the cueing object in relation to
what was already understood. The crux of this subquestion is, 'did
this recognition take place and how did it change students'
negotiation with the problem as they moved from being presented
with the question and coming up with their solution?'

Objects imposed order on how they could be used by students,
and students imposed order on objects as resources to maximize
efficiency and accuracy towards a problem's solution. For example,
the grapefruits were whole objects yet the students could use them as
whole objects that contained half objects. This is the dialectic nature
of situated cognition where students are involved in the recognition
of informative resources — literal (meaning that one grapefruit
equalled just that) and/or interpreted (meaning one grapefruit was
used as equalling two halves). The nature of the dialectic is
indexically constructed by the student as is the creation of the problems and the decisions about appropriate solutions for dealing with those problems. The most literal description of the grapefruit problem was that it was about buying grapefruits at the store. It seems that the point of cognitive focus for several of the students was that it was about providing half grapefruits to the customers. This redefinition of the problem by students is a resituating of the context concept of the question.

The grapefruit question was understood differently by different students. It also became understood differently by the same student when presented with the grapefruits as supportive resources. Those students who were in the top section and strong in math, such as Michael and Steven, they were able to conceptualize questions as having to do with fractions. Their uses of objects were more in a manner of checking up on their math. They did not need to conceptualize the questions beyond the math because this was a sufficiently situated goal and resource for them to work towards their solution. For other students less strong in math there seemed to be a greater reliance on the objects as integral resources in working towards their solutions. This is evidenced by the greater likelihood of their answers being more precise than if they had to solve the problem using algorithmic math alone. Their understanding of how to solve the problems changed from doing abstract math to doing "object
math." In other words, they resituated the problem from having to rely on their "pure" math knowledge to one where they could now rely on their knowledge about things because those things were made available for them to work with.

2) How does the presence of support cues influence strategies for solving word problems?

Verification

The process of verification is a checking activity for determining whether or not conclusions are warranted. The data indicated a distinction inherent in students' problem solving activities between 1) verification as an ongoing activity within the process of working out a solution and; 2) verification as a concluding activity for checking solutions derived as a result of that process. In the former instance the data indicated that students were involved, in many instances, in a personally initiated checking process as part of gap closing activity, working towards an acceptable correct solution. In the latter instance, students were capable and did check their solutions when asked to by the researcher. The data, however, are not being used to support any claim that students would have automatically verified their answers in order to confirm the correctness of their solution, although they may have in fact done so. In most cases students were specifically invited to demonstrate a checking process.
Gap closing verification

There was evidence of gap closing strategies as defined by Lave (1989, p. 159). Gap closing seemed to occur whenever students were able to understand what was ultimately being asked of them but could not pinpoint one particularly efficient strategy, particularly when a first attempt was unsuccessful. Another characteristic that initiated a gap closing strategy was that students seemed uncertain of the resources that were particularly relevant to the solution, or else uncertain for how those resources could be brought together with respect to solving the problem at hand. The most common occurrences of gap closing were when students were unable to mathematize solution strategies successfully. They would then "try out" alternative strategies using what they did know.

One characteristic of gap closing is the elimination of non viable approaches or resources. This allowed the student to concentrate attention on more promising resources and approaches. An example of this is given by Michael:

R: Here is a nut. Which of these wrenches are you going to select to tighten this nut?
S: It is definitely not this one because this one is way too big.
R: How do you know?
S: Well I can kind of compare by the size. By distance. If I hold this here (comparatively scanning wrench in relation to nut size) I can figure it won't go in. It will fit too loosely. So this one is out.
R: All right.
S: Then I do the same thing with this one. It looks like it will fit around a bit better. This one. This one won't. So I say it is the 5/8 inch wrench. (Tries it and it does not fit) See that's not always correct or a good idea. (Chose the remaining one and it fit). (aaa67)

Although in the top math section and proficient in calculating in fractions, Michael realized early on that fractions would not suffice because there were no fraction sizes printed on the nut. He quickly moved on to visibly comparing wrench and nut sizes, dismissing the largest wrench and concentrating on the two with the most viable affordances of correct fit. With respect to gap closing, this approach is evidenced in how all the students approached this particular problem.

Mary evidenced another characteristic in gap closing activities. A solution was calculated, presented, and refuted.

R: How much money is there?
S: Three dollars.
R: Supposing you were going to split that up with four people. Me, you, and these two [fictitious] people here. How would you do that? We have all got to get the same. This is our stand. We have sold our Kool Aid. We have made three dollars.
S: You get a dollar each.
R: Are you sure that's right?
S: No. I think it is wrong.
R: Why?
S: You can't get a dollar each if there are three dollars. (ggg159)
Clearly Mary tested her solution in some way in order for her to be able to support or not support the result. It may have been purely algorithmically but it is equally possible that she chose to use the external support of the four people to whom she was being asked to distribute the money. It is important to recognize that of the four people, two did not exist. Together with the interviewer, Mary created the context where they then became viable, imaginary resources to help Mary work towards her solution.

But verification within gap closing activities is not solely demonstrated with reference to the verification of a possible series of end solutions as the student worked towards a definitive solution. The process also involved the constant going back and forth between information in search of potentially important information. For example, students at various points would ask clarification questions or for further relevant information from the interviewer. They often picked up available objects to examine and work with, and these apparently were being used as their gap closing tools of choice as "objects to think with."

Conclusion verification

Students demonstrated a wide assortment of verification activities. Some were based on mathematical algorithms, others were based on context resources, others were based on information that
went beyond the immediate context. Unsurprisingly, some of these approaches were used in combination.

As consideration is given to the particular circumstances of the context in which the students were working, the influence of the interviewer cannot be overlooked as it related to students' verification of their answers. When students were given word problems without the support of objects, students were particularly concerned with having the interviewer respond to the correctness of their answer. This was indicated by an uneasiness and lack of confidence in their voices as well as their acceptance of correctness being contingent upon the interviewer's acceptance. For example:

R: I have walked that far [3/10ths of a mile]. How many tenths left do I have to walk?
S: Two.
R: (no response)
S: Em. (pause) Seven.
R: Seven tenths. That's right. Do you know how fast Noell was walking? (cc81)

Lawrence seemed to take the interviewers no response as a measure of correctness for his answer. His "reading" of the no response was that his answer was wrong so he recalculated and offered an alternative solution. The interviewer's response that his answer was right and then moving on to the next question, was most
likely understood by Lawrence as other indexical confirmations that his answer was acceptable.

When checking an answer mathematically students almost always used a different algorithm and tended to work backwards from their solution. For example:

R: A guy went to the arcade and spent half his quarters. He had twelve. How many did he have left?
S: Six quarters.
R: Are you sure about that?
S: Ye.
R: Why are you so sure?
S: Because six and six is twelve. (ccc177)

Thea in the following is seen to have used algorithmic math to do a double check:

R: If you were to get a half and I were to get a half. How many pennies would we get each?
S: (unhesitatingly) Five.
R: How do you know?
S: Because ten. I mean five plus five equals ten. And if you take away one five you get a five remainder. (jjj167)

Steven who was skilled in both math and object-constructed solution strategies moved freely between both in his choice of verification strategies. In the following example, Steven shows great
dexterity in using math skills and object information in his verification process:

R: Remember the questions, Isabel had twelve pennies and she spent half of them.
S: She has six pennies left because half of twelve is six.
R: So how would you use those pennies to check your answer?
S: Well, if she had spent half of them, (counts pennies) one, two, three, four, five, six, she wouldn't have all of these over here (indicating the remaining six).
R: Ok.
S: And she'd have this many left. (counts remaining pennies) One, two, three, four, five, six, left. And plus it helped to know division and multiplication 'cause division is the opposite of multiplication. But if she had a money back guarantee if she didn't like it, she got her pennies back, and there she was.
R: Half of twelve is six. How could you use those coins to check that half of twelve is six?
S: You could count them. (counts pennies into separate piles of six) One, two, . . . twelve.
R: How do you know that's two halves?
S: Because one half and one half equals a whole.
R: Ye, but how do you know you have got an equal number on each side?
S: Because they line up perfect, and they are right there. (mmm105)

The presence of artifacts that related to the word problems offered Steven a checking resource which he used. But being proficient in math did not mean that students necessarily adopted a mathematized verification strategy. Michael, who was also in the top math section, similarly chose to do a double check on his answers:
R: Let's say you had to divide that evenly among four people. We are each going to get a quarter each. A quarter of that pile [twelve quarters].
S: Ok. So I know that there are twelve here. And there are four people. Twelve divided by four is three. (divides coins into four piles of three) Person one, person two, for you, and for me. (aaa94)

Like Steven, Michael sometimes went directly to objects to verify solutions by, for example, separating objects and counting out the different piles. And, as pointed out earlier, evidence of the artifacts superseded the evidence of the algorithmic conclusions. Perhaps this is because the students presumed it gave more clarity to the problem and confirmation of their solution.

When they had objects to work with, students, especially those in the lower math sections, had a greater confidence in their answers. Their confidence, it seemed, came from their greater understanding of how numbers related to the objects rather than how numbers related to abstract algorithms. At various points during the interviews students were not only asked if they were sure of their answers, but they were asked also to show some evidence of why they were so sure. They showed little reserve in demonstrating how they knew they were correct.

Particularly for the lower math group students, the opportunity to verify through objects frequently made the difference between
them getting things right or wrong, or even being able to engage
themselves in getting an answer at all. Mary, for example, who was
in the middle math section had great difficulty working out questions
that related to the pizza in interview two, but was very proficient
when asked similar questions in interview three which had pizzas
physically present for her to work with. Compare the following
responses by Mary:

<table>
<thead>
<tr>
<th>Interview Two</th>
<th>Interview Three</th>
</tr>
</thead>
<tbody>
<tr>
<td>R: Kikko and Robert each got a pizza. Kikko's was cut into sixths. How many pieces is that?</td>
<td>R: Kikko and Robert each got a pizza. Kikko's was cut into sixths. How many pieces?</td>
</tr>
<tr>
<td>S: Six pieces.</td>
<td>S: Six.</td>
</tr>
<tr>
<td>R: Robert's was cut into eighths. How many pieces?</td>
<td>R: And Robert's was cut into eighths. How many pieces?</td>
</tr>
<tr>
<td>R: They both ate half of their pizzas. How many more pieces did Robert eat?</td>
<td>R: How do you know?</td>
</tr>
<tr>
<td>S: (long pause) None.</td>
<td>S: Because that is how many they are cut into.</td>
</tr>
<tr>
<td>R: None more. Why do you say that?</td>
<td>R: Do you know that because you know what an eighth is or because you can see</td>
</tr>
<tr>
<td>S: Because if you cut them into eighths its smaller.</td>
<td>S: Both.</td>
</tr>
<tr>
<td>R: Ok. Now they both ate half of their pizzas. So how many pieces were in Kikko's half?</td>
<td>R: They both eat half of their pizza. How many more pieces does Robert eat than Kikko?</td>
</tr>
<tr>
<td>S: Em, five.</td>
<td>S: (no hesitation) One.</td>
</tr>
<tr>
<td>R: And how many pieces in Robert's half?</td>
<td>R: How do you know that?</td>
</tr>
<tr>
<td>S: Five.</td>
<td>S: Because?</td>
</tr>
</tbody>
</table>
In comparison with responses from interview two, in interview three Mary was clearly more accurate in her responses, she demonstrated a superior confidence, and it would seem that she evidenced a greater ability to generate a working relationship between the numbers and the objects so that objects could be mathematized and the math could be verified by direct reference to the particular objects that the math was representing.

In some instances students chose to recognize objects primarily to verify "math solutions." In these instances students were primarily concerned with confirming their computations — not testing algorithmic reasoning or conclusions from "first principles." Vicky calculated seven as a quarter of thirty two and then looked upon the availability of the cards for verifying her inaccurate solution:

R: Let's just say you weren't sure of your answer. And I am not saying you are right or wrong. How could you use the cards to check your answer?
S: I would. (begins to explain verbally)
R: Do it.
S: (Counts cards). I could put the whole pile of cards together and then I could subtract twenty five and then see how many cards he had left. (bbb170)
Vicky's verification process lacked the flexibility of being able to consider the cards as having the potential of affording other approaches to solving the problem. Eron approached this question in the exact same manner and came to the same erroneous conclusion (eee322). In both cases, as long as they focused on formal math as the primary resource they failed to provide the correct answer but continued to confirm their wrong answer. Interestingly Michael, a student in the top math section used the same kind of verification strategy but as he was correct initially, the outcome for him was not so profound (aaa117).

In the instances of Vicky and Eron discussed above, it can be argued that their error was due to a lack of transparency between the abstract calculation and its visual impact on how the piles of cards looked when grouped. In other words, the "evidence of objects" was not very obvious. Some students, however, were so intent on working with math algorithmic strategies that they ignored the what appeared to the researcher as the most glaring "evidence of objects" in order to support the original algorithmically constructed solution:

R: Let's just say the children ate half of the (eight) hamburgers that were cooked. How many hamburgers would they eat?
S: (pause) Six.
R: Show me. Split them into half. You have got eight hamburgers. Half them. Half on one side and half on the other.
S: There would be three on that side and three on the other.
R: What about these two? (two not counted)
S: Those are seven and eight. They don’t go in there. Then it wouldn’t be fair. Because that side got three and that side got five.
R: All right. So. I have eight hamburgers and half of those are. Half of eight is what?
S: Four. (kkk416)

In this instance John gave the wrong answer and checked it using the buns to work backwards to support his original solution. It can be seen, as with the other examples, the students worked towards confirming their solutions rather than verifying the correctness of their solutions. This exclusively math focus may be interpreted as the result of defining their activity as having to do math rather than having to solve problems. The consequences of such actions, however, were only supported when there were no other implications beyond the answer. That is to say, for example, John did not have the task of actually distributing the eight buns to the people. In contrast, some of the questions presented to students did have consequences beyond the answer and students had to continue the verification of their answers in response to those contextual conditions.

As pointed out earlier, Vicky consistently looked to the wrench size numbers as her selection guide. She considered 3/4 inch wrench to be the smallest wrench, "Because the numbers are lower than these [5/8] numbers and these [13/16] numbers," even though there were
distinctive physical size differences between them. Unlike the question about the cards or the buns, however, the consequences of the reasoning and solution to the wrench question were more pressing; the students had to immediately confirm the selection of wrench for the nut size by putting the wrench around the nut. Vicky was thereby forced to consider the physical attributes of the wrenches and eventually made selection judgments based on her observation of physical sizes. She concluded the correct wrench based on trial and error through observational activity and not through numerical information. She displayed, however, a reluctance to abandon number information as she explained her reasoning; she justified not trying the biggest wrench by saying, "Because these numbers are bigger," but significantly she quickly acknowledged, "And it doesn't look like this would fit because it would be too big." (bbb102)

As students engaged in problem solving activities they often evidenced conflicting positions with respect to how they verified their conclusions. It seemed that their solution strategies had to be explained as math knowledge even though it appeared to be derived from object knowledge. For example, Lawrence explained his decision on which was the smallest wrench based on the fraction sizes printed on the tools — math knowledge. However, the biggest wrench was described as the "heavy" one (ccc118), and his selection of the wrench
to fit the nut was supported because it, "Looks the smallest and the [nut] looks a little small" (ccc124) — object knowledge, indicating that Lawrence, like the other students, was carefully selecting object features which could help him towards the correct answer. In fact this first selection didn't fit, so Lawrence reconsidered his selection. When the correct wrench was chosen, Lawrence reverted back to a numbers-constructed solution to explain the correctness of his choice, "Because it [the wrench] is 3/4 and this [the nut] looks a little smaller than 2/4ths" (ccc142).

Evidence of Eron's deliberate selectivity of the important features in his solution process is even more striking in this further example:

R: Ok. We are having a picnic and we are cooking eight hamburgers. Take out the number of buns we need for those eight hamburgers. Take them out of the bag.
S: (takes eight buns from the bag)
R: How many are left?
S: Four. Because there are four in there. (corrects himself) Because if you take eight away from twelve it is four.
R: But you were right the first time because there are four in there. That's right too. Which do you think is more right? Because there are four in there or because when you take eight away from twelve is four? Which is the better answer do you think?
S: Because there is four in there. (eee379)
Eron's response in this instance could be interpreted as "reading" the situation as demanding correct mathematized solutions thereby marginalizing other solutions as invalid or perhaps even "cheating." In Suchman's terms this activity might be described as "doing math" demanding a "math plan" that had to be later substantiated despite what might have in fact taken place.

Counting strategies

Perhaps one of the most concrete verification strategies used by students was being able to physically count objects that were in front of them. Irrespective of math ability group, this strategy was used by all. Students all counted in ones at various points, otherwise students differed markedly in how they used the objects to count. Greeno (1991) attributed such differences in strategies as examples of "number sense" that develops as a repertoire of techniques through exposure to circumstances where their use has allowed them to become meaningful and efficient.

Some of the students demonstrated rather complex but efficient ways of counting objects. Michael, having just counted twelve coins one by one, proposed the following counting strategy for counting the thirty two baseball cards:

R: How many baseball cards are here?
S: That's harder to tell 'cause these things kind of blend in together so you can never tell. But then again, there is a way. Let's say I was going to divide them up between you and me. I would start with one to you and one to me. Keep on going. Then if I end up putting one down on mine I know there is an even number. So then I just count these up, multiply by two and then we will find out. (aaa97)

This was in fact how Michael counted out the number of cards. Steven, on the other hand, an ardent baseball card collector proposed a strategy that kept the "counting" to a minimum:

R: How many cards are there?
S: How many packs are there here?
R: Well, there are more than two.
S: So that there is at least forty five in here. I know there is because they usually come in packs of fifteen. (counts cards individually) Thirty two cards. They usually come in packs of fifteen. I guess that these are two packs and two cards. (mmm133)

Steven, by using the information of how many cards were in a pack when they were bought, was involved in the integration of information that went beyond the immediate context. He was involved in gathering information in order to determine the viability of one solution strategy through knowing how many were in one pack, but finding such information incomplete he proceeded to abandon that strategy and began to physically count the cards one by one.
Thea, who was in the lowest math section, took a middle road to keep the physical counting to a minimum. She counted objects by grouping them sometimes in twos, sometimes in fours, and sometimes in sixes. Whatever method was being used, a common characteristic was the manner in which students adopted strategies to organize the cards into manageable 'chunks' and then took note of how their organization was developing as they counted. For instance, most strategies involved separating objects counted from those not yet counted. This was done by counting them either into the other hand or by putting them onto the table.

Eron, however, had a method that seemed as if it were going to fail but in fact ended up being as accurate as any of the others. Rather than physically separating the counted from the uncounted cards, Eron counted out the cards one by one, putting the counted cards to the bottom of the pile in his hands, physically unseparated. While it looked as if he would end up recounting the cards already counted, Eron stopped at thirty two. When asked, "How did you know you had counted every card?" he replied, "I remembered the first person's face." This strategy did not involve separating the counted cards from the uncounted, but kept them together using memorized characteristics of the first card as the key organizational element.
Error handling

Every student made errors, with an error being defined as an answer that is either algorithmically or practically inaccurate. For example, to answer that the restaurant owner would need to buy four and a half grapefruits is an error because, although the owner would only use four and a half grapefruits, under common shopping conditions grapefruits are not sold in halves; therefore the correct answer would be five grapefruits. Students' errors were sometimes in their reasoning, their computations, or a combination of both. Although math algorithms were most often used as the first, most immediate resource for problem solving, those who recognized errors were most likely not to recalculate their solutions algorithmically, but instead use the objects to help them work out a more acceptable solution.

Several of the students made counting errors, including Vicky who was in the top math section. For example, she counted eleven pennies instead of ten. Having been invited to recount she then counted ten. What is important is not that the errors were made, but that the contextual circumstances presented the students with discrepancies in their calculations that they did not ignore. For instance Mary, having counted out the thirty two baseball cards as thirty seven cards and having been asked to divide the cards as evenly as possible among four people, discovered in the process of
dividing them out that she could not give each person nine cards, which was her original estimate. Mary then gathered the cards together and distributed them into four separate piles, one card at a time. This is an example, like the example of the wrench question, of the circumstances of the context giving informational feedback that promoted a recognition of error and instigated a process of verification and correction on the part of the student.

Whenever errors were identified, students overwhelmingly seemed to have greater confidence that the math constructed solution to the problem was in error, accepting the object constructed solution to be correct, or at least more likely to be correct. Lawrence, for example, at one point made vigorous efforts to answer a question algorithmically but finally resorted to an object constructed solution as a way of avoiding further error:

R: He gives away a quarter of his [32] cards. How many does he have left?

S: He gives away ten.
R: Does he? So how many has he got left?
S: Twenty two.
R: Twenty two. Supposing me, you, Bob and Jim [fictitious characters] are each going to get the same amount of cards. How would you make sure we all would get the same amount?
S: We each get, I think, ten.
R: All right.
S: No, (pause) Seven.
R: Why did you change your mind about ten?
S: Because if you gave away ten. That's ten and ten. (pointing to each of 'us') That's twenty. Thirty. Forty. You would have to have forty cards.
R: And how many have you got?
S: Thirty two. Oh! (as if he realized something)
R: Then why did you say seven?
S: (no response)
R: Ok.
S: How about eight?
R: What makes you think its eight?
S: Because we just had ten and that's forty. Minus eight. That's thirty two.
R: Ye. Very interesting.
S: (picks up the cards and starts to count with them. Distributes them into four piles counting as he does it) We each got eight.
R: Are you satisfied? Are you sure we all got the same?
S: Ye.
R: No doubt whatsoever?
S: (picks up one pile and counts eight) That means that you should have eight, he should have eight, and he should have eight. 'Cause I have eight and so the rest of you should have eight because I ended up with none of them.
R: Are you satisfied?
S: Ye. (ccc225)

The progress from initial math constructed solutions in favor of object constructed solutions, as evidenced by Lawrence above, suggested his greater confidence in his skills as a "math practitioner" with the attribution of significance to objects as definitional support to his strategy. Eron, who was described as relying heavily on math to derive and verify his solution with the cards, calculated the correct answer for the measuring cup problem, checked it against the measuring cup, and having misunderstood the measuring cup gave
the wrong answer but assumed that the answer using the cup had more credibility — and that was the answer he finally accepted as most likely to be correct (eee116).

By far the money questions provided the most error free responses. Although the money questions may have been easier for the students in terms of complexity, it is important to consider that perhaps the money questions were correct because students had working, "hands on" experience to draw upon in their modelling of the problems. But this argument cannot be developed without due consideration to the likelihood of students' having a working familiarity with halves and quarters as part of that money handling experience. In Greeno's (1991) terms this might be described more accurately as "money-number sense." An example of such activity is given by Mary:

R: How does knowing numbers help you work with pennies and quarters?
S: So you know how to split it up.
R: So why would you want to split it up?
S: In case you were earning some money with a friend and you wanted to split the money up.
R: Do you ever do that?
S: Selling Kool Aid. (ggg151)

The most acceptable explanation seems to be not just that the students were more experienced when dealing with money matters,
as opposed to deciding wrench sizes for example, but that within those money matters fractions of halves and quarters were familiar to them. This interpretation is consistent with Greeno's (1991, p. 170):

Number sense is an example of cognitive expertise — knowledge that results from extensive activity in a domain through which people learn to interact successfully with the various resources of the domain, including . . . perceiving and understanding subtle patterns, solving ordinary problems routinely, and generating new insights.

Students who were in the top math section, as opposed to students in the lower math sections, made fewer miscalculations with "mental" problem solving strategies. When trying to mathematize their problems lower section students' errors tended to evidence not computational error per se but a lack of understanding with respect to the conceptual nature of the fractions being used. For example, as indicated earlier, the treating of fractions as whole numbers rather than distinctive concepts for representing amount. Although students seemed to have confidence in their solution strategies when working with objects, errors in these instances were primarily counting errors. For example, Mary miscounted the number of baseball cards she had and then proceeded to "solve" the problem based on that erroneous number.
Estimation

While in the majority of instances students seemed to be working towards a precise solution, sometimes approximations were proposed as solutions to a problem question. The process of estimation was evidenced primarily by those students in the top math section who were the most adept at demonstrating variety in their solution strategies. This observation is consistent with a study by Reys et al. (1982), who also discussed characteristics of good estimators in greater detail. The types of estimates given fall into two categories; 1) estimates where the student did not seem to consider a precise answer as very necessary, although in most instances they could have been more precise had they wanted to be, and 2) estimates where the student took into consideration conditions of particular circumstances beyond the immediate context of the questions. That is to say they described their estimate within contextual circumstances other than the circumstances described in the particular question.

What is being used to differentiate approximation from "guesswork" is the fact that students were able to present a logic for how they reasoned out their answer. Vicky presented a clear example of this:

R: How do numbers help anyone collecting baseball cards?
S: If they wanted to trade with someone, the person would say I want half of your baseball cards and I would give you half of mine. They would have to know what half of thirty two is. And after they have traded they would probably have the same amount of base ball cards.
R: What do you mean probably?
S: Someone might steal one.
R: Let's just say no one stole anything.
S: Then they would have the same amount. (bbb 155)

Although thirty two could be halved equally, Vicky presented her answer as no more precise than she deemed necessary. Hence she did not calculate sixteen as a half of thirty two, but simply concluded that they would "probably" have the same amount. Furthermore, although the possibility of someone stealing cards might seem rather extraordinary, Vicky presented this as an explanation for her answer, indicating, perhaps, that the conditions described in the card question might be inappropriate because of circumstances that are part of the card trading activity she described; trading might not necessarily be a one-for-one activity.

This highlights a common condition within which estimations took place. In every instance, students moved away from defining the conditions of the word problem as presented in the text to conditions outside of the word problem and interview contexts. Having already discussed how arithmetic can help you when using grapefruits Steven was asked:
R: So if you were counting it. Let's just say it was going to cost a dollar 85 cents per grapefruit. And you were going to buy six grapefruits, how would you calculate that?  
S: Well you would probably round it up to two dollars. Two times six equals twelve so it is little less than twelve dollars. Eleven fifty or around there. (mmm31)

Here Steven indicated how purchasing in a supermarket did not demand that he needed to be particularly accurate in calculating the amount of money he needed to buy items. In a similar type of question Vicky pointed out that when shopping it is not important to be specifically accurate because, "If you give more than what it is, you will get change back" (bbb40). Vicky indicated that in the context of the supermarket the onus of responsibility for accuracy falls on the shoulders of the store and not on the shopper therefore precision for the purchaser was being defined as ensuring enough money was tendered. This reasoning on her part was inferred from her saying that she would tender "two dollars and get change back" from a purchase of one dollar one cent.

These students evidenced a reasoning that explained their recognition of the appropriate level of solution detail necessary for their definition of the problem being presented. This apparent discrepancy between "book answer" and student's answer can be described as the difference between "solving" a problem and
"resolving" a problem. In the first instance, book answers tolerated only the solving of problems. This demanded numeric precision on the part of the student for the problem to be concluded with the correct answer. In the case of problem resolving, the problem exercise is defined as demanding a conclusion that satisfies the conditions of a problem, allowing the student to conclude their resolution efforts at that point. In this case "answer sufficiency" is all that is necessary for problem resolution and conclusion to be reached.

Herein the data are not supporting an analysis of computational strategies for estimation (see Reys et al., 1982). The data does support, nevertheless, that students did transform the problem by drawing in information from previous experiences. They redefined the parameters of the question through which estimation was considered an appropriate problem resolution strategy.

Ownership

A student's sense of ownership of a problem had significant implications for the amount of invested mental effort (AIME) (Salomon, 1984) that was brought to bear during efforts to obtain the "correct" answer. Two of the students, Michael and Steven, both considered as 'serious students' by their teachers, were particularly proud of their math ability. To them, getting the questions right seemed to be more than just an exercise, it gave them a sense of
personal satisfaction. When asked a question they would be more inclined to check their answer and/or go beyond what was being asked to supply further information by way of justifying their responses.

In contrast John, a student in the low math section, was quite comfortable with giving "ballpark" estimates in interview two, with little to no apparent desire or ability to verify the correctness of his estimate. Perhaps because he had been informed that this interview was not a test, nor was it have consequences beyond the present moment, John seemed unconcerned about the precision of his answer. For example, when asked how many hamburgers did the children eat, John replied, "Five. I'd say about five." When asked why, he justified his answer by saying, "Because, em, five is like a half." There is evidence, however, from the question about John walking to school that John did know what a half was; he answered a half of four correctly and without hesitation. John may have perceived working with larger numbers as more demanding and therefore decided that the personal mental investment for the question was more than the question was worth to him.

Ownership for the students can be best described as commitment not to the problem, but to the answer. That is to say, Isabel's pennies, the restaurant owner's grapefruits, and so on, were
only considered as vehicles for presenting the math such that the students did not look to the people in the word problems as beneficiaries of the correct answer. This dissassociation with the contextual circumstances of the word problems by the students was identified quite markedly by Steven:

R: What do you think of John walking four miles to school? Do you think that's real?
S: No. Because I usually hear that if they live more than one mile from school they either ride the bus or take a car.
R: Does it make any difference though?
S: No, basically not.

S: No. It just asks you to tell how far. He lives one mile from school, after he has walked half, how far does he have to go?
R: So this is a question about what?
S: About distance. (mm 83)

As an exemplar Steven's explanation indicated that the students did not accept the problem situations that they were being presented with as being either legitimate for the problem characters or potentially viable for themselves.

Summary

The most striking observation with respect to the use of support objects is that the cues changed the students' approaches to the task. Objects changed the working context for the students in that they designed and initiated alternative approaches to finding a solution as
they worked through the problem. This phenomenon was identified through evidence of a dialectic relationship between students and objects that became apparent as they intuitively used objects as resources to come to an answer, and then to check, recheck, verify and conclude the correctness of their answer.

In terms of problem solutions, students were seen to adopt a different disposition towards their strategies using support cues such that they evidenced the ability to "support" their problem conclusions through activity rather than simply declaring the correct answer. The ability to "support" gave students confidence in the mathematical accuracy of their answers because they could be confirmed through not just one immediately available means (i.e. algorithmic computation), but through several, depending on the resourcefulness of the individual student. Noticeably, however, students were very aware of the importance of appearing to confirm answers algorithmically, that is to say through math knowledge rather than object knowledge. This dynamic is represented in Figure 11:
The data do not imply any conclusions about the proportional use of different knowledge domains. They do, nevertheless, allow the conclusion to be drawn that the different knowledge domains were used to different extents and this differed from student to student, and question to question. Those strong in math were able to lean heavily on their math knowledge because they could comfortably define the problem in those terms. Others leaned more heavily on objects, especially when they felt confident in observing the consequences of their own manipulative activity.

"Extra content knowledge" must be seen as a very particular component in the problem solving activity. What students already knew about the objects or the kinds of problem they recognized
became evident in some cases as they explained how they approached the problem. Knowing "extra" information gave students other resources to consider using; for instance, Steven knowing about how many cards in a pack when you buy them. But when doing problems that were abstracted from contextual supports in the way standard classroom word problems are, students considered "extra knowledge" as unusable, even irrelevant.

What is evident from the data is that students were involved in the use of math, in some cases very elaborate math, as they tried to work out their answers. What is strongly questionable is the implicit assumption by the textbook designers that the questions necessarily supported students' uses of formal fractions. For some students the solution was in simply counting out objects, for others it was trial and error, and of course for some fractions were used. The point is that while solving questions without supportive objects automatically made algorithmic math seem the only available resource, the presence of the objects changed the definition of both problem and solution strategy. Simply put, instead of having to think in abstract fractions the students were able to think in concrete terms. It is also clear that such differing strategies need not necessarily have occurred at once as one big plan, but that each circumstance of trial and error, success or failure created the conditions for other solution possibilities to be generated.
Cognition implications

When presented with problems unsupported with objects, students generally seemed first to take the position that it was a formal math problem, but not necessarily to do with fractions. For those who were not strong in formal math, there was little contextual support with which they could compensate for this deficiency. Given objects to work with, students were given a resource with which to compensate for any formal math skills deficiency. In many respects the use of object resources exemplifies the concept of "scaffolding" support inherent in the Inverse Tool Principle (Belland, 1985). Although in some cases students had had very little experience with some of the objects, such as the nuts and wrenches, they were able to come to understand the objects right there and then, using newly constructed information in relation to working out their answer.

Students' recognition of the physically present objects stands in marked contrast to students' recognition of the described objects presented through word problems. It has already been established that they generally ignored described resources which suggested that the mere description of things did not necessarily constitute a supportive resource that automatically conveyed information to the student. The term "necessarily" is used because in some cases students who had built up a repertoire of experiences with objects,
such as baseball cards, were able to "tap into" this resource and use it when it became propitious to do so. They were able to situate such resource information into their thinking by virtue of the fact that it was a resource that they themselves brought to the context, not because it was a resource inherent in the context as described. The presence of the objects themselves, however, became an information resource for all the students and allowed them to learn the characteristics of the objects in situ from which they could decide on which characteristics of (the) objects were most pertinent to advancing towards the goal of generating a reasoned problem solution. Thus, object information was being situationally filtered through the gauze of "what information is going to help me towards a solution."

It is evident that students' sense of being involved in a math activity, or doing math, became transformed through the presence of the objects. The presence of the objects often put math into a subordinate role as the students recognized more obvious ways to solve a problem. In fact, in the case of the wrenches, the students completely discarded trying to mathematize the problem because they realized that the solution lay through the use of other means. In every case for this question, observational data became the primary resource and in all instances students' activity resulted in the correct choice of wrench for the nut.
While the data does not support situated cognitive activity as having the characteristic of individuals automatically checking final results, there was evidence of an automaticity in the checking of ongoing information as they worked towards their solutions. The presence of the objects allowed the students to see the implications of tentative solutions as they tested those solutions on objects. A clear example was deciding how to divide the cards equally. Students constructed information as they distributed the cards and they checked this new information with their plan for how the distribution was to work out. Satisfactory comparisons allowed for solutions to be verified; discrepancies initiated the activity of further "working out" of a solution.
How do teachers' perceptions of the purposes of classroom instructional activity compare with the perceptions of their students?

1) How do teacher's perceive the functions of classroom instructional activities within the lives of the students?

While teachers were very well aware of concepts such as "teaching for the future," they pointed out that most children come to school because they knew that they had to. Perhaps the most distinguishing feature that characterized teachers' perceptions of formal schooling as a preparation for the future was that, while teachers recognized preparation for the future as important, the overall focus was on helping students deal with their present. Mrs. Mulholland puts it this way:

You hear all this stuff about preparing them for the future, but they need to get through today too. So they need to learn how to cope with where they live and where they are right now too. (c*25)

And so to say that I am preparing you for the future, they couldn't care less. The future is "when is recess." (c*103)

This understanding suggested that the teachers were highly sensitive to students' awareness of the world around them and how they fitted in. In keeping with the Individually Guided Education philosophy of Linden Park, teachers were equally aware that schooling meant different things to different children and, for each
child, that could vary from day to day depending on the child's "other" circumstances.

Teachers did not see students as "human data bases." Rather the philosophy of schooling presented by the teachers is typified by their statements during the interviews:

School helps students get to know themselves and what they can do.

School is about getting children to want to learn diverse things and to be successful at it.

I think the biggest thing is to create life time learners.

We are hoping that what we teach gives them some knowledge to build on.

Helping them to learn how to organize their thinking. Schooling is about developing critical thinking skills.

The teachers pointed out the legitimacy and prominence of "other" learning in the lives of the students; that is, learning that could not be specifically attributed to formal schooling but served to influence what was being learned in school. This was referred to by one teacher as "street education." Such education was explained in terms of the outside of school experience that each child brings into the classroom. For example, the teachers were cognizant of the fact that ability in doing "school fractions" was not necessarily a valid
measure of a student's ability to fractionate in order to solve problems. Mrs. Morrison pointed out that a student's ability to divide a pack of M&Ms among friends did not depend, necessarily on what they had picked up from fractions done in school. She explained a students' possession of prior knowledge and skills as potentially coming from learning that occurs naturally as they go about their daily business as young people. She states:

I think that a lot of the kids have had to deal with things within their own neighborhood or something. And they have had something they have been given and they have had to share, for example. So basically what I mean by prior knowledge is that they have been through a situation like that and they have had to come up with a way to share it or something and they have just done it on their own. (B*59)

2) What do the teachers perceive as the learning value of students working through math word problems?

Teachers were asked how they understood students' thinking as they worked through math word problems. Once again the teachers emphasized that the doing of math word problems was potentially different across students. Despite the fact that the teachers had no knowledge of the student interview data, particular students were identified by the teachers as exemplars of different approaches. Michael was described as the kind of student for whom math word problems would be approached as an exercise in finding the
algorithm and the relevant numbers to "plug in" in order to come up with the answer. For Michael, this kind of activity would be like a game that would be looked upon as a challenge (c*101). Benita, on the other hand, who was in the low math section would be "sidetracked" by information that was not central to the mathematics of the problems. For example, with respect to the grapefruit problem, low math group students were likely to become involved in whether or not they liked grapefruit, or who was going to cut it, or even who was going to get the "bigger half." Students, such as Benita, would see little reason within the problem for doing it.

Significantly the teachers' descriptions of both Michael and Benita fit exactly with the study data on how they approached the problems during the "transforming experiments." This awareness of such different student approaches was evidenced for all the teachers interviewed. An equally common position among the teachers was that, given the differences in how students perceived the activity of doing word problems, the teachers were ready to transform the nature of the question to facilitate student's ability to make sense of it. In Vygotskian terms, the teachers were ready to provide instructional "scaffolding" for students who were having difficulty "constructing" the problem. Such "scaffolding" was described as having the students draw circles to represent grapefruits, or even make it a problem about "teddy grams" (cookies) where students had
to work out how to divide the cookies among classmates, so that each got a half. Being able to eat a half cookie at the end of the activity would serve as the reason for doing it because for them, Mrs. Mulholland pointed out, an understanding of purpose in an activity was very important. Furthermore, teachers also pointed out that the manner in which students worked the math they were being taught into their own lives was most likely to be situational through the use of "objects to think with."

The teachers were quite explicit about how they perceived students' understanding of purpose in doing math word problems. Students were described as being able to identify word problems as "about" math because they were presented during the math class. It was further understood that students identified the problems to the extent that students' reading skills allowed them to understand the text. One of the differentiating characteristics of the students in the higher math sections, it was pointed out, was that they had better reading skills which made the interpretation of word problems substantially easier for them.

At the end of the teacher interviews, each teacher was given an explanation of the specific nature of this study and some of the findings from the student data. It appeared to come as no surprise to any of the teachers that the students' problem arena when doing
math word problems was centered around success defined as classroom goals. Teachers understood that the students generally defined math word problems as problems about math; namely algorithms and numbers. Such conceptualization of a problem on the part of a student was understood not to be concerned with the circumstantial details through which the math was being presented; for example, characters in the story. Doing well for a student, Mrs. Mulholland pointed out, was not concerned with accumulating skills for the future. Rather, school math took its major significance for the students in terms of, among other things, "a grade to take home to show their mom and dad" (c*109).

Although teachers were aware of discrepancies between math taught in the classroom and the kind of math students might use at home or in the playground, they were equally appreciative of a role for school math as resource for helping children make sense of their world. In their view, formal school math had a place in helping students to function better outside of school, from simple things such as slicing a pizza, to balancing a check book, or deciding how much material needs to be bought to decorate a room. A most important feature common to the teachers interviewed was the perspective taken as to the value attributed to math problems as a format for presenting math. The teachers did not believe that doing math word problems could stand alone as sufficient for students to be able to
work formal math into their lives. If math word problems had value for these teachers, it was in their potential for developing students' skills in interpreting problems, eliciting important considerations, and deciding on appropriate solution strategies. Indeed it was the underlying development of strategy skills that the teachers considered to be more important than the ability work out the mathematically correct end result.

Summary

While teachers and students played different roles within the classroom, the main concern of this study question was the examination of whether or not teachers were appreciative of how students understood being in school, in the classroom, and how they engaged in particular instructional activities. A comparison between student data and teacher interview data is used to support the conclusion that teachers modelled learners as situational thinkers, although they may not have used such terms, and they were particularly alert to the potential for differences as students involved themselves in instructional activities.

The teachers of the students in this study paid particular attention to "who" each student was as they approached the classroom instructional arena. Of particular relevance to a study of situated cognition is the evidence that teachers were sensitive to the
"immediate context" of students as definers of present moment conditions and goals. In short, while neither students nor teachers were unaware of external political and social definitions for what schooling was about, they clearly worked within the exigencies of their own particular (shared) circumstances that became relevant as they went about their daily classroom business.

Mrs. Hall, discussing the IGE philosophy of Linden Park, pointed out that, as teachers, their concept of schooling worked towards creating "people places" for learning:

I do think that it works very well because we take the kids at where they are and move them on. We don't fit them into a mould. We mould our curriculum around them.

Observational data from classroom activities can be used to substantiate how this particular philosophy was translated into day to day activity for each student. While students were clustered under broad ability bands for each subject area, it was the rule rather than the exception that students would be found involved working at differing levels of the same general activity (e.g. math or writing). The desire on the part of the teachers to set up instructional conditions that did not assume that all students had to understand whatever was being presented in the same way or at the same time,
is evidenced by the amount of individual tutoring that went on as students worked in class.

Cognition Implications

Did the teachers in this study recognize that their students thought situationally? The data presented from teacher interviews indicated that while teachers would be very unlikely to use some of the vocabulary used in this document, they were acutely aware of the importance of student's own processes of meaning making as they worked within the conditions of formal classroom instruction. Their versatility in adopting different approaches to the presentation of content to students is aptly summed up by Mrs. Mulholland when she said, "Don't knock it if it works." That is not to say that the teachers' approaches were haphazard. On the contrary, the teachers in Betelgeuse, and indeed throughout the school, spent many hours planning and preparing materials. What is important is that their instruction was not plan-driven but would be better described as plan initiated and driven by student and teacher together.

As particular students were discussed, the teachers seemed aware of the kinds of supports that the students would need as they tried to make sense of doing math in the classroom. For students in the top section, the meaning making was embedded in the activity of doing math for its own sake, and for the sake of proving themselves
capable. For students in the lower math sections, the teachers indicated that a more interventionist structure was needed for them to make sense of doing math in the way they were being asked to do "school" math.

This highlights the question of whether or not school math in the form of word problems can be described as "authentic activity" as discussed in chapter two. In terms of the use of math and how math is assumed to structure the solutions to problems described, the "authenticity" of such mathematizing is strongly questionable. The role of math in the use of wrenches is a particularly glaring case in point. However, to suggest that student or teacher participation within the classroom context is not "authentic" is equally questionable for regardless of circumstances, cognition is inevitably situated and in that sense inevitably "authentic." That is to say that teachers clearly recognized that from the students' perspectives, being a participant in their classroom context was beyond a doubt "authentic" activity for the students. While it may not have been "authentic math" it was certainly "authentic school math." Doing word problems was authentic in that students worked within a context where their goal, perhaps among other goals, was to get the right answer. To get the right answer had very real consequences for the students. They recognized this, and the teachers recognized that students posited word problems in this manner.
As authentic activity, teachers appreciated the importance of students having a sense of "real" consequences for their activity. The concept of "real" consequences is easily translated into the language of motivation because teachers indicated that the consequences of school work became, most often, the motive behind the action. Students such as Michael were described by the teachers as being motivated by the satisfaction of getting the answers correct and demonstrating his mastery of the technique. For Benita, getting the answer correct failed to take on any substance as being a "real" consequence. Teachers appreciated such considerations on the part of the students and while little intervention in terms of Vygotskian scaffolding seemed necessary for Michael, Benita would have been one of the students for whom Mrs. Mulholland would have redefined a problem as not dealing with grapefruits but cookies instead. Furthermore, the definition and consequences of such a problem became very immediate when success or failure were determining features as to whether or not there were to be enough cookies to share with the group.

The fact that both teachers and students were likely to share in a sense of their instructional activity being about "doing math," and the fact that the teachers were willing and able to change goals and strategies for different students in different circumstances suggested
that the "coproduced intention of outcomes" were created as students and teachers involved themselves in their activity. Examples of such intentions for each lesson period might have become realized as a common (perhaps tacit) agreement of what would be accepted as sufficient "on task" activity for the time period, or even a mutual recognition that both teacher and student had their own reasons for being in class and that such reasons were likely to be different.

Data Conclusions

This chapter presents data derived from the study of students and teachers at Park Elementary who, as they participated in interviews and specific activities, provided activity from which the question of situated cognition was examined. From this data specific inferences were made as to how the students engaged in meaning-making as they negotiated the contextual circumstances of their activity. Such inferences are particular to the interpretation of the present author but whenever possible specific references to the data are used, the intention of which is to allow the reader access to the particulars of data from which the author's inferences were derived. In so doing, it is hoped, the reader is given the opportunity of validating that the present author's inferences and conclusions are in fact warranted.
The data presented in this chapter warrant several conclusions:

1) Students did not consider the classroom or the interview situation as neutral arenas for activity. Students' perceptions for what they were being asked to do involved an understanding that served to define purpose and approaches with which to negotiate the task at hand.

2) Presented with particular math word problems, students were involved in personally defining the attributes of the problems that related to their interview/classroom contextual goals for the activity.

3) Objects and information presented within the immediate context were recognized by students to the extent that the contextual conditions legitimized their use as potential resources to facilitate a redefinition and potential simplification of a task.

4) On no task did all students in the low section, middle section, or high section, respectively perform at lower or differentiating levels when they were asked to solve problems using object support.

5) Teachers were aware of the influence of contextual structure in students' ability to engage in instructional activities. Furthermore, teachers paid particular attention to differences in how students perceived task goals and differences in their recognition of related contextual supports.

Such considerations support the study conclusion that students in the classroom were involved in situating their thinking and action
with direct reference to the contextual conditions of the activity. In addition, students, while recognizing the potential importance of contextual resources for what they were doing, were also bringing to their activity personal contributions that were most likely to be the result of personal knowledge and skills recognized by the student as related and potentially relevant to the task in hand. While the students evidenced a common understanding about their role as students in the classroom engaged in "school" learning, the particularities of "cognitive focus" indicated that students were involved in a personal determination of what "counted" in a context. Furthermore, particular decisions for proceeding were created as a "real time" dynamic cognitive process through which meaning was constructed and realized in action.
CHAPTER V
CONCLUSIONS AND IMPLICATIONS

This study explains the existence and influence of cognition as a situated phenomenon observed in students' activities while solving word problems. The data describe students' cognitive processing as a "here and now" activity that was made visible, at least partially, to the researcher through students' activity and their explanations for what they were doing.

Situated cognition

The participants in this study evidenced their understanding of school activity in different ways. On a broad environmental level, school was a time for employment preparation and preparation for adulthood. Students accepted this because they were able to see connections with the particular subjects they did in school and the kinds of activities they knew occurred outside of school, such as reading and counting.

As arenas for thinking, the contexts described by word problems did not serve to establish the boundaries of a working
context for students. As participants in classroom instructional activity, students explained a shared, communal understanding for how they were expected to work with word problems in the classroom; and yet, students often thought about such problems in ways that allowed them to make individual sense of what they were being asked to do. The uniqueness of students' thinking became clear in the transforming experiments through the variety of strategies used by students to solve what was ostensibly the same problem. This is clear in the data which serve as an example of the personal uniqueness of situated cognition through the particulars of individual interpretation.

The transforming experiments of this study allowed for three major observations about the situated nature of students' activity. First, although students were able to negotiate with the problems presented to them in various ways, for some their acceptance of a real or assumed requirement that they use abstract algorithmic mathematics restricted their ability to solve problems. The presence of objects to think with allowed students to demonstrate that they had a far richer expertise in problem solving using mathematical thinking than could be recognized in conditions that valued only the use of abstract algorithms. Secondly, the supposition that problems can be designed in such a way as to guarantee that students will adopt a particular solution strategy is strongly questionable. The fact that students defined problems in different ways (e.g., thinking of the
problem of the grapefruit special from the perspective of the
customers rather than the owner) necessitates recognition of the
situated nature of how students make their own sense within
problem solving activity. Thirdly, students must be assumed to be
resourceful when it comes to negotiating their way through a
problem. Students recognized useful relationships in information and
used this information to find satisfactory solutions; yet they felt
obliged to camouflage what they were really doing as they solved
problems in order to make it appear that they were adhering to
perceived expectations for how to do math in the classroom.

**Authentic activity**

The "lack of fit" for some students between situated ways of
solving problems and having to make abstracted algorithmic
mathematics *appear* to be their way of solving those problems is an
issue of "authentic activity." However, "lack of fit" has to be examined
on at least two different levels; fit for the student in terms of a
developing understanding for how they make *their* sense of a
situated math activity, and fit defined in terms of the relationship
between what becomes understood in reference to how it can be of
use to the student beyond the classroom.

Irrespective of their ability grouping or their classroom
experience in learning formal fractions, all the students in this study
evidenced *in varying degrees* that abstracting a mathematical
construction from a problem statement was a powerful, indeed efficient, strategy for solving certain problems. Central to this observation is that students' use of abstract mathematics was situationally recognized by them as appropriate and became a definitional component for the authentic character of their activity. The degrees to which students demonstrated their ability to introduce mathematics into their problem solving strategies can be understood as on a continuum from concrete (hands on) constructions in relation to cognitive (in head) constructions.

Students who were more expert in formal, abstract mathematics demonstrated that they were using *their* mathematics as a powerful abstract "thinking tool" for solving their problems. What is more, their proficiency and experience gave them sufficient confidence that their final solutions were correct. The availability of "objects to think with" provided, for them, a secondary rather than a central resource. For students less proficient in formal, abstract mathematics, their ability to situate *their* mathematics within their activity differed in that their use of arithmetic looked for the support of "objects to think with" as a central resource for solving problems. As an available resource, objects allowed these students to compensate for their lack of expertise in understanding abstract math as a "thinking tool." Nevertheless, given sufficient resources these students were able to mathematize problems and solutions in relation to their ability to function with *their* math as a useful problem solving resource.
Such conclusions drive at the heart of authentic activity and the role of mathematical knowledge and understanding therein. The problem lies in assumptions that the "cognitive tool" of math (e.g., addition, multiplication, fractions) is authentic with reference to some pre-designed definition of an activity, thereby denying the student their own experience of coming to recognize the relevance of mathematics as a situationally authentic tool of their own. This is especially consequential when, as indicated in the data, students were working with an understanding of their problem solving situation as recognizing the use of fractions as the only conceptual tool that was valid for determining their problem solution.

Internalized use of fractions as abstractions for understanding and modelling their world was not a "cognitive tool" that was available for all the students to the same degree. In short, not all the students could make sense of their "world" of fractions abstractly. Those who could, did so by imposing an abstract understanding allowing them to calculate solutions that made personal sense to them. Those who could not were tied to the concrete objects and for them these objects provided their only reliable resource for making sense of fractions.

The data from this study demonstrated, nevertheless, that left to their own devices students can compensate very efficiently for
skill deficiencies in abstract math by utilizing their ability in recognizing object affordances in relation to problem solutions. Indeed in some cases, despite their lack of expertise in situating their problem solution in purely abstract mathematical terms, students were able to situate other personally constructed abstractions to facilitate their problem solving. Mary presents an example of this by approaching the problem of dividing thirty two cards by four as being the same as distributing those cards among four people and calculating how much one person would get. Such an abstract modelling of the problem allowed Mary a very powerful "thinking tool" with which to reconstruct the problem in such a way that she was capable of deriving the correct answer.

To define math expertise as a skill in abstract thinking alone undermines the legitimacy and in fact the manageability for students who use math in some of the different ways demonstrated in this study. The instructional issue becomes one of bridging the gap between having the novice develop from their manageable but limited expertise in using math to a realization of the potential of abstract math as a powerful thinking tool as recognized by the more expert math practitioner.

The second issue of authentic activity concerns the relationship between what can be learned in the classroom in relation to its function beyond the classroom. Given that the word problems used in
the study were taken from the classroom text books, the manner in which students are assumed to recognize the role of mathematics in the situations described is problematic. While several of the questions are suspect in terms of how math might become integrated into such problems, the question relating to the selection of wrenches is particularly glaring in its lack of fit between how "wrench users" might use math to select wrenches and how the students were to assume "wrench users" use math to select wrenches.

Although wrenches have their sizes marked on them in fractions, the fraction information plays a negligible role in the selection of the correct wrench to fit a nut. The central issue is that, in this case, the use of fractions has been artificially and erroneously imposed on the activity of selecting wrenches in order to have students develop their understanding of fractions as abstract constructs. A concern for authentic activity poses the question of how an activity reflects the practice of expert practitioners. When students were asked to solve a wrench related word problem on its own, those who were skilled in abstract fraction algorithms were able to do it, but the majority of the students could not. When presented with the nut and the wrenches and then asked to solve the problem, all of the students did it, and none of them evidenced the use of algorithmic calculations in doing so. The irrelevance of fractions in their activity only became clear for the students as they involved
themselves in uncovering aspects of the problem as part of their ongoing problem solving activity.

How can authentic activity be designed into learning math, and indeed learning how to do any "subject"? In the first instance, authentic activity must have a recognized purpose for the student where the termination point goes beyond reaching someone else's conclusions. Students must be considered as problem posers as much as problem solvers. If the intent is to expose students to the use of mathematics in practice then instructional activities need to be designed in such a way that students can be guided towards the use of math as a consequence of looking for problem solutions. The use of mathematics must be designed into a problem activity as a resource and not the end or only resource. In this way activity settings become more in-tune with the ordinary practices of the culture of "everyday" activity.

It can be assumed that, in varying degrees, students who are being introduced to new knowledge and skills will need guidance, or to use Vygotskian terms, intellectual scaffolding (see Greenfield, 1984). This can be considered as an expert-apprentice relationship between instructor and student (see Brown, Collins & Duguid, 1989). The instructor, having expertise that the student must acquire, becomes a central resource for the student. The expert understands the culture of math in "everyday" activity and can alert the student to
how it can provide an intellectual tool with which to negotiate the problem. While the instructor as expert may have a more mature sense for how to incorporate math into the process of solving a problem, it becomes the process of guided discovery that characterizes the instructional activity for the student.

**Transfer**

This study supports the position that thinking is situated in such a way that knowledge and context exist for the thinking individual in a symbiotic relationship. If the context of the classroom is not the context of the grocery store, or whatever, what can students learn that will make sense to them outside of the classroom? Butterfield and Nelson (1989) point out that while instructional activities in the classroom must reflect activity in the wider lives of students, it is impossible to fully specify all the features and conditions that students are likely to meet. Therefore, given that classrooms, like any other context, cannot be more than what they are in terms of defining a specific context for situated activity, this study supports the case that any instructional approach needs to recognize the limitations of the classroom for what can be understood by students who inevitably are thinking situationally.

It is important to consider the question of how situated thinkers recognize information relevant within the circumstances of one context as having relevance within the circumstances of different
contexts. The case can be made that effective transfer is as much a question of teaching students how to use information, as it is in teaching the information in and of itself. The data in this study show that as situated thinkers, students were relating information derived from other contexts into their immediate interview problem context (e.g., Steven considering how many packs of cards were in the pile to be counted). This strongly suggests that learning transfer is more usefully considered as a skill-building process whereby students develop their skills in looking for resources in terms of contextual affordances that support meaningful ongoing activity. The significance of this understanding for classroom instruction is that as situated thinkers students are learning to look for and apply resource information as they work within a classroom context and in so doing develop skills in looking for and using resource information in other contexts. In short the role of classroom instruction is to help students recognize that they are active situated thinkers and in doing so help them recognize and develop this potential in themselves.

**Instructional design**

Streibel (1989b) argues that a "marriage" is possible between traditional instructional design and situated cognition. The crux of the matter lies in the underlying assumptions within the field of conventional instructional design that our legitimacy and "power" lies in assumptions of instruction as a technology, where technology is defined in terms of the power to predict and control. The information
processing paradigm that has been the mainstay for claims of controlling learner direction and learning outcomes is no longer adequate when a student is modelled as a situational thinker.

This formulation of an empirically supportable theory of situated cognition means the necessity of introducing new modes of practice in how instruction is designed and conducted both in schools and in other instructional settings. In particular, the context of instruction must be redefined as more than the delivery conditions for information transfer as proposed by Gagne’ (1985). As the data in this study and other studies in situated cognition indicate, situations can be understood as coproducing knowledge with the student. Instructional activity, therefore, must be embedded in contextual activity that is substantively rich with respect to the skills and knowledge students hope to master. In essence, instructional systems design must define the student as being conscious of the learning context and not simply participants being processed through a predetermined, contextually inconsequential learning procedure.

Predesigned, step by step, instruction, therefore, can no longer be designed on the assumption that the process can control the specifics of meaning constructed by the learner. This has profound implications for how computers are designed into instruction. If computer assisted instruction has a role within the instructional process, its contribution seems to be most viable as a resource rather
than a total instructional program. The development of increasingly powerful and diverse resources within the computer environment make it an attractive tool for learning. Hypermedia and Virtual Reality environments allow for the computer to be considered as supportive of the situated thinker. Their increasing flexibility allow for greater tolerance for students who construct their sense of situations in ways that differ from the general expectations of the program designer.

Within traditional instructional design models, measurement of learning outcomes is considered an integral element within the design of instruction. Assessing student competence is no less important within a situated instruction model. The difference lies in the degree of specificity for learning outcomes. Objectives for situated learning practice are not used as termination points. Rather, objectives are constructed as expectations that guide the direction of the learning activity. Given that authentic activity is central to the process of learning, then authentic activity must be given the same centrality in evaluating students' competence. The implications of this are indeed radical for school based education. Competence and capability can no longer be rigidly compart-mentalized; rather the mastery of skills and knowledge have to be measured as a composition of integrated understanding and skill that become a hallmark of a student's ability to situate his/her thinking in relation to the circumstances of what is being asked.
How such an approach might translate into curriculum content is problematic when classroom activity is exam-driven. As situated thinkers in the classroom, students inevitably come to conclusions about what is educationally important through having their abilities defined by formal paper and pencil testing. The same, however, can be said about how teachers are expected to engage students in instructional activity. The teachers in this study evidenced their dilemma of appreciating the situated nature of students' activity in the classroom while at the same time having to "train" students in how to do book word problems, irrespective of their meaningfulness for the individual student. This dilemma for teachers can be summed up by them knowing what knowledge and skills have the most potential to be useful for a particular student, while at the same time knowing also how that same student is to be evaluated and therefore what he/she must be taught. This particular phenomenon is particularly insidious when schools have imposed on them city and state-wide standardized testing.

Recommendations for further research

In response to the findings of this study, further refinement in our understanding of situated cognition is called for. An important question is why students in a classroom take different approaches to what is ostensibly the same school task. Do students choose to situate their thinking or is it something that happens automatically, giving
them limited control over its occurrence? An important related question is whether boys differ from girls in the nature of their situated thought. This becomes particularly important considered in terms of the numbers of men as opposed to women who are involved in fields that relate to math, science and engineering. While many of the studies relating to situated cognition were done in cultures other than the U.S., nothing has been done by way of cross cultural comparison. Precedents for the importance of such cross cultural work have already been established by Geoffrey Saxe and others.

A situated cognition perspective on many of our established fields of study is likely to introduce fresh debate. For example, studies into how media are perceived are likely to deemphasize the attributes of the media per se, in response to considerations of individual perceptions of what they are being used for. A situated cognition perspective is likely to bring new insights into reader theory and the implications of the current trend for a whole language approach to reading in our schools. This study provides added support for understanding human cognition as an activity rooted in the conditions of context and ultimately unique to the individual. This invites researchers to reconsider conclusions about how we think derived from examinations of thinking under experimental conditions.
Anecdotal evidence of how students often lose their enthusiasm for school learning as they move through grade levels might be examined from a situated cognition perspective. The question might focus on the extent to which students perceive the increasingly abstract content of school instruction as lacking in authenticity and real-life value for them. To succeed within the culture of school learning seems to force students to think in a manner that undermines their more situated approach to thinking in action. The implications of this study suggest the need for inquiry into the cognitive culture of the classroom and how it influences the substantive experiences of students' learning. Such a study would assume investigation into questions of motivation, learning styles, and the individual educational goals determined by the students themselves.
APPENDIX A
APPENDIX A

INTERVIEW ONE QUESTIONS

1) What is your name?
2) How old are you?

General conversation about my accent and where I come from in order to help make the children comfortable with the interview setting.

BACKGROUND
3) How many brothers and sisters do you have?
4) Questions about the family.

SCHOOL
5) Do you like school?
6) What do you like best about school?
7) What is your favorite subject?
8) What do you think is the subject you do best?
9) Why do you think that is?
10) What is the subject you do worst?
11) Why do you think that is?
12) If your mum or dad woke you in the morning and asked you if you wanted to go to school, would you go?
13) Would you come some days?
14) Why do you think your mum and dad want you to go to school?
15) Do you think that school will help you when you are grown up?

SCHOOL SUBJECTS
16) What subject do you think will help you the most?
17) What other subject will help you?

18) Can you tell me how what you are learning is going to help you?
19) If you were asked to help your mum and dad with the shopping, is there anything you are learning in school that would help you to do that better?
20) Do you have any hobbies that you can do better because of what you are learning at school?

21) How does learning to count help you?
22) How does learning to read and write help you?
23) How does learning to draw help you?
24) How does learning to sing help you?
25) How does learning to play games in the gym help you?
26) How does doing science experiments help you?
APPENDIX B

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APPENDIX B

INTERVIEW TWO WORD PROBLEMS
TRANSFORMING EXPERIMENT ONE

1) *There were nine people who wanted the breakfast special in the restaurant. How many grapefruits does the restaurant need to buy for them if each person gets a half a grapefruit?

2) *A recipe for muffins calls for 7/8th cup of bran and 5/8 cup of whole-wheat flour. How much more bran is used than whole-wheat flour?

3) *Jess lives 3/4th of a mile from school. How far does he have to go after he has walked 1/2 mile?

4) *Noell lives one mile from school. How far does she have to go when she has walked 3/10th of a mile?

5) *Sometimes boards are bolted together to give more strength. A 5/8 inch wrench was too small for a nut. Is the next larger size a 13/16 inch wrench or a 3/4 inch wrench?

6) John lives four miles from school. How far has he walked when he has walked half way to school?

7) *Isabel had ten pennies. She spent 1/2 of them. How many pennies did Isabel spend?

8) Paul had twelve quarters at a video arcade. If he spent half his quarters on games, how much would he have left?
9) *Javier had 32 baseball cards. He gave away 1/4 of them. How many baseball cards did Javier keep?

10) *Keiko and Robert each got a pizza. Keiko's was cut into sixths. Robert's was cut into eighths. They both ate half of their pizzas. How many more pieces did Robert eat?

11) *The May family decided to cook 8 hamburgers at the picnic. The children ate 1/2 of them. How many hamburgers did the children eat?

12) *Two chickens were packaged together for an order. One chicken weighed 2 and 3/4 pounds. The other weighed 2 and 1/2 pounds. What was the total weight of the order?

13) Two chickens were packaged together for an other order. One chicken weighed 20 and a 1/2 pounds. The other weighed twenty and a 1/4 pounds. What was the total weight of the order?
APPENDIX C
APPENDIX C

INTERVIEW TWO FOCUS QUESTIONS
TRANSFORMING EXPERIMENT ONE

1) What is this question asking you to do?
2) Do you think that you can do it?
3) How would you do it?

4) Who do you think (name of subject in the problem) is?
5) Why do you think she/he is part of the problem?
6) Is (name) important to solving the problem?  
   (If no, why is it given as part of the problem?)

7) To do think that this problem could exist in real life?
8) Do you think that it is important that you get the right answer?
9) Why (not)?

10) Have you ever been in this kind of situation before?
    
    Explain what happened.
    How did you deal with it?

11) If no) How would you have gone about dealing with this situation?
APPENDIX D

INTERVIEW THREE WORD PROBLEMS
TRANSFORMING EXPERIMENT TWO

1) There were nine people who wanted the breakfast special in the restaurant. How many grapefruits does the restaurant need to buy for them if each person gets a half a grapefruit?

2) A recipe for muffins calls for $7/8$th cup of bran and $5/8$ cup of whole-wheat flour. How much more bran is used than whole-wheat flour?

3) Sometimes boards are bolted together to give more strength. A $5/8$ inch wrench was too small for a nut. Is the next larger size a $13/16$ inch wrench or a $3/4$ inch wrench?

4) Isabel had ten pennies. She spent $1/2$ of them. How many pennies did Isabel spend?

5) Paul had twelve quarters at a video arcade. If he spent half his quarters on games, how how much would he have left?

6) Javier had 32 baseball cards. He gave away $1/4$ of them. How many baseball cards did Javier keep?

7) Keiko and Robert each got a pizza. Keiko's was cut into sixths. Robert's was cut into eighths. They both ate half of their pizzas. How many more pieces did Robert eat?

8) The May family decided to cook 8 hamburgers at the picnic. The children ate $1/2$ of them. How many hamburgers did the children eat?
APPENDIX E
APPENDIX E

INTERVIEW THREE FOCUS QUESTIONS

1) Do you know what these [grapefruits] are?
2) Have you ever eaten one?
3) How does knowing numbers help you work with grapefruits?
4) Read question to student. Use the grapefruits in front of you to help you work out your answer.
5) Do you know what these [measuring cup and drinking cup] are?
6) How does knowing numbers help you do things with these cups?
7) Read the question. Which one of these would you use to help you work out an answer to that question?
8) Have students show were the cup would be filled to for each amount.
9) Do you know what these [wrenches] are?
10) Which of these wrenches is the biggest/smallest?
11) How do you know?
12) What do you think those numbers marked on them mean?
13) [Present bolt in the wood] Which of these wrenches would fit this nut?
14) Count the pennies here.
15) How does knowing about number help you when working with things like pennies?
16) Read question. Show me how you could those pennies to check your answer.
17) Count the quarters.
18) Read question. If you had to divide those quarters among four people how would you do it?
19) Do you know what these [baseball cards] are?
20) How does knowing about numbers help you to work with baseball cards?
21) Count the cards.
22) Read question. How can you use those cards to answer that question?
23) How does knowing about numbers help you when working with pizza?
24) Read question. Use the pizza to help you answer that question.
25) Who gets the most pizza to eat?
26) How many buns are in this bag?
27) Read question. How can you use these buns to help you answer that question?
APPENDIX F
APPENDIX F

TEACHER INTERVIEW QUESTIONS

1) What is your name?
2) What is your teaching experience?
3) How many years have you taught at Linden Park?
4) What do you think are the qualities of Linden Park that set it apart from other schools?
5) What do you think is the purpose of schooling for your students?
6) If you were to ask students why they come to school, what do you think they would say?
7) How do subjects done in school prepare students for life?

8) Faced with the question: There were nine people who wanted the breakfast special in the restaurant. How many grapefruits does the restaurant need to buy for them if each person gets a half a grapefruit? how do you think the students would interpret that question?
9) What other ways do you think students would use to solve the problem?
10) How do students use fractions outside of school?
11) What is the learning value of students working through math word problems?
12) Do you see any distinguishing features in the use of fractions between asking a child 1/2 of twelve, as opposed to sharing twelve items equally between two people?
13) What kind of differences?
14) Does schoolwork recognize such differences?
15) What kinds of knowledge and skills do you consider most important for your students?
I like myself.
I am responsible for my actions.
I am going to do my best.
APPENDIX H
**APPENDIX H**

**SCHOOL DAILY SCHEDULE**

<table>
<thead>
<tr>
<th>TIME</th>
<th>MON</th>
<th>TUES</th>
<th>WED</th>
<th>THURS</th>
<th>FRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00-9:30</td>
<td>Silent Reading</td>
<td>Silent Reading</td>
<td>Silent Reading</td>
<td>Silent Reading</td>
<td>Silent Reading</td>
</tr>
<tr>
<td>9:30-10:30</td>
<td>Reading</td>
<td>P.E./Art Music/Library</td>
<td>Math</td>
<td>Language Arts</td>
<td>Math</td>
</tr>
<tr>
<td>10:30-11:45</td>
<td>Language Arts</td>
<td>P.E./Art Music/Library</td>
<td>Language Arts</td>
<td>Math</td>
<td>Language Arts</td>
</tr>
<tr>
<td>11:45-12:45</td>
<td>Lunch Recess</td>
<td>Lunch Recess</td>
<td>Lunch Recess</td>
<td>Lunch Recess</td>
<td>Lunch Recess</td>
</tr>
<tr>
<td>12:45-1:00</td>
<td>Care Club</td>
<td>Care Club</td>
<td>Language Arts</td>
<td>Care Club</td>
<td>Care Club</td>
</tr>
<tr>
<td>1:00-2:00</td>
<td>Math</td>
<td>P.E./Art Music/Library</td>
<td>Vocal Music</td>
<td>Math</td>
<td>Math</td>
</tr>
<tr>
<td>2:00-2:15</td>
<td>Recess</td>
<td>Recess</td>
<td>Recess</td>
<td>Recess</td>
<td>Recess</td>
</tr>
<tr>
<td>2:15-3:00</td>
<td>Health or P.E./Art Music/Library</td>
<td>Math</td>
<td>Health or</td>
<td>Health or</td>
<td></td>
</tr>
<tr>
<td>3:00-3:30</td>
<td>Science or Social Studies</td>
<td>Language Arts</td>
<td>Language Arts</td>
<td>Science or Social Studies</td>
<td>Science or Social Studies</td>
</tr>
</tbody>
</table>

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APPENDIX I
APPENDIX I

CLASSROOM LAYOUT
APPENDIX J

PROPORTIONAL SIZES OF WRENCHES
APPENDIX K

TEACHER PROFILES

Mrs. Mulholland is a Betelgeuse Learning Community teacher. She had been teaching for sixteen years, together with five years of tutoring. She had been full time at Linden Park for three years. That she came to teach in this school has much to do with the fact that not only did she make special efforts to have her own children attend this school when they were younger, but Mrs. Mulholland also did voluntary work for the school as a tutor. Mrs. Mulholland is qualified with a Bachelor of Science degree in elementary education and Special Education certification.

Mrs. Hemp is a Betelgeuse Learning Community teacher. She had been teaching for twenty one years; eight with hearing impaired students, and thirteen at Linden Park. Mrs. Hemp has a Bachelor of Arts degree in elementary education and a Master of Arts degree in supervision. She also has certification to teach the hearing impaired.

Mrs. Morrison is a Betelgeuse Learning Community teacher. She had been teaching for seven years, including five years at Linden Park. She has a Bachelor of Arts degree in elementary education.

Mrs. Hall is a Betelgeuse Learning Community teacher. She had been teaching for thirteen years; nine of those years at Linden Park. She has a Bachelor of Arts degree in elementary education.
APPENDIX L

STUDENT PROFILES

Michael Burton was a third grade student, age eight. He came from a two parent family and had one younger brother. Both his parents had college degrees. His mother worked at Ohio State University as a zoologist professor. Michael was in the top math section. He acknowledged math as his favorite subject in school. This claim is evidenced during "silent reading" periods. During these times, Michael read his math book. Michael indicated that he could get through his math work "like a bullet" (a14). As a third grader he found the fifth grade text book "easy." He was confident with the math work he did in school and confidently pointed out, "Decimals, fractions, geometry, ... almost anything you can think of I can handle" (a20).

Michael was, indeed, a good student in terms of doing well in school based activities. He was in the top section for all his subjects and all his teachers recognized his ability to learn quickly and accomplish tasks without too much trouble. Although he didn't hold reading to be one of his favorite activities in school, he did acknowledge that reading was one of his pleasure pastimes. He liked adventure books and he indicated that he was getting interested in learning German but had difficulty in finding spare time to pursue this interest. Given the choice to come to school or not, Michael would have chosen to come to school.

Vicky Morrison was a fourth grade student. She was in the top math section. She was recognized by her teachers as a very capable student who found little difficulty with doing school
based work. Her mother was an instructional aid in an elementary school. Her father was an accountant. Vicky attributed her "love" of math to her father's influence. As she put it, "My dad loves math and that is why he is an accountant. He got me 'into' math" (b12). Vicky was also learning to play the violin. Given the choice to come to school or not, Vicky would choose to come to school.

**Lawrence Simpson** was a third grade student. He was in the intermediate math section. His mother worked to support the family. He was also in the intermediate groupings for all grouped subjects. Teachers acknowledged that he was a hard worker in all his school activities. Lawrence enjoyed math but wasn't too clear as to why. He just found it interesting and declared his interest in math was because of "the stuff you learn" (c6). The subject he disliked most was reading, although he made an exception to that when he had books on basketball which for Lawrence was a passion. Indeed, he wished to be a basketball player when he grew up. This is evidenced by Lawrence during recess when he tended to play basketball with his friends. Given the choice to come to school or not, Lawrence would only come to school some days; apparently he didn't like the cold days.

**Eron Barbour** was a third grade student. He was in the intermediate math section. Both his parents worked; his mother in a nursing home, his father in a factory. Eron said that his favorite subject was math (e.22). He attributed his enjoyment of math to the fact that, as he said, I am, "... kinda good at it. Whenever somebody has trouble with it I can go over and help them" (e32). His second favorite subject was reading (e24). His teachers recognized Eron as a hard working student. He was an active boy who enjoyed soccer. He played center forward for a team known as "The Copperheads." Eron enjoyed coming to school (e.27). He was also learning to play the piano. His interest probably came from his mother who played at Eron's church. Given the choice to come to school or not, Eron would choose to come to school every day.
Mary Duffy was a fourth grade student. She was in the intermediate sections in all her core subjects. Mary was a quiet girl who was recognized by her teachers as a hard worker. Both her mum and dad worked. Her mother delivered advertisements from door to door, while her father worked nights at the post office. Mary found reading to be her favorite subject (g18). She read for pleasure. Mary liked school and attributed this to the fact that she "likes to learn" (g6). Given the choice to come to school or not, Mary would come to school every day.

Benita Getting was a fourth grade student. She was in the low math section. She was also in low sections for all her core subjects. Benita was a new student to the school this year (1991). At the start of the year she was identified as being remedial in all core subject areas but she was recognized by her teachers as outstanding in terms of her progress. Indeed during one of the "Pride Talk" assemblies Benita won several awards for progress and for being such a helpful person as evidenced from the number of Care Club slips she had had written out for her. Despite Benita's progress within the Betelgeuse Community, it was felt that she should be held back from moving up to fifth grade at the beginning of the new school year. Given the choice to come to school or not, Benita would come to school every day.

Thea Michaels was a third grade student. She was in the low math section but pointed out that math and reading were her two favorite subjects (j4). Thea was in the intermediate section for English. Given the choice to come to school or not, Thea would choose to come to school only sometimes, having a particular liking for "activity days."

John Forbes was a fourth grade student. He was in the low math section. Both his parents worked; his mother baby-sat and his father was a mechanic. John was also in the low sections for other core subjects. John described math as his favorite school subject (k4). Given the choice to come to school or not, John unequivocally declared that he would not go, even though he also stated that he liked school.
Latishia Robinson was a ninth grade student. She was in the top math section, but it was pointed out by her math teacher that she often had difficulty with the work although she can eventually accomplish what had to be done. Both her parents were unemployed. Latisha described math as her favorite subject. She attributed this to finding math easy (L11). When asked in more detail how she found math-work, she acknowledged how difficult the work was for her. Given the choice to come to school or not, Latisha would come every day.

Steven Black was a fourth grade student. Steven was in the top math section. Both his parents worked; his mother was a nurse and his father worked at an electronics factory. He liked math, but consistently declared that he did not like to write (m50). He found writing tedious. Steven was considered by his teachers to be a particularly "bright" student. Some evidence of this came when his classmates tried to use the class pencil sharpener that had a missing part to the handle. While the others struggled to use what was left of the handle, Steven used one pencil as a handle while he sharpened his other one. Given the choice to come to school or not, Steven would come every day.
APPENDIX L

List of data codes

Student interview data are coded with reference to the student, the interview in question, and the line reference number derived from the study transcript documents.

For example:

\texttt{a17} refers to line seventeen of the first interview with student a.
\texttt{aa17} refers to line seventeen of the second interview with student a.
\texttt{aaa17} refers to line seventeen of the third interview with student a.

Teachers are designated by a letter with an asterisk, and then the line reference number derived from the study transcript documents.

For example:

\texttt{a*20} refers to line twenty of the interview with teacher a.
LIST OF REFERENCES


