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Cultural contexts and mathematical practices: A study of school children, newspaper vendors and cigarette sellers in Delhi

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CULTURAL CONTEXTS AND MATHEMATICAL PRACTICES:

A STUDY OF SCHOOL CHILDREN, NEWSPAPER VENDORS AND CIGARETTE SELLERS IN DELHI

by

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Abstract

Cultural Contexts and Mathematical Practices: A study of School Children, Newspaper Vendors and Cigarette Sellers in Delhi

by
Farida A. Khan

Adviser: Professor Joseph Glick

This study was an attempt to discover the relationship of cultural contexts and mathematical practices of children in three different activities which require some amount of mathematical competence. Subjects were school children, cigarette sellers and newspaper vendors and the practices within which their mathematical practices are defined were the activities of schooling, cigarette selling and newspaper vending.

The first phase of the study consisted of detailed ethnographic observations of the activities, which was followed by a series of mathematical tasks. Subjects were assessed on their ability to count, their familiarity with the conventional orthographic representation of numbers and their knowledge of math facts.

Addition, subtraction, multiplication and division word problems on two levels of familiarity were administered to all three groups and performance was analyzed in terms of accuracy, strategies used and the types of errors committed. Significant main effects were observed for groups, operations and levels of familiarity. Results indicated that across operations and familiarity levels the cigarette sellers' accuracy levels were significantly higher than those of the school children and the newspaper vendors. Differences between the newspaper vendors and school children varied with operations and within the familiarity levels.

The newspaper vendors performed significantly better on the familiar problems as compared to the unfamiliar problems, whereas accuracy levels for both the school children as well as the cigarette sellers showed no significant differences for familiarity levels.

The two vending groups displayed marked similarities in using oral non-school strategies in contrast to the school group, which depended largely on written and school-algorithmic procedures. Consequently errors for the school group stemmed largely from their inadequate use of these algorithms, or the inability either to find the right procedure, or, having found it, to apply it correctly. Errors for the cigarette sellers were largely computational with some inability in working with large numbers orally. This inability of handling large numbers orally was also the major source of errors for the newspaper vendors.

The performance of the three groups was also compared on word problems using combined operations, profit and loss problems and a proportions problem and the performance of the two vending groups was better than that of the school children.

The results are taken as confirmation of the importance of locating practices and practicing individuals within the contexts in which they are functioning. The practice of schooling is revealed as an activity situated within "modes of thinking and ways of speaking" just as much as the practice of cigarette selling or newspaper vending is. The ways in which Vygotsky's socio-historical theory encourages investigations of the world of practices was explored as a means of understanding that practices are embedded in ideologies and socio-historical contexts and that in making claims about differences in cognitive functioning we need to be sensitive to these contexts.

Acknowledgements

This project was inspired by a course on culture and cognition taught by Sylvia Scribner, and it is under her guidance that the dissertation took shape. Working with her and learning from her was an invaluable experience for which I feel a deep debt of gratitude and hope that she would have approved of the finished work. I am very grateful to Harry Beilin for his help and guidance and to Katherine Nelson for her encouragement always. I am grateful to the faculty of the developmental psychology program for intellectual stimulation and to Brenda and Dianne for helping me through many administrative difficulties.

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The children I worked with were a source of joy, I thank them from the bottom of my heart and hope that some day this world will be a better place for them to live in. Along with the children I would like to thank their families, employers, associates and teachers, all of whom accepted my intrusion so willingly, and generously gave me all the help I needed.

Thanks are also due to my research assistants Anuradha and Amrita who besides their able assistance gave useful suggestions. My friends Ira and Amy were there through many difficult times: a special word of thanks for all it meant to me.

My deepest appreciation and gratitude go to my husband Arif and my two sons Ali and Abid, who have willingly and cheerfully lived and shared this experience with me and helped and encouraged me at every step. My mother and my brother Afzal have been a source of great

emotional support.

I dedicate this dissertation to my father, who encouraged me, inspired me and always believed in me. I deeply regret that he did not live to see me complete this work.

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NB.

This dissertation deals with children, their work practices and mathematics. For purposes of this study I have not highlighted the major policy controversies surrounding the relations between formal education and the attempts to teach working children in street-corner schools. My approach sees all three contexts studied here as "work practices" - including schooling. As such, "schooling" is not a unitary variable, but one which will vary with local conditions (children, teachers, resources, teacher's assumptions about children, etc.), and it does not have a "privileged place" in mathematics learning. As far as I could tell the children themselves were not "involved in" the controversy. To be sure there are socio-cultural factors which fall outside of my vision in this study.

Equally surely, one side or the other will attempt to appropriate the results of this dissertation to support their views. I remain convinced, however, that there is no substitute for a fine-grained analysis of the issues studied here.

CHAPTER 1.

Introduction

This dissertation is an attempt at understanding culture and cognition relationships - an enterprise that psychologists have undertaken seriously only in the last few decades. It is firmly rooted in the belief that "...subject and object, self and other, psyche and culture, person and context, figure and ground, practitioner and practice live together, require each other, and dynamically, dialectically, and jointly make each other up." (Shweder, 1990. p.1) Cognition is understood as activity, that is inextricably bound up with the practices and contexts that it operates within. Psychological functions are viewed not as abstract, decontextualized and transcendent, but as constituted within real, material beings situated in material cultures and contexts. A framework that offers a space for such research is that of activity theory (Leontiev, 1979), which takes culturally organized human activity as its primary unit of analysis. This framework evolved out of Vygotsky's cultural-historical theory of human development where "culture is understood as an accumulation of the social experience of humanity in the concrete form of means and modes, schemes and patterns of human behavior, cognition and communication" (Stesenko,1993. p.38). The main task of psychological research, asserts Stesenko, from this point of view is "to analyze and reconstruct all those multiple transformations of a certain type of activity which are crystallized in mature forms of human consciousness and hidden in them." (p.43)

Research programs within this framework which have shaped the present study and will be dealt with in more detail in the review of literature, are those of Scribner's laboratory at CUNY, Lave's studies with Vai tailors in Liberia and grocery shoppers in California, the work of Nunes, Carraher and their colleagues with street vendors in Brazil, and Saxe's work with the Oksapmin and with children in Brazil. Recent studies in the domain of mathematical thinking have been investigating such thinking as a function of the varying socio-cultural life experiences and contexts within which human cognitive functioning operates. Thus, in addition to the literature documenting the learning of school mathematics, there now exists an increasing body of literature on the development of mathematical reasoning in out-of-school situations and the contexts within which it is practiced. This research has given a new impetus to the culture-cognition relationship in analyzing and interpreting the texture of the interactions that exist between the functioning of the individual and his or her psychological and material environment and the shifting boundaries between the two. The present study is an attempt to carry forward this research, which encompasses the felt necessity to situate the study of cognition in a domain occupied by individuals in a material and social world, rather than as an *a*historical, *a*cultural phenomenon. The cognitive activity that this research undertook to study is the practice of arithmetic by children in school and children in work activities, which necessarily involve the practice of arithmetic. The study was carried out in New Delhi, India, where out of a population of 2.2 million children, 18% are working as registered or unregistered labor.

Subjects employed in two different vending practices which demand different levels of mathematical competence were compared to observe the differences in mathematical reasoning as a function of the vending practice. An attempt was made to investigate the role of schooling and school-learned mathematical strategies in order to observe how far the subjects incorporate them into their mathematical repertoire and in what contexts they are actually manifested by the concerned population. The richness of the interactions of the subjects and their practices is difficult to capture within a strictly psychological research framework, but some effort has been made to describe and to situate the doing of the arithmetic within the contexts where it is created and integrated and subsequently utilized in the service of the activity that the participant is engaged in.

Assessment and observations were carried out on three different groups of children - newspaper vendors, cigarette sellers, and a group of non-working school children. Their competence with arithmetical functioning, and ways of solving arithmetical problems are seen as a function of the everyday practices, the role that such practices assume for them as participants, and the social and material organization of the context within which the practices function and are situated.

CHAPTER 11.

Theoretical Perspectives.

Mathematics has traditionally been viewed as a highly abstract, formalized and theoretical system which fits perfectly into the mold of a decontextualized cognitive activity, so appropriate for experimental investigation. According to Hodgkin "Mathematics is the oldest science to develop a rigorous - even rigid - idea of its own practice, so that the scientificity of mathematics has come to seem not so much historical as natural after 2,500 years. The idea that the history of mathematics should include social determinants is seen as absurd even by Marxists." (Hodgkin, 1986, p.173) Two plus two make four is a "fact" that can be stated with a confidence that few other statements can. It carries a conviction somewhat of the weight of Descartes' "I think therefore I am." The concepts contained within this "fact" fit in easily with the classical view of concepts as having necessary and sufficient conditions which define them. Surely there is no room here for a fuzziness that needs recourse to an exemplar or prototype formulation, just as there is not much room for variations in an approach to solving such basic arithmetic problems. Such an assumption becomes valid within the confines of a traditional cognitive approach where rational abstract activity is clearly delineated from a concrete, contextualized sphere. However, when cognition is relocated within a context, and cognitive activity is situated in concrete everyday settings, the certainty of even such statements seems to flounder. The necessity of a grocery shopper who needs four items of a particular commodity buying five because of an offer of a discount, or that of a newspaper seller being content with the sale of ten papers when ideally he needs to sell 15 to cover his buying costs because "people don't have the time to collect the change and therefore they pay more for each paper", seems less compelling.

The research therefore that is situating and exploring mathematics in everyday activities is a confirmation of the belief that all scientific practice is social, and that all scientific knowledge changes character with changing culture. It brings into focus the social character of cognition and knowing. As Wittgenstein remarked : "Our children are not only given practice in calculation but are trained to adopt a particular attitude towards a mistake in calculating." (Remarks on the foundations of mathematics, V, 40).

Mathematics as the epitome of abstract and scientific reasoning has a long history. The Greek philosophers who pursued mathematics as pure knowledge, eliminated the physical substance from mathematical concepts. Arithmetic, said Plato, ``has a great and elevating effect, compelling the soul to reason about abstract numbers, and rebelling against the introduction of visible or tangible objects into the argument." (Kline,1953 p.33) The Greeks, enamored of deductive thinking, developed a highly theoretical mathematics. The Egyptians and the Babylonians who had a notable civilization as far back as 3000 BC, on the other hand, developed a mathematics rooted in the practicalities of physical reality. It was in the fusion of cultures at Alexandria that the pure mathematics of the Greek tradition was given application. According to Kline, "the new mathematics enabled men to travel over land and sea; the older one prepared him to sit motionless and to view with his mind's eye the immaterial abstractions of philosophic thought." (p.63) The contribution from the Indian civilization came in the form of the use of special number symbols from 1 to 9, the introduction of zero, and the use of the positional notation with base ten, which is the modern method of writing numbers. The formal system of present-day mathematics is therefore a product of this rich intermingling of diverse cultural origins; a legacy of cultures and of historical developments.

Among the earliest psychological studies of mathematical thinking was E.L.Thorndike's book titled "The psychology of arithmetic" which appeared in the U.S. in 1922. Thorndike, working in the associationist tradition formulated his "law of effect" followed by the law of exercise, on the basis of his extensive experiments with animals, which he applied to his later work in educational psychology. The law of effect was formulated as follows:

> Any act which in a given situation produces satisfaction becomes associated with that situation, so that when the situation recurs the act is more likely than before to recur also. Conversely any act which in a given situation produces discomfort becomes dissociated from that situation, so that when the situation recurs the act is less likely than before to recur. (1905, p.203)

The companion law of exercise stated that any response made to a given situation becomes associated to that situation in a way that the more it is used in response to that situation the stronger would be the association, just as prolonged disuse would weaken the association. Associationism therefore held that all knowledge however complex was built of the simple connections that had been observed in animal behavior and learning, and consisted only of establishing and strengthening the needed associations. Thorndike's book attempted to explain how the subject matter of arithmetic could be translated into stimulus-response bonds, which could then be strengthened by drill and practice. Although these theories fell into disrepute among psychologists, the usefulness of the drill and practice method in computation has persisted. In fact recent information processing theories focus on some possible justifications of drill and practice in so far as it promotes automaticity, therefore reducing the processing load on human memory and leading to more efficient functioning. This approach however is highly limited - it views the human organism as an automaton that is molded entirely by an associationist determinism and which plays no part in its own development.

In the constructivist approaches on the other hand individuals are granted a participant role in their development as cognitive subjects. The two developmental constructivist models which have greatly influenced and guided research in the area of cognition and culture are those of Piaget and Vygotsky. Piaget rejected both the empiricist and the nativistic formulations of intellectual development. In working out his theory he focussed on the child's construction of reality and the intellectual developments thereafter, arguing that the origins of logical structures are elaborated in sensorimotor activities and transformed into mental operations in the course of development. His formulation asserts that the logic of thought is preceded by a logic of action. The acquisition of knowledge is a constructive process that goes through an invariant sequence of stages which he identified as the sensorimotor, the pre-operational, the concrete operational and the formal operational stage. In his quest for studying the construction of reality Piaget has offered a developmental analysis of several logico-mathematical concepts, such as those of space, time, cardinal and ordinal number and the composition of numerical relations. It was in 1941 that he, along with Szeminska, published 'The child's conception of number'. The number concept, he stated, presupposes the principles of identity and conservation, and like other rational concepts, developmental changes in each of these is a manifestation of a general shift in the structures of logico-mathematical thought. The progression is from a stage where the child is unable to conserve, through a period of wavering and conflict, to a stage where the child no longer needs to reflect, but knows necessarily that there is a conservation of total numbers when in fact nothing has been added or taken away. Prerequisites for the number concept are the principles of one-to-one correspondence, ordinality, cardination and seriation (Piaget, 1965). Number is a synthesis of classes and relations and consequently the operations for classes, relations and numbers should appear about the same time in the developmental sequence. It is at the concrete operational stage that the child learns to deal with number as an abstract entity apart from its physical concomitants, where the logic of relations and the logic of classification are integrated. Later psychologists working within the Piagetian framework, have looked at the socio-cultural influences on cognitive development (Dasen, 1972) though Piaget himself had not shown any inclinations for such investigations. Chapman (1988) argues that though Piaget's own interest was in the form rather than the functions of the logico-mathematical structures, he neither that the structures function in a context-free manner nor did he ignore their functional aspect and quotes Piaget:

> In our hypothesis, according to which logic is constructed, it remains to be proved that a formal mechanism like the composition of two relations can be elaborated independently of the contents to which this coordination is applied. Conversely one can expect that the formal structure (X=Y; Y=Z therefore X=Z) is not acquired all at once independently of its content, but requires as many distinct and repeated acquisitions as there are contents to which it is applied. What is more, the formal structure (X=Y; Y=Z therefore X=Z), like all formal structures, is only a coordination of a particular grade, capable of being carried out only as a function of the comprehension (structuration) of the terms or relations coordinated and consequently having to be reconstituted in the form of a new coordination every time it is applied to a new class of objects of thought. (Piaget & Szeminska, 1941/1964, p.263)

This has without doubt been the most influential theory in the area of cognitive development and research generated by it probably forms the bulk of what has emerged in this field in the last few decades. The fact however remains that sociocultural factors are subordinated to the equilibration process and consequently they are seen to interact as external variables and not as involved and complex interactions within which the individual ultimately develops.

The concept of broad stages of development and the concomitant "structures d'ensemble" in Piaget's theory have consistently been a target of criticism. Research on children's number conservation strengthened these criticisms and led psychologists to posit more domain-specific approaches. Gelman and Baillargeon argue "for domain-specific descriptions of the nature as well as the development of cognitive abilities." (Gelman & Baillargeon, 1983) There is evidence indicating that children who are not able to conserve in Piaget's classical experiments are nevertheless capable of grasping the concept of number and the process of counting with an understanding of the following principles:

1) The one-to-one correspondence principle, which states that each item in an array has to have a unique tag.

2) The stable order principle: that tags used for identifying items must be arranged in a stable

order.

3) The cardinal principle: the cardinal value of a set of items is represented by the final tag used in tagging these items.

4) The abstraction principle: that the preceding three principles can be used for any collection of discrete items, no matter what the nature of the items, and,

5) The order irrelevance principle: which states that the order of enumerating the items is irrelevant so long as the how-to-count principles are honored (Gelman and Gallistel, 1978).

This research reveals that children have some understanding of the counting principles as early as the preschool age. Groen and Resnick (1977), have demonstrated that not only do they understand the principles but that children around 4 years of age can make use of a counting algorithm in solving simple addition problems, and at a little over two years have demonstrated a systematicity in using number lists that Fuson & Richards (1979) call standard and Gelman & Gallistel (1978) call idiosyncratic. Development in Piaget's theory is explained by an active constructive process. This process is also a dialectical one wherein tensions in the understanding of reality are resolved by the construction of more adequate structures and on these depend the cognitive functioning of the individual. The spate of cross-cultural research generated by this theory addressed the universality of these constructive processes but instead of characterizing the richness and variety of cultural forms, the agenda was one of unifying and abstracting, to arrive at general principles of understanding human development. The search however proved elusive and research produced findings for which existing theoretical explanations did not seem adequate.

The theory which does address issues of culture and socio-historical contexts is that of the Soviet psychologist, L.S.Vygotsky. Cross cultural tests of Piaget's theory helped to highlight the usefulness of Vygotsky's ideas and to focus on development within these varying socio-historical and cultural contexts. Vygotsky formulated his theory within Marx's historical materialism elaborated on Engels' concept of human labour and tool use as the means by which man changes nature and in so doing transforms himself (Thought and Language, 1962; Mind in Society, 1978). One of the central premises of this theory is that the development of the higher mental functions begins on a social plane. According to Vygotsky, "All higher mental functions are internalized social relationships.... Their composition, genetic structure and means of action - in a word their whole nature is social." (Vygotsky, 1978, p. 164) The social and the cultural are therefore inseparable from the individual development that takes place in shaping human cognition.

> Cultural development is superimposed on the processes of growth, maturation, and the organic development of the child. It forms a single whole with these processes. It is only through abstraction that we can separate one set of processes from the other. The growth of the normal child into civilization usually involves a fusion with the processes of his/her organic maturation. Both planes of development - the natural and the cultural - coincide and mingle with one another. (Vygotsky, 1960, p.47)

The child appropriates means and modes of psychological functioning that have evolved socially and historically and it is this socially and historically constructed cultural context that acts as an impetus for potential development. Elaborating the concept of the `zone of proximal development', Vygotsky stated that there are two aspects of a child's development to be considered: the actual developmental level and the potential developmental level.

> The zone of proximal development is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers. (Vygotsky, 1978, p. 86)

Social settings and social interactions create zones of proximal development which at the outset are operational only in the social settings but are gradually "...internalized, they become part of the child's independent developmental achievement." (Vygotsky, 1978, p. 90) Research in different cultures with a focus on informal learning demonstrates how in the process of initiating novices into adult world activities, collaborative learning environments lead to acquisition of general cognitive skills (Greenfield, 1984, Lave, 1977; Lave, Murtaugh & Rocha, 1984).

The distinction between formal and informal systems of learning is captured in this theory in the distinction between scientific and spontaneous concepts, which have been dealt with in considerable detail, both in Vygotsky's writings as well as his research. He writes:

> Instruction has a decisive influence on the course of development because these functions have not yet matured at the beginning of the school age and because instruction organizes their further development and partially determines their fate. It is important to stress however that the same can be said of scientific concepts. The basic characteristic of their development is that they have their source in school instruction. Therefore the general problem of instruction and development is fundamental to the analysis of the emergence and formation of scientific concepts. (1978, pp.213-214)

Children develop spontaneous concepts in their everyday lives and informal encounters. The focus in the development of these concepts is the object and not the act of thought itself. The process of acquiring scientific concepts reaches far beyond the immediate experience of the child. The relationship between the development of the two types of concepts is however complementary and not contradictory - spontaneous concepts have their source in everyday activity and learning of scientific concepts raises them to a new level of consciousness, whereas scientific concepts have their source in formal instructional contexts and the course of their development is guided by their interface with spontaneous concepts.

In bridging the gap between the psychology of consciousness" and the "psychology of behaviour" Vygotsky introduced the concept of socially meaningful activity, which requires mediators such as *"psychological tools* and the means of interpersonal communication" and "establishes premises for the unified theory of behavior and mind" (Kozulin, 1986). Taking off from Vygotsky's ideas, activity theory (Leontiev,1978) deals with life processes that link together the subject's organization and the surrounding reality. The construct of activity unifies the individual, the world of objects and the society. According to Leontiev:

> The real function of this unit is to orient the subject in the world of objects. In other words, activity is not a reaction or aggregate of reactions, but a system with its own structure, its own internal transformations, and its own development. (1979, p.46)

Activity is therefore situated within a socio-cultural context, and forms a link between mental and behavioural processes. Activities can be analyzed on a number of levels: the guiding force at the level of activity is the motive; at the level of actions they are determined by goals, and at the level of operations, by the conditions under which they are performed. In Leontiev's formulation:

> Consequently, it is the activity of others that provides an objective basis for the specific structure of individual activity. Historically, i.e. in terms of its origin, the connection between motive and object of activity reflects objective social, rather than natural relations. (A.N.Leontiev, 1959/1981, p.281)

In this three-tiered model motives belong to a socially structured reality, whereas it is actions that function in the immediate reality of practical and concrete goals. Leontiev's model has come under criticism for its stress on the interiorization of ready made standards of behaviour and cognition and for its rejection of semiotic mediation while insisting on the role of practical actions. A reformulation of the theory and one that makes it more appealing is the effort to re-incorporate within activity theory Vygotsky's concepts of mediation and the mediated character of all human phenomena. In this connection Lektorsky states:

> The so-called inner world (and all processes connected with it) arises as a result of the outer activity of a subject mediated by intersubjective relations. In order to create or to change "inner" or "subjective" phenomena, it is necessary to create some objective thing, that is, a process of "objectification" is a necessary pre-supposition for the existence and the development of the ``inner" world. Thus what is most important about the features of human beings is that they (the features) are not naturally given, but mediated by artificial objects produced by human activity. (Lektorsky, 1993, p.49)

It is within this approach that the research and consequent writings of Cole, Scribner and their associates (Cole & Scribner, 1974; Scribner & Cole, 1981; Cole et al., 1971; Gay & Cole, 1967) are situated and also from within this literature and theoretical perspective that the concept of the "cultural practices" approach emerged. This hypothesis asserts that there are certain human capacities which are shaped by commonalities in the human condition and that many higher mental functions like perception, attention and memory involve the same psychological processes, though the life experiences in response to which they develop may vary. Differences in mental functioning on the other hand are a result of the way these capacities are organized and employed for particular purposes and hence the importance of particular contexts. According to Scribner & Cole (1981), "functional systems" are not unitary unchanging abilities but are situation specific and therefore sensitive to socio-historical changes.

While accepting Piaget's understanding of development as a series of qualitative changes that are actively constructed by the experiencing individual, this research leans heavily on Vygotsky's socio-historical perspective and the concept of activity as a unit of analysis. The focus on activity as 'functional systems' allows us to shift from the individual to the person-in-practice, and hopefully, to an understanding of the relationship between cultural experience and cognitive outcomes. This focus on functional systems acts as a deterrent to separating the individual from the world of experience and provides us with a framework within which to connect and ground the cognitive functioning to the cognizing individual as a social historical being.

This process of redefining the unit of psychological investigation necessarily excludes the concept of an isolated individual mind functioning within clear-cut boundaries. The boundaries of the person-in practice provide a permeability which allows the individual to possess a culture and a history which defines her. When we situate the subject in an activity we are recognizing the cultural baggage that pervades this unit. We are also recognizing the implication of a continuing and contextualized relationship which is dialectical and necessarily dynamic, and within which cognitive functioning can be understood as a focus of psychological investigation.

CHAPTER 111.

Review of relevant literature.

Research on the development of childrens' mathematical thinking and relevant to the proposed study is broadly categorized here as:

1. that coming out of the Piagetian perspective and the information processing theory and
2. that which can be referred to as the cognition-in-culture model and fits in well with the Vygotskian perspective.

Childrens spontaneous mathematical development.

Much of this research originally stems from Piaget's constructivist approach and stage theory of cognitive development and focusses on the emergence and understanding of number concepts in children. The information processing approach has been extensively used in research in this area, and though it has made valuable contributions to our understanding of these concepts, the socio-cultural context of development has been largely ignored, or used as one of many variables that have an impact on our cognitive development. A substantial body of work in this direction is that of Gelman and her associates, who have made an attempt to define more minutely the principles involved in the understanding of number, and to determine how early the child is capable of grasping these principles (Gelman, 1972; Starkey & Gelman, 1982; Gelman & Gallistel, 1978).

Klein and Starkey (1988), have presented a model of early arithmetic cognition which outlines three types of arithmetic knowledge that universally underlie young children's arithmetic thinking. These are: enumerative processes, computational procedures, and knowledge of the natural number system. Enumerative processes are used to generate numerical representations of sets of concrete or imaginary objects. Examples of these in early childhood include subitizing, correspondence construction, and counting. Computations, the second component, are the procedures children use to perform arithmetic computations on their representations of these sets. Knowledge of number systems constitutes the structural component of the model and is also believed to be universally present though it develops over a protracted period of time. Evidence for the presence of these systems is reported from research in Western as well as non-Western cultures (Gelman & Gallistel, 1978; Ginsburg & Russell, 1986; Saxe, Guberman & Gearhart, 1987; Siegler & Robinson, 1982.)

A large body of research of this nature focuses on the analyses of strategy choice and strategy use in the process of solving arithmetic problems. The target population is pre-schoolers and school children, and context is not a major consideration. This research tradition comes out of the cognitive-developmental theories such as those of Case (1985), Klahr (1984), Sternberg (1985) and Siegler and Shrager (1984). There is ample evidence to show that in solving arithmetic problems very young children use efficient strategies (Groen & Parkman, 1972), that they use a variety of strategies (Baroody,1984; Carpenter & Moser, 1982; Fuson,1982) and, that these strategies undergo developmental changes (Siegler & Shrager, 1984)

In an attempt to incorporate socio-cultural influences the research within this tradition has contrasted performance amongst different cultural groups, with a predominant use of Piagetian tasks. Ginsburg, Posner and Russell (1981) have explored the development of mathematical thinking within and across cultures and conclude that schooling furnishes subjects with certain specific problem-solving skills as much as certain cultural practices do in the absence of schooling.

Jill Posner (1978) looked at the effects of specific aspects of culture on the development of quantitative knowledge. Her research compared children from a merchant culture with children from an agrarian culture: the Dioulas and the Baoules of the Ivory Coast, and observed the effects of schooling in these two groups. She found that though all the groups conserved number by the age 9 or 10, the merchant culture and the schooled children were more advanced in the acquisition of the concept. She also reported that the schooled and the merchant groups were able to count more efficiently and to exhibit greater flexibility and efficiency in applying strategies than the agricultural group. She makes an interesting analysis of strategies that the children used on the basis of whether they guessed, counted or used math facts or pictorial representations of the objects to be counted. An error analysis also revealed differences in the modes of functioning amongst the three groups. Though this body of research has not explored the interplay between socio-cultural contexts and cognitive development, it nevertheless added to the understanding of some of the work that was undertaken on the development of mathematical understanding within socio-cultural settings.

Mathematical systems and practices within particular socio-cultural contexts:

Most of the research in this section is influenced or directly derived from within Vygotsky's socio-historical theory of cognitive development and the later activity theory approach. It represents a body of work that is steadily coming together in attempting to shift the focus of the study of cognition from the individual in the laboratory, to a broader understanding of cognitive functioning as distributed and dialectically created and manifested by the individual within a social and material world. It comes out of a felt need to situate cognition in its naturally occurring contexts, in the wake of diverse strands of research that demonstrated the ability of subjects to perform at different levels of competence with variations in context, presentation of tasks and familiarity of materials (LCHC, 1979; Rogoff, 1981). Gladwin (1970), reported phenomenal calculational capacities, memory and reasoning skills in Micronesian navigators, who performed very poorly on standard tests of intellectual functioning. Similarly, subjects dealing with skills in communication and logic displayed poor performances in test situations, but demonstrated perfectly adequate performances in familiar contexts (Labov, 1970; Cole, 1975; Scribner, 1976). This research has necessarily also resulted in a rethinking of the methodologies of traditional psychology, and opened the way for less rigid and formal ways of assessing and interpreting cognitive functioning of psychological subjects.

Attempts to document the use of indigenous counting systems in cultures that do not use the modern base ten system reveal that some form of counting is found to exist in virtually every culture (Saxe & Posner, 1983; Zaslavsky, 1973). Saxe (1982), in his detailed study of the numeration system of the Oksapmin, looked at the effects of socio-historical change as new forms of social interaction emerge in the community. In detailing the body-part counting system used by these people, he demonstrates how the introduction of a system of currency has necessitated a new form of exchange and therefore led to an adaptation of the numeration system. He also observed the learning of formal mathematics in school children to determine their use of body parts in solving school problems involving number. Children used the body-part counting system more efficiently with advancement of grade, whereupon he concludes that the changes observed were not simply the replacement of old forms with new ones, but that subjects were constructing more specialized forms of symbolization out of the existing ones.

Brenner (1985) studied arithmetic and classroom interaction and cultural practices among Vai children in Liberia, building on research carried out by Lave among adults in the same community (1977). The Vai number system is quinquavigesimal i.e., the numbers five, ten and twenty serve as basic tallying points for constructing other numbers, and basic operations in Vai have some procedural implications that differ from the English. In addressing the question of how children combine or reconcile their two systems of arithmetic when doing problems in school, she found that the children in her sample used a combination of Vai, school and invented arithmetic algorithms during both individual testing and classroom lessons and that each method was used with problems where it was most applicable.

Research across a range of cultural settings has revealed that children develop fundamental intellectual skills as a result of participation in school contexts, as well as out-of-school contexts (Greenfield & Childs; Cole, Gay, Glick & Sharp, 1971; Scribner & Cole, 1981). Gay and Cole working among the Kpelle in Liberia, were among the first to describe a traditional non-Western system of quantification and demonstrate its incompatibility with school mathematics. Lave's work with tailors in Liberia (Reed & Lave, 1979; Lave, 1982) focused on their arithmetical problem solving as a function of schooling and of the practice of tailoring. Her findings indicate that the extent of school experience was the best predictor of success for school-like problems, whereas success on tailoring problems was predicted by years of tailoring experience, which she views as supporting the cultural practices approach to cognition.

Rosin (1973) reports the performance of an illiterate Indian peasant, Rupsingh, in the calculation of the price of a quantity of gold. Rupsingh's arithmetic knowledge was derived from culturally shared, folk arithmetic techniques and invented strategies. His performance nevertheless indicated a well-integrated, reflective, and explicit knowledge of money, gold weights and of abstract numerical relations.

Scribner and Fahrmeier (1982), conducted a study of the practical arithmetical skills among workers in a milk processing plant. Workers in the plant, using arithmetical skills in their daily activities, were compared with fifth and ninth-grade children on school-like mathematical tasks involving number facts and mental and written computations. Though students and workers were equally competent on the last two tasks, workers demonstrated a higher accuracy on the math facts task. It was also observed that workers used memorized solutions or regrouping of numbers on the mental computation, whereas students resorted to school algorithms. A further comparison of students and workers on simulations of work tasks revealed that workers used a greater variety of strategies in performing the tasks and also achieved a greater accuracy in doing so.

Petitto (1979), in extending Lave's work on transfer of mathematical thinking from one context to another, looked at two professional groups: cloth merchants and tailors. The concrete contexts in which she assessed them were equally familiar for both groups (cloth, meter measures and money) but the operations required of each profession were different. In designing abstract mathematical problems, which were then posed to these two groups, she found differences in the groups that were related to the operations that each group was familiar with. The problems posed to the two groups involved operations that the merchants were more familiar with, and this was reflected in their performance in that tailors were less adept at solving problems which involved operations that they did not routinely perform. She concludes therefore that it is not only the familiarity of the contexts but also the familiarity with operations that may be needed for transfer to take place.

The adult math project undertaken by Lave and her colleagues argues for an approach where the activity to be studied is located in the everyday functioning in the lives of the participants (Lave,1988). The project focused on 35 subjects - men and women, 25 of whom participated in a supermarket study and 10 in a diet study. Participants varied in age, income, family composition and size, schooling and years since schooling had been completed. Observations of activity were followed by simulation problems - best-buy problems for the shoppers and meal preparation problems for the weight watchers. This was followed by a session of problems testing school math - a multiple choice test, paper and pencil math problems, number and measurement facts, mental math problems and calculator problems. Accuracy of shoppers on the math test was 59%, whereas in the price comparison in grocery shopping and the simulation tasks was as high as 98% (Lave, Murtaugh & de la Rocha, 1984; de la Rocha, 1985; Murtaugh, 1985; Lave, 1988). There was no significant correlation between frequency of calculations in the supermarket and scores on math test, multiple choice test and number facts. Scores within school-like math problems are correlated with each other, and age and schooling were good predictors of performance on the arithmetic scores. Supermarket and simulation problems indicated a success rate that had no statistical relationship with schooling, years since schooling was completed, or age. Amongst strategies used for the best buy problems were left to right calculation, recomposition, rounding, ratio comparison, transformation of both problems and solutions in the course of problem solving and use of the environment as a calculating device.

Carraher, Carraher & Schliemann (1985, 1987), carried out research with children and adults who are engaged in practices that involve the use of mathematics in situations outside of school. In a series of studies they have been observing and analyzing what they designate as mathematics `in the streets' and looking for a relationship between this mathematics and the mathematics taught in schools. They found evidence of within-subject differences in the practice of mathematics depending on the context within which the problems were presented. Five children ranging in age from 9-15 years and in schooling from first to eighth grade were used in the study. Subjects were administered an informal test consisting of 63 questions about actual or potential purchases in the subject's natural working conditions. This was followed by a formal test constructed for each child on the basis of the informal items they had earlier solved, and consisted of 99 questions. Each subject was given a score based on the percentage of correct items and comparisons were made on the basis of the rates of correct responses between the informal condition and the formal condition, the latter sub-divided into word problems and math operations. Subjects performed significantly better on the informal test than on the formal test involving operations. Subjects gave 98% correct responses in the street, 74% when solving word problems, and only 37% when asked to solve computational problems. They also approached the problems differently - problems in the street were solved orally, but the word problems and the computational problems led the children to resort to writing, and the use of school algorithms (Carraher, Carraher and Schliemann, 1985). A later study (Carraher, Carraher, & Schliemann, 1987), was carried out with 16 third-grade children, who were tested under three different conditions. Differences in performance that were observed were attributable to the form of representation used by the child, since children spontaneously employed oral or written solutions across conditions. A detailed analysis of the oral procedures revealed the use of the following hueristics:

1. Decomposition: This consists of breaking down numbers into parts and operating sequentially on the parts. Although this is a strategy that draws upon properties underlying the school taught algorithm, the school algorithm is performed in the direction units to tens to hundreds, while the oral procedure follows the direction hundreds to tens to units.

2. Repeated groupings: This is used in the case of multiplication and division - the strategy is to use repeated additions and subtractions respectively.

Acioly & Schliemann, (1989) in a study with lottery bookies, examined their arithmetic performance with familiar and unfamiliar lottery problems. Higher levels of schooling led to more accurate solutions and greater flexibility and variety of strategy use with both kinds of problems. Subjects with less schooling did well on the familiar problems but not on unfamiliar ones. These and other subsequent studies with farmers and carpenters (Grando,1988; Schliemann,1984) have led them to conclude that mathematical problem solving involves the use of two types of representations: 1. representation of the problem situation and 2. representation of the mathematical relations. School based mathematics concentrates heavily on the second, and in fact tries to get away from the problem solution so as to maintain its abstract character. Street mathematics on the other hand focusses on the problem situation and connects the mathematical relations to it, as a result of which the problem solving strategies are related to the situation and solutions tend to be more accurate (Nunes, Schliemann and Carraher, 1993).

In a series of studies and a sustained research program starting with his investigations of the Oksapmin number system and its applications, Saxe has formulated a framework for the study of culture and cognitive development. Three analytic components form the core of this framework: goals that emerge from participation in cultural practices, the cognitive forms and functions constructed to these goals and interplay between forms linked to out of school practices to forms linked to school practices (Saxe,1991).

A study in 1988 compared 23 sellers with 20 urban non-sellers and 17 rural non-sellers, to investigate whether engagement with practice-linked problems leads children to construct differing forms of mathematical understandings. Subjects were presented with the following tasks:

a) Identifying and comparing numerical values.

-identifying numerical values using the standard orthography,

-Identifying numerical values on the basis of the orthography versus figurative characteristics of bills, and

-Identifying numerical relations between currency values.

b) Arithmetic: Addition and subtraction of large values, and

c) Ratio comparisons.

Responses were scored for accuracy in every category, as well as for coding categories identifying errors (on the first task), categories for different magnitudes of errors (on the arithmetic problems) and adequate judgements and justifications (on the ratio problem) .

Results of the study indicate that vendors and non-vendors had both developed non-standard means of representing numerical values which is explained by the fact that these currency values are used in the course of the everyday activities of each group. For both the addition and subtraction problems, the urban children gave more adequate responses, whereas urban sellers fared better on the subtraction tasks. As for the ratio problems, sellers generated more sophisticated understandings than the other two groups, which confirms the hypothesis that children generate mathematical problems as they participate in cultural practices, since this was the only group that dealt with ratio problems in their everyday activities.

A later project explored the interplay of mathematical learning that occurs in and out of school (Saxe, 1991). Subjects were candy sellers with varying amounts of schooling and school children with varying amounts of street-vending experience. The purpose of the study was to assess if formal schooling has an impact on the way children conceptualize and solve mathematical problems in informal practices, and conversely, if children's participation in cultural practices that involve math has an impact on the way they conceptualize and solve school problems. To study the influence of school experience, vendors were asked to solve mathematical problems involving mental representation, arithmetic and ratios, based on earlier observations where children involved in vending were addressing such problems. On problems of representation, the study provides evidence that sellers with little or no schooling construct a representational system linked to their medium of exchange - in this case the size of the bills being used as token of the number. Arithmetic problems requiring them to add and subtract currency denominations were used to assess their arithmetic problem solving capacities, and though no differences were noted in addition strategies, subtracting strategies did demonstrate differences. Sellers with greater levels of schooling were more likely to use paper and pencil strategies, though there was no difference in the accuracy of answers. For the ratio problems, sellers of all school levels demonstrated adequate understanding.

To study the effects of vending experience on schooling, children were asked to solve arithmetic problems involving addition, subtraction, multiplication and division. Children's solutions of these problems differed as a function of their vending experience. At an earlier grade level the vendors had a greater number correct than the non-sellers, though this difference was attenuated for a later grade. Sellers made use of the regrouping strategies which helped them with the problem solutions and also showed evidence of combining this strategy with school algorithms as a more efficient way of solving school problems.

Much of this research has focussed on the development of arithmetic and other mathematical skills as a function of schooling, and as a function of participation in cultural practices other than schooling. Repeatedly, findings reveal that schooling and formal teaching are not the only sources of mathematical knowledge and practice. The object of study in this research enterprise is clearly more inclusive than an abstracted individual, and the studies quoted above are concerted efforts at discovering practices and the characteristics of the specific experiences which lead to this knowledge and competence.

This review therefore underlines the usefulness of the study of mathematical reasoning and arithmetic practice as an important site for the understanding of cognition and cognitive development. It brings to the fore several questions that face the investigations of cognition as a subject matter of psychology. Although mathematics has an immaculately defined status as an academic discipline, the research quoted above which focuses on how this body of knowledge is acquired and practiced raises questions about its abstract and disembodied nature. It becomes an enquiry into the acquisition and development of mathematical concepts within everyday activities, whether it is schooling, street vending or another activity involving the manipulation of number. Situating the mathematical transactions within the practices in which they are embedded is an important part of this research program. The boundaries between what has been termed as formal and informal mathematics are hard to define, just as it is difficult to categorize those who are aware of their `doing mathematics' from those who are involved in practices that involve mathematics, but are not conscious of it.

This research also emphasizes Vygotsky's observations of basic versus higher psychological functions and the dependence of the latter on the symbol systems available. Some of these systems, such as language, are universal but others are culture-specific and therefore necessarily produce differences in the organization of the psychological functions. Vygotsky wrote about this course of development:

> The use of notched sticks and knots, the beginnings of writing and simple memory aids all demonstrate that even at early stages of historical development humans went beyond the limits of the psychological functions given to them by nature and proceeded to a new, culturally-elaborated organization of their behaviour..... we believe that these sign operations are the products of specific conditions of social development. (Vygotsky, 1978, pp. 38-39)

Amongst these culturally elaborated systems he classifies mathematical languages and their accompanying symbolic forms such as numbers and notational systems. That societies and cultures the world over have one or another such system available is evidence of the universality of such functioning. But just as, within the universality of language, the forms of speech bear the unique features and developmental influences of a particular cultural group, mathematical systems and their forms are modified and enriched by the contexts of their functioning, the accumulated experiences of a society and its culture and the personal experiences of those encountering it.

CHAPTER 1V.

Methodology.

The aim of this study was to understand the differences in the practice of arithmetic as a function of the different settings within which it emerges, which are characterized here by the three activities of schooling, cigarette selling and newspaper vending. Since the research is premised on the belief that cognition cannot be completely understood outside its cultural and social context, the settings within which these activities emerge are seen as crucial to the mathematical functioning and competence of the participants in the experimental setting created during the course of this research. As a first step it was necessary then to arrive at a meaningful understanding of the activities and the participants, and the levels and modes of interaction between the two.

The study used both observational and experimental methods in an attempt to situate the cognitive functioning within its social and material context. The research was consequently conducted in two phases, the first of which consisted of detailed observations of the activities and the participants of these activities. This enabled the formulation of the more specific research questions and the selection of subjects for the second phase of the research. The second phase focused on the selected sample of 48 children, who were observed in the course of their work and school activity. Detailed interviews were carried out with them and finally a battery of arithmetic tasks (constructed on the basis of observations in the first phase), was administered. The activities chosen for the study were:

1. Newspaper Vending: The afternoon and evening newspapers in Delhi are sold by hawkers in the busy shopping centers and at major traffic lights. A large number of children are involved in this activity and make their daily living out of it.

2. Cigarette and *paan* selling: The paan is a betel leaf preparation, with or without tobacco,

consumed widely all over India. Paans are freshly prepared and sold at the paanshops, and it is the sale of the paans that chiefly draws customers to these shops. The activity of paan and cigarette selling is largely restricted to adults but there are establishments that employ children as assistants, and who are often left to manage the shops on their own. Some children run the establishments unassisted and therefore are solely responsible for all money transactions.

3. Schooling: Since India provides free elementary education, and mathematics forms a core part of the school curriculum, mathematics as formal school practice was chosen as the third site to explore the relationship between formal and informal cultural practices in the construction of mathematical understanding.

CHAPTER V

Phase 1. The School, the Shop and the Street as Sites of Arithmetic practice

The first phase of the study relied on participant observation and ethnographic methods, with the help of which, data about the groups was collected over a period of about 5 to 6 months by the researcher, using a variety of formal and informal methods. This was an important pre-requisite to the second more formal and structured phase of data collectioon. Since the study aimed at exploring arithmetic practices within the activity of the participant, it was important to discover the nature of the given activities, the forms of participation by the individuals and the socio-cultural context within which the activities unfold, and over which they are distributed.

The Setting:

This research was carried out in Delhi, the capital of India. The site was chosen because of a large population of working children that exists in this city. Children are employed in several different kinds of street-vending activities which necessitate the use of numbers and number representations and a variety of mathematical skills.

India is a country of about 850 million people and is divided into twenty-two states and nine union territories. The constitution of India has specified fifteen languages besides English which are used in the country, in addition to a number of dialects. Every major religion is represented in India, which adds to the cultural diversity of the nation.

The population of working children in the union territory of Delhi is (conservatively) estimated at 400,000, which is 18% of its total child population (Panicker & Nangia, 1992), though the 1981 census puts this number even lower at 26,000. Most of these children are migrants, living alone or with their families, largely from the neighbouring Hindi-speaking states though there are migrants from other states as well. There is, however, an erroneous assumption that all children in urban areas have the benefit of various services that exist in that environment, one of these being education. In actual fact nearly 42.5 million children in India live in dire poverty in the urban slums (Swaminathan, 1979).

With the attainment of independence in 1947, and the enactment of the constitution of India in 1950, universal elementary education was made a priority issue. Article 45 of the Indian constitution states that "the State shall endeavour to provide, within a period of ten years from the commencement of this constitution, for free and compulsory education for all children until they complete the age of 14 years." Efforts to implement this directive have been made through successive 5-year-plans. During the sixth 5-year-plan, enrollment in classes 1 to 5 was expected to increase from 71 million to 82 million. Economic exigencies, however, prevent such plans from being put into practice. Families that can barely make ends meet, need the human resource that the children provide and therefore cannot afford to send them to school. In rural areas, children add to the agricultural work force and help their parents with farming and household work. In the urban areas, families having migrated to the cities in search of jobs, find it impossible to cope with the expenses of living and again need the children as extra sources of income, however meager they may be.

The Activities:

The following sections presents the information gathered in the first phase of the study. The focus of the investigations was the practice of arithmetic within the broader work activity, therefore the activities are described from that vantage point.

1. Schooling.

Data on schooling was gathered from two N.D.M.C. schools in the New Delhi district through:

1. Classroom observations,

2. Interviews with teachers,

3. Interviews with students, and,

4. Perusal of textbooks and study materials.

The New Delhi Municipal Committee is one of the government organizations which runs a network of schools in New Delhi, and caters to the working class population of the capital. It is from within this system that the sample for the present research was selected. This particular student population became the target of observation as it is roughly equivalent in socio-economic status to the two working groups that the study focusses on, i.e the newspaper vendors and the cigarette sellers. Children from both these groups who had attended school or are presently in school were registered in the NDMC schools. The schools are governed by the central board of education, and follow the syllabi laid down by the National Center for Educational Research and Training. Rules governing the functioning of the schools, the curriculum, teaching schedules and the examination schedules as well as the appointments of teachers and principals are centrally controlled and laid down. Though a number of factors combine to make each school unique in many ways, the government school is not an independent institution.

Schools are divided into primary, middle, secondary and senior secondary levels, and children enter school around the age of 5, or earlier, if there is a nursery section in the school. Because of increasing numbers of students, most of these schools work on a shift system, with the senior school functioning in the mornings and the junior school in the afternoons. The medium of instruction is Hindi, and arithmetic as a subject is introduced at the earliest levels. The schools are co-educational and teachers are both male and female. Children from the families of daily wage earners, labourers, domestic servants, drivers and lower level employees in government services or private companies, and usually residing in the vicinity are to be found in these schools. Since the state is obliged to provide primary education, admission are given in order of application on the basis of the number of places available in each school. Teachers and other functionaries associated with the teaching and administration within the schools belong to a higher socio-economic class than the student population that they cater to. The authority that this status and their position within the educational system enjoins upon them creates a powerful dichotomy between the school authorities on the one hand and the students and their families on the other hand.

A majority of the parents of these students are unschooled or even illiterate and consequently feel inadequate in making any decisions, nor are they given any opportunity to participate in the functioning of the school or to comment on the teaching methods, courses of study or any other activity that goes on in the school. Their interaction with the school authorities is limited to the child's admission; though parents are often summoned by the principal or the class teacher and appraised of a child's misbehaviour, indiscipline or absenteeism. Students are consequently tutored in explicit and in subtle ways about correct forms of speech, behaviour and comportment. The legitimate authority of the expert which accrues to the teacher within the classroom leaves the student bereft of any confidence to rely upon their personal experiences in dealing with the formal disciplines that are imparted to them in this context.

Strict discipline is maintained in the classrooms and the teachers role is that of an authority figure who directs the teaching and the behaviour of the children. Each class consists of up to 40 children, and in the time period of 30 minutes allotted to each subject there is no time for discussion. From grade 4 onwards examinations are conducted three times a year on the basis of which students are promoted to the next class, though there are some allowances for a child to re-take the exam, if he or she has failed only a single subject. Officially students require 33% marks to pass the examination, but in practice the evaluation is flexible and students are marked in accordance with the performance of the class which varies from one teacher to another or also from one school to another.

The Daily routine.

School starts at 7.30 a.m. and ends at 12.30 p.m. for the morning shift, and 1 p.m. to 6 p.m. for the evening shift which makes it a five-hour schoolday divided into 8 periods of half an hour each for academic activity, a half-hour lunch break and a morning assembly. Children get one period a day for most subjects but 8 periods a week for both mathematics and language. 8 to 9 periods a week are reserved for games, yoga, library and music. Children are taught addition and subtraction in class 1, moving on to multiplication and division subsequently. Algebra and geometry are introduced in class 5 though concepts such as area and its measurement are introduced earlier. On an average, from class 4 onwards, science and mathematics are taught by teachers who are specialists in these areas, whereas the class teacher teaches language and social studies. Children are therefore introduced to the concept of the compartmentalization of disciplines at an early stage and it is a rare teacher who actually takes the trouble to make the children aware of the links between disciplines. A physical disjunction between classes comes in the form of a loud ringing of a bell which announces the end of each period; teachers move from one classroom to another and the students put away one set of books and notebooks and get started on another. Mathematics is one such academic discipline, practiced in an allotted time period and quite removed from anything else that the students participate in. The teacher is a figure of unquestioned authority and all interaction and communication within the classroom is formally conducted by him or her. Rules of classroom behaviour dictate that students do not talk out of turn or communicate with each other unless permitted to do so. Thinking and working within the classroom is considered a strictly individual enterprise and collective activity in this space is strongly discouraged. These rules pertain to the teaching of all academic disciplines. Co-curricular and extra-curricular activities are fashioned differently where children have access to spontaneity and free interaction: it is not surprising that the games period is a firm favourite with all children.

Mathematics classes are no different from any other academic discipline and teaching is done by the lecture method. Classes are addressed collectively and problems are worked out on the blackboard for the students to copy. Children are, in principle, allowed to ask questions, but neither is such activity encouraged nor do teachers have the time or the inclination to answer them. Class time is spent in working out problems which the teacher then corrects, but almost no discussion is allowed. A great amount of stress is laid on rote learning, and learning of procedures rather than understanding is rewarded. The main tools used by the children are paper and pencil, though in the earlier grades counting with fingers or using tally marks on paper is encouraged. Sometimes children are called up to the blackboard to work out a given problem. The mathematics syllabus for each year is covered by a prescribed textbook and teaching is scheduled by the number of chapters to be covered each term rather than the level of understanding attained by the students. This is true of other subjects as well and children must go through the routine, irrespective of their integration of the material.

2.Newspaper Vending:

The information about newspaper vending and the newspaper vendors was gathered by:

1. Interviews with news paper sellers - both adults and children, interviews with suppliers, and an interview with the editor and the marketing manager of one major evening newspaper.

2. Observation of the activity of buying and selling the newspapers through its several phases - preparing to buy, buying, selling and post-selling.

3. Close interactions with and observations of the larger network and setting within which the vendors exist and operate. This included meeting and visiting families of the working children and observing them at work and sometimes at home.

Two specific sites that were chosen for this phase are:

1. Connaught Place in central Delhi, which is a major commercial centre, and

2. Moti Bagh crossing in South Delhi, an important intersection on the road leading to the airport and several colonies in southern Delhi.

There were several reasons for picking these locations. Each of these centers is a major outlet for the evening papers, where large numbers of adults and children are engaged in the activity of selling. At both sites fairly large and cohesive communities are involved in the selling and an entry into the community enabled the experimenter to interact with members involved at various levels of work at the work site and in their homes.

Delhi has 5 major evening papers - 3 Hindi and 2 English ones. The `Delhi Midday' alone prints about 22,000 copies on an average. Of this number about 15 to 20% are distributed to institutions and the rest are sold on the streets. There is no system of home delivery as in the case of the morning newspapers due to various constraints. The sales section of the newspaper targets certain routes, for which several `points' are picked for distribution. A number of salespersons are responsible for the distribution of the paper at each of these points. Senior hawkers collect the papers from the newspaper offices and it is from these senior hawkers that the local vendors buy their copies for the daily sales. The newspapers are sold on a commission basis and all unsold copies are returned to the newspaper office. The newspaper vendors (the target population for this study) enter this process at the last level or the last distribution point. They come in contact with the senior hawkers from whom they buy their stock for the day on cash payment. The deliveries start in the early afternoons, the first papers arriving around 2 p.m. The street sellers congregate in and around the point where the papers are distributed. This is usually a convenient central location where copies of all the papers are picked up and from which the sellers then fan out to adjoining areas marked out as a profitable territory, which are usually major intersections where the momentarily halting traffic is targeted for sales, or busy shopping areas where there is a flow of pedestrian movement. The vendors buy the newspapers for a fixed discounted price and sell them for the printed price which ranges from 1 rupee to 1.50 rupees.

The vending sites are to a large extent territorially divided between ethnic communities. The communities are composed of families having migrated to Delhi in the not so distant past, as a result of which similar ethnic and linguistic groups draw together and live and work in the same areas. This enables the newer migrants to assimilate more easily into this big city, especially as a number of them are inter-related or have had some connections in the region of origin. The Connaught Place area is largely serviced by the Tamil community housed in a jhuggi jhompdi colony[1] not far from here. The vending activity is carried on by both adults and children and usually by several members of the same family. Consequently most children from this community who are employed in newspaper vending are accompanied by one or more adults and buying, selling and accounting often ends up being a joint venture. Although I did not have the opportunity to observe a complete novice being initiated into the trade during the period of my interactions with them, a novice to expert hierarchy was evident. The adults or older children made the decisions on amounts to be purchased and number of copies to be sold by each member. It is usually women and children who engage in this activity, the men seeking employment as daily wage labourers or in other slightly better paid jobs. A number of these children have some

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[1] colonies established by migrants, comprising of large settlements of semi-permanent dwellings, on unauthorized land, usually highly congested and lacking most basic amenities.

education or are currently in school and often they leave home as early as 7 a.m., proceed directly to the vending site from school and do not return home before 8 or 9 p.m.

The other ethnic community which dominates this activity especially in areas of South Delhi is a large migrant population from Rajasthan, which is relatively newer to the city. They also work as family units and share the responsibilities of buying and selling. Most of the children have had no schooling at all and since they belong to a state which borders Delhi, they often go back to Rajasthan for months and then reappear in the capital. During the harvesting or planting seasons in the agricultural regions of their state, when daily wage labour is needed for short periods of time, whole families go back to work on the farms and return to Delhi and get back to newspaper selling when the farming is over.

A third category of children who participated in this study are more recent entrants into this activity. They are not linked to a particular ethnic community and do not function in family or community units, though some work community ties get established with the co-workers and the suppliers. These are children in the Connaught Place area, who come from a marginally higher socio-economic class and have taken up newspaper selling on their own initiative to augment family income and to earn a little pocket money. They live in the Connaught Place area itself, and attend schools in the vicinity.

The newspaper vending within the observed groups functions as a distributed activity, and initiation into the activity is possible with very little training. It is usually a means of a support income and not the major supporting wage for a family. It also allows participants to take off and re-enter the activity without any major disruption and often families and individuals will go off for days or months on a visit back to the home town or to take up temporary but better paying jobs which are intermittently available. The newspaper vending seems to have provided some means of earning a livelihood for large groups who are brought into the capital as cheap migrant labour, and rendered jobless as soon as the contracts are over. The senior vendors, who earn a commission on the number of copies sold, play a supportive and encouraging role, and are generous with their time, and any computational help that vendors may require. Pre-requisites for this trade are a minimal counting ability and some knowledge and recognition of monetary denominations.

For a novice to participate in the practice of selling newspapers,it is enough to know what her or his investment is at the purchase phase, and the selling price of each copy. Beginners will start with one newspaper and a few copies only, before adding other newspapers and increasing the number of copies for each. Very young children who accompany their mothers or older siblings are not required to deal with the purchasing at all, but are often handed over a few copies of the paper which they are required to sell. Gradually the bulk of selling increases, and as they become more familiar with the process of buying and selling they can decide to take on the responsibilities for their own purchases, and sometimes that of other members too.

The Daily Routine.

Around 1 p.m. the newspaper vendors arrive in groups to wait for the senior vendors from whom they buy their newspapers for the day's sale. Unsold copies, if any, of the day before, are brought along to be exchanged for the current days papers. The suppliers start arriving soon after, and by about 3 p.m. all the papers are delivered. Each senior vendor comes to a pre-designated point and stations himself there for 15 to 20 minutes, during which time each vendor picks up his or her share of papers for the day. The interactions between buyer and seller go on rapidly and in a cooperative and friendly manner, with the latter cross-checking the amounts and the computations. The senior vendors in each area are regulars and know their buyers fairly well. Sometimes the vendors purchase papers on credit, and pay for them only after having sold the papers, just as they accept the papers very often without counting them. Vendors when questioned about purchases mention the monetary amount that will be utilized rather than the amount of copies they are going to buy, therefore preparations for buying are made accordingly. Thus when questioned as to how many papers she was planning to buy, Kanchan answers: ...I will buy 45 rupees worth of Evening News and 45 rupees of Midday, then we distribute it (she has a brother and sister who sell as well)'.

HOW MANY PAPERS WILL YOU GET FOR RS. 45?

-I get 50 for 45 rupees
-WHAT IS THE PRICE OF EACH PAPER THEN?
-well 10 papers cost 11.25
-SO HOW MUCH IS 1 PAPER?
-Its 1 rupee and something but I never buy 1 paper only.
- HOW MUCH WILL YOU SELL IT FOR?
-the price of the paper is 1 rupee 50 paise.
-SO HOW MUCH SHOULD YOU GET FOR 50 PAPERS?
-75 rupees.

Kanta, a 12 year old who sells at Connaught Place:

-WHAT IS THE COST PRICE OF THE MIDDAY?
-I buy 20 papers for 22.50.
-BUT WHAT IS THE PRICE OF 1 PAPER?
-well actually a paper costs 1 rupee and 12 1/2 paise, but we never buy 1 newspaper only, I usually buy Midday for 22.50 and Sondhya Times for 45 rupees
-HOW MUCH DO YOU SELL IT FOR?
-1 rupee 50 paise.

Of all the vendors who were questioned about the cost price of the papers not a single one, adult or child, responded by giving the price of 1 newspaper. Prices were invariably given in units of tens, and often directly related to the quantity purchased by the vendor. Vendors generally buy and sell a fixed amount, except when some sensational event takes place and extra copies of the paper are printed. As is evident from these interviews, the selling price is reported as per copy, since the major part of the sellers activity time is spent in disposing of copies at that price.

The vendors usually wait for all the papers to arrive before they set out to sell them. They therefore sit around in groups, the adults talking to each other and the children engaged in some game or another. When the senior vendors arrive one of the members of the family or group is handed money by several others and he or she will purchase and hand over each of the sellers their copies. After the last paper is delivered individual sellers spread out to their familiar beats to peddle their papers, sometimes at a considerable distance from this central point. Selling is centered around busy thoroughfares, and often at very busy crossroads where the target clientele is the population travelling by cars, who will most often buy the English papers. Busy shopping areas like Connaught Place have a large pedestrian population, which becomes the target for sales transactions in this area.

The amount of papers to be bought and sold is a decision that is not made on an every day basis, but over a period of time taking into account the locale (which determines the flow of traffic), and the vendors selling capacity. It usually depends on the amount of money at the vendor's disposal, and is determined for a family unit, which makes individual decisions redundant. A sensational news item breaks down these norms as the demand for papers goes up considerably. In such cases, it is the publishers who decide to increase the number of copies, which are then given to the vendors for selling, and payments from them are expected only after the sales are over.

> Kanchan. (15 yrs.), ASKED HOW MANY PAPERS SHE BUYS EVERY DAY.
> - I've 40 evening news and 20 middays. That cost me 45 rupees and 22.50 for the midday. That's how much I spend every day. sometimes if there's not enough money I buy less....
> - HOW DO YOU DECIDE ON THE DAYS WHEN THERE IS A SENSATIONAL NEWS ITEM AND THERE IS A GREAT DEMAND FOR THE PAPER.
> - Well that's different.. When there is some special news, like when Mrs Gandhi was killed, we sell hundreds of papers but we don't pay for them. You see the supplier on such occasions lets us have extra papers and as soon as we sell these, we come back to him with the money and he gives us more.

Selling on a daily basis on the other hand is geared to disposing of the limited number of papers that the seller already has, rather than trying to sell as many papers as possible. The urgency, in fact is to break even i.e. to recover the money invested, as additional copies can be returned in exchange for the next day's papers and do not involve a loss. Responses such as the following were common:

> Seth, 13 yrs.
>
> ...I've sold almost all my papers...no, not all, but I have enough money. I've given the money to my mother ..it's enough for tomorrow's papers. I'm just sitting down for a while, its late now.
> -WHAT ABOUT THE PAPERS YOU HAVEN'T SOLD?
> I'll try and sell them, otherwise I'll exchange them tomorrow, I'm tired, I don't know if I'll sell any more.
>
> Sayiri, 12 yrs.
>
> ...It was a bad day today, a lot of my regular customers didn't come. I have enough money to buy tomorrow's papers. Well my father will be angry but its getting dark now... no one will buy now. The rest of them? ... I'll exchange them tomorrow, it doesn't matter... I don't have to pay for them.

Calculations of the day's earnings are made on basis of the amount of money in hand at the end of the day, instead of any complicated computation of the cost price or sale price of the newspaper in question.

The two phases which require number knowledge and computational ability are the purchase phase and the selling phase. The first, that of the purchase, can be and is tackled at various levels which are characterized by the following hierarchy:

1. No involvement at this level, if papers are bought by someone else and only selling is required.

2. Being given a designated amount of money for a determined number of papers, in which case the vendor makes the exchange without being required to do any computation.

3. Making the decision for the amount to be bought, and carrying out the transaction.

4. Taking the responsibility for others, making collective purchases and distributing the papers amongst vendors.

The selling phase requires more than computational ability alone. The computational skills include:

1. Knowing the price of each paper,

2. Identifying each newspaper,

3. Recognizing denominations of bills and coins, so that less money than the cost of the paper is not accepted,

4. Calculating the change to be returned to the customer,

5. Adding the total amount earned after a days selling.

Other skills that vendors display and which are an aid to selling are:

1. Identifying prospective customers,

2. Building up a rapport with commuters who are likely to become regular customers, and,

3. Using the right sales pitch to persuade customers to buy the papers.

Since most of the customers of the papers are passengers in motor vehicles, the vendors are usually handed the exact price amount so as not to risk losing the change as the lights change and the vehicles move on. For the same reason the monetary units that these children have to deal with seldom exceeds the sum of 5 rupees, and more often is confined to 2 rupees. Occasionally, if the amount involved is a small one, customers do not take back the change. Vendors will very often state that they do not have change, hoping that the customer will not demand it. However if they realize that the customer is not willing to buy unless their money is returned they will produce it so as not to miss the sale. The daily sales of each member of the family are in the range of 20 to 30 rupees, and often the family group puts the proceeds from the sales together at the end of the day.

Participation can therefore range from a minimal involvement where a seller is involved only in the selling, to an involvement at all levels of decision making, keeping accounts, buying and selling. The first case is usually represented by very young children who accompany parents or older siblings. They are usually handed one copy of a newspaper and asked to sell it, with specific instructions of how much it costs. On the other hand most older children, usually above 8 to 10 years of age and all the adults handle their own purchases, sales and accounts. The decisions for the amounts to be bought are taken within a family unit, depending on the number of members available and each members track record. Subsequently each of these members must carry out the following responsibilities:

a. purchase of a number of copies of each of the different newspapers,

b. verification of the amount spent and the amount of papers purchased,

c. occasionally distribution and division of the papers between two or more members of the family (this will involve decisions as to who should receive how much),

d. sale of the papers for the evening - which involves determining the price of the paper, receiving an amount and if necessary, giving back change,

e. verification of the amount earned and it's tally with the amounts sold,

f. addition of the amounts, a count of the number of copies left over, if any, and finally,

g. setting aside the money for the next day's purchases.

3. Cigarette and Paan Selling:

Observations on this population are based on:

1. Interviews with owners of several paan shops,
2. Interviews with children working at these shops,
3. Observations of transactions between customers and the vendors,
4. Observations of transactions of vendors with the wholesale suppliers who deliver stocks to the vendors.

Cigarette and paan selling is a thriving trade, and every major commercial and residential area has a number of kiosks selling these and other related items. Although many of these establishments are licensed and therefore have permanent locations, there are many more that do not have licenses and are temporarily set up so that they can be easily packed up and shifted if the local authorities decide to conduct investigations. Unlike newspaper vending the setting up of a paan shop requires a considerable initial investment and some amount of know-how of making paans as well as contacts with whole-salers, suppliers etc. The paan-shops are therefore rarely owned and run by the children independently. Children working at these shops are either members of the owner's family or employed on a monthly salary. Items of sale include paans, paan masala which is a commercially marketed substitute for paan and a variety of brands of cigarettes of varying prices, and very often candy and other packaged food items. Some of the larger establishments also sell cold drinks and tea, which adds to the turn-over and the profit margin considerably. Stocks are purchased from wholesalers, and prices fixed at the established market rates. There is some amount of flexibility on setting the prices of items that do not carry a printed price. Stocks are replenished as and when the need arises, and can range anywhere from daily to a weekly supply. Shop is set up around 9 or 10 a.m. and business goes on all day, depending on the location.

The number of items sold, and consequently the price range is far more varied than what the newspaper vendor deals with. The stock of cigarettes ranges from 3 or 4 to as many as 8 to 9 brands of cigarettes, each varying in price. Cigarettes are sold either by packets or in smaller quantities from an open pack. Besides this, vendors stock an assortment of brands of 'beedies' - an indigenous, locally manufactured cigarette substitute. These again are sold in singles or by the packet. The paans vary in price depending on the ingredients used, though the variation is not large. Other articles sold are a variety of betelnut mixtures and sometimes candy. Business is carried on at a fairly brisk rate all day, lunch time and office leaving time being peak hours. Sales to a customer can consist of a single paan or a cigarette, to a combination of the two and occasionally to a larger number and combination of items.

Daily sales can run into several hundred rupees, and vendors need to deal with all denominations of currency ranging from less than 1 rupee to over a 100 rupees. The combinations and permutations are far more varied than what the newspaper vendors work with. This group has to constantly deal with handing out change, which again varies from one article to another and is nowhere as limited as with the newspaper vendors. Prices of single cigarettes vary between 50 paise and over 2 rupees, and prices of packets of cigarettes from 4 rupees to 38 rupees or even more and if imported brands are sold. This occupation therefore necessitates a much greater flexibility of arithmetic calculations, and presents a variety of computational problems to the participants of the activity.

The cigarette-sellers are a less homogenous population than the news paper vendors. Many of these children have come to Delhi, without their immediate families, and live with a relative or an acquaintance from the village (Tuli, 1989). Subjects occupied in this activity fall into three broad categories:

a) those whose families are involved in the trade and own a paan shop,

b) children who have come to Delhi in search of employment and are trained and hired by the owner of the shops, and

c) adolescents who have some work experience of vending and have set up their own independent units.

The group character of this activity differs from both that of schooling and newspaper selling. Vendors do not function in physical proximity with other vendors though sometimes the owner or an older family member is present at the site. More often however each vender carries on the selling independently, though expertise is acquired through apprenticeship, and children who own paanshops have worked in other supervised jobs before venturing out on their own. All the subjects interviewed in this phase could recognize and identify the price of every item that the shop stocked. Identification is based on the appearance i.e. the color, shape and size of article rather than the printed information available on all packaged goods.

Harish, a 12 year old seller, made the following remarks when asked how he identifies the packet of Gold Flake:

"Its easy to recognize, I sell them all the time... I suppose its the colour, it's gold and red....yes the packet of Classic is gold too, oh but they don't look alike... I can make out at once, see the shape is also different, the writing is different too... No I don't read the name... Why? I don't really know, oh it would take me a long time then ...I wouldn't be able to sell if I had to read each time I was looking for a different brand (laughs). In the beginning yes, I couldn't recognize them so easily but once I had worked for a few days it was quite simple. Why should it be a problem, if I give the wrong cigarette the customer is not going to smoke something he doesn't want!"

At most pan-shops there is a continuous stream of customers, but very little verbal interaction was observed between the vendor and customer about the purchase. Customers will ask for what they need and hand the money to the paanwala, who then hands out the commodity and change if necessary. None of the sellers were observed to be using a paper and pencil for calculations during selling, though a majority of them can read and write, but a number of them did verify totals with the help of paper and pencil, when making purchases from wholesalers. The presence of the customer is a constant check on the price as well as the change that the vendor returns, and though there is no supervisory presence in the form of peers or coworkers, responsibility of calculation is jointly shared by the seller and the buyer unlike the classroom situation.

Selling of goods forms the major part of the paanwalla's activity, and although most of them do not make the ultimate decision of what level of monetary investment is to be made when stocks are bought, they do participate in the actual buying of stocks where prices need to be determined and payments made. Purchase of stocks is done either at a neighbouring wholesale outlet or salespersons for each company routinely stop by the shops to supply the needed goods. All calculations at this stage involve both the supplier and the seller, and since the relationship between supplier and the vendor is fairly permanent and a long term one, transactions are carried on within a mutually trusting context. Buying of bulk stocks involves large sums of money, and observations revealed that in more than 90% of the interactions use of paper and pencil was made for the calculations, or at least to keep an account of the number of items and the total amount spent. The external aids available to the paanseller are the currency notes and coins as well as the array of articles each with its distinct appearance and in some cases the printed price.

The Daily Routine.

The paanshops in Delhi start functioning any time between 8 a.m. and 10 a.m. Owners and employers start their day around this time, when the wares are laid out and arranged, ready for the sales to begin. The activity at the site consists largely of catering to customers - preparing and selling paans or cigarettes and other paraphernalia that the store stocks. A large proportion of the customers buy cigarettes in ones or twos, therefore sellers are constantly opening up packets of different brands of cigarettes and then handing them out. Peak activity periods differ from season to season, and from one location to another, and paanwallas will do their purchasing when the flow of customers slows down. In the course of the day, at the bigger and more established paanshops, agents will arrive with supplies from different companies. The goods required are purchased and further orders placed. The less busy times of the day are also used for checking out stocks and making a note of what needs to be replaced. Sometime during the course of the day a trip is made to the wholesalers to replenish stocks. This is done usually by the owner but sometimes by a trusted employee, but all transactions with the wholesalers are recorded by way of bills stating quantities, prices etc. At the shops where children are working for a family establishment, work work timings are less rigid but where children work as paid employees, timings are fixed and fairly long. They are expected to be at work from the time of opening between 8 to 9 a.m. to closure time which varies between 6 to 7 p.m. and can be as late as 10 or 11 p.m. in areas where there is a lot of late evening activity, for example in the vicinity of restaurants, at the entrance of cinema halls etc.

The world of the children working at the paanshops is peopled mostly by adults whether it is the owner of the establishment, the wholesalers from whom the buying is done or the customers. The mathematical functioning within this context is distributed and does not become the sole responsibility of the single vendor. These figures act as a check on the vendor's efficiency as much as a support system which is readily and easily accessible for a smooth functioning of the practice of selling.

Overview.

There are two major distinctions between the three activities described here: one which groups together the vending activity as distinct from school activity and two, the distinction between the two kinds of vending itself, on the basis of which their mathematical involvements and experiences differ.

For the school children, the social context available for the practice of math is predominantly the classroom peopled by peers and the teacher. The cultural artifacts available are the tools of trade of all school children: text books, notebooks and writing materials.

The distinction between the two vending activities is one of degree, both groups functioning with or without some schooling in an economic activity. The settings are informal and peopled by a network of participants, each of whom has a stake in the smooth and successful functioning of the activity. Participants are the wholesalers, the vendors (our sample), coworkers in the vending practice and the customers with whom the economic exchanges take place. The cultural artifacts available to the vendors are the items to be handled and sold, and the denominational units of currency which form the functional unit of working with the prices and if utilizable, the orthographic representation of the prices for items like packets of cigarettes and the newspapers. The structure and functioning of the two vending activities however is different in several ways. The cigarette sellers as compared to the newspaper vendors, handle a large variety of selling items, the prices of which range from item to item and sometimes within varieties and sizes of the same item. They have well defined working hours wherein a continuous flow of customers regulates the pace of the transactions whereas the pace of the activity in the case of the newspaper sellers is determined within loosely defined limits by the individual seller, who sets targets according to the number of papers to be sold, and closes shop when that is over. No single item in newspaper vending costs over 2 rupees, and only a rare customer buys more than 1 copy of the same paper, or more than 1 newspaper at the same time. Cigarette selling activity, even of a very limited kind, deals with at least 10 to 12 items of varying prices which on a minimum, range between 50 paise to 12 to 15 rupees.

The setting within which the school children function has formally defined roles of student and teacher and the rules for functioning within this system are explicitly laid down. What needs to be underlined however, is that the sample of school children included in this study is representative of a standard of schooling provided for a particular socio-economic class: that of the working children in the two activities that the study focused upon. The children serviced by these schools are largely first generation literates, coming from homes where an educational degree is increasingly viewed as a passport to jobs and to social status. The schools observed are however <u>not</u> representative of all categories of schooling since Delhi boasts of some of the best schools in the country. These fall broadly into two categories: government schools and private schools. It is largely the private schools that cater to the education of the elite classes, while the government schools cater to the lower socio-economic sections of the society. Though it is difficult to generalize across the board, it is broadly accepted that to get a good education, one has to look to the private schools, which though expensive, provide a level of education, that the government schools do not seem to be capable of providing. The N.D.M.C schools in New Delhi fall under the second category and are a typical example of this kind of schooling.

The attitudes of the teaching staff to the students and to the process of teaching is lackadaisical, to put it mildly, and the motivation to teach seems to be by and large, missing. A remark made by one of the teachers seems to sum up this attitude "...these children are a nuisance, you see they have no concept of education... they come from homes where the parents are totally illiterate, they can't even look after their books, there's no one to guide them with their homework... it's very difficult to cope with them." This lack of motivation is more than evident in the functioning within the schools, and the behaviour of the teachers in the classrooms. On several occasions the teachers were missing from the classrooms having left the students to carry on with some text book exercises they are required to work out in the absence of any guidance. This was often the case during a mathematics class and consequently if the students needed any help there was no-one to turn to. Since the majority of the children attending these schools come from a lower class working population, the teachers have scant regard for them and treat them in a patronizing manner or with outright disdain. No effort is made to integrate the personal lives and the out-of-school experiences of these children to their understanding of a school curriculum. Some of the working children who were enrolled in the school and whose acquaintance I had made in the course of the study, especially requested me to not show any signs of recognizing them in the presence of the teachers. They explicitly stated that if the teachers get to know of their involvement in street vending they are ridiculed and mocked at publicly and become a butt of jokes and insults by the teachers. Ironically, instead of using their street experiences as a source of strength and a starting point for the understanding of numbers, currency and its usage, the children are made to feel ashamed of being anything other than schoolchildren and to therefore shut out any means of understanding and comprehension which could become an entry point to the school curriculum for them. They are, in effect, forced to decontextualize the experience of school learning and to keep it from being tainted by any personal reference.

The math classes, as explained earlier, follow a set routine based on the prescribed syllabus. The teaching of arithmetic as it proceeds in this atmosphere is a rigid and painful experience rather than a process of discovery and learning. Counting and number enumeration is one of the first activities on the school agenda, and is drilled into the children whether or not they are ready for it. Prescribed textbooks for each school year set out the courses to be covered and it is the responsibility of the class teacher to make sure that the annual requirements are met. The school authorities expect the courses to be taught according to the set schedules and therefore if anyone needs to suffer it is the children, who are inundated with facts and figures without any consideration of their capacities of understanding or their levels of cognitive development. There is a great emphasis on rote learning and memorization is accepted as an apt indicator of understanding. It is in such a context that one has to understand the arithmetic activity of these children and to interpret their ways of dealing with the math problems that were presented to them in the course of this study. The goal of the activity in a mathematics classroom is to solve each given problem correctly, and the motivation comes more from the terror of punishment and ridicule, rather than some higher motivation of becoming adept at the task of doing mathematics as a precursor to other more rewarding activity. The focus is on finding the correct operations and procedures to solve problems rather than developing a conceptual understanding of the operations, their properties and their relationship to numbers.

In short, the practice of mathematics remains external for the school child who has very little or no control in defining either its subject matter or the ways and means by which it is incorporated into his or her cognitive awareness. As participants they have to grope to find its connections with a real world and to find ways of internalizing this experience. For the vendors on the other hand, mathematical functioning is woven into the context of their everyday practices, where problem solving is not an end in itself but a means to other goals on which their existence as livelihood earners depends.

The theoretical approaches and the literature surveyed in the earlier chapters together with the ethnographic observations of the three activities and their participants provoked the research questions and hypotheses outlined below. The subsequent chapters deal with the research that attempted to answer these questions and to verify the hypotheses.

RESEARCH QUESTIONS:

1. If number development is a universal phenomenon, is the understanding of number devoid of contextual overtones?

2. How and why is number understanding and working with numbers facilitated by the understanding and practice of working or schooling?

3. What could be the defining features of school learning of mathematics which distinguish it from learning of mathematics outside of school or vice-versa?

4. Consequently, what are the experiences of learning mathematics in school or out of school that account for observed differences? and,

5. Are the broad categories of "school mathematics" and "out-of-school mathematics" justifiably categorizable? What are the differences that might manifest themselves in different practices of mathematical activity outside of school that an analysis of such activities might reveal?

HYPOTHESES:

1. Children in the absence of schooling and formal transmission of mathematical skills will demonstrate an ability to deal with numbers and mathematical formulations when they are engaged in activities where such skills are practiced.

2. That the experience of mathematics in the context of the three activities described will influence the participants' ways of dealing with numbers and mathematical problem solving in ways that relate to these activities.

3. Therefore, that differences will be observed in the competence and strategies of solving mathematical problems between:

a. the school children and children involved in vending practices, whether they are schooled or unschooled, and

b. the participants of the two vending practices as a function of the characteristics associated with each of these practices.

CHAPTER 6.

PHASE 11.

This phase focussed on a sample of 48 children selected after the initial observations. Two to three interview sessions were conducted with each subject. The first was an informal session, used for establishing rapport and for subjects to ask questions and get clarifications regarding the interviews and the interviewee. The newspaper vendors enjoyed this session, and the least questions, not surprisingly came from the schoolchildren.

The second session consisted of an interview where demographic information about the subject was obtained (see table 1), as also some informal information about their involvement, know-how and level of participation in the activity. This session was also used for the preliminary tasks i.e.counting, orthographic knowledge of numbers, and math facts. The last session concentrated on the experimental tasks i.e. arithmetic operations, multiple operations, profit and loss problems and a proportions problem.

For 9 of the paanwallas, the sessions had to be limited to two, as they have a long and busy day with hardly any breaks. The day starts early and ends late, therefore it seemed easier not to stretch the sessions. The 5 paanwallahs who were available for longer periods were those working with other family members. In fact the size of this sub-sample was confined to 14, firstly because there are fewer children employed in this trade, and secondly, since they are more often employees, they did not have the freedom and flexibility enjoyed by the newspaper vendors, and employees were not willing to give them time off for the interviews.

SAMPLE.

The sample used for this study consisted of 18 school children, 14 paanwallahs/cigarette sellers and 16 newspaper sellers. The paanwallahs and newspaper sellers were approached at their site of work, and interviewed in the vicinity of their work area. The schools from which the school sample was derived were chosen as a consequence of the composition of the student community, which was matched to the other two population groups in terms of age and socio-economic status. Two schools in the Connaught Place area, where some of the newspaper sellers had been students or were currently registered were finally targeted, and 18 students were selected in a pre-determined randomized order within a specific age range and sex ratio.

Table 1 gives demographic details of all three population groups, henceforth referred to as SC - school children, PW - paanwallas and NP - newspaper vendors.

TABLE 1.
Biographical details of the three population groups.

	SC	PW	NP
AGE:	M = 11. (min.8,max.16)	M = 13 (Min.9,max.15)	M = 12.8 (Min.11,max.15)
SCHOOLING:	Mean = 6 yrs.	Mean = 4 yrs.	Mean = 3 yrs.
WORK EXPERIENCE:	0	Mean = 3 yrs.	Mean = 5 yrs.
SEX:			
Female:	7	0	7
Male:	11	14	9
ORIGIN:			
Delhi:	5	4	3
Other States:	13	10	13
MOTHER TONGUE:			
Hindi:	18	13	4
Other:	0	1	12
EDUCATION OF FATHER:			
Some Education:	12	1	0
No Education:	6	13	16

TABLE 1. (continued)
Biographical Details of the three population groups

EDUCATION OF MOTHER:			
Some education:	2	0	0
No Education:	16	14	16
OCCUPATION OF FATHER:			
Farming:	0	7	4
Salaried:	14	7	5
Vending:	0	0	5
Other:	4	0	0
OCCUPATION OF MOTHER:			
Vending:	0	0	9
Housekeeping:	7	8	5
Other:	11	6	2

The Tasks and procedure:

Observations from the first phase of the study revealed that there were no specifically newspaper-like arithmetical problems as opposed to problems that were specific to the cigarette and paan selling. In both types of vending a sum of money was received, the vendor calculated the price of the item and change was returned to the customer. In both cases the external and visible tools available to the vendor were: the notes or coins at hand, the item or items to be sold, and the customer as a check on whether the calculations had been correctly carried out. At no point did the vendor have to mathematically figure out the prices. They did however have to identify the items; in the case of the newspaper sellers the specific newspaper and in the case of the paanwallahs the brand of cigarettes asked for, and to identify the correct price for each.

Arithmetic competence that is necessary for both types of vending activity includes the operations of addition and subtraction. The operation most frequently used in the course of both kinds of selling is that of subtraction, when change has to be given to the customer. Addition and multiplication are called upon when more than one item is sold. The newspaper sellers can operate without ever using division, and paanwallahs may use it when determining the price of one item where the price of the collective quantity is known. Therefore the difference in arithmetic computations is one of degree: the paanwallas use the operations across a greater variety of numbers, use them more frequently, and need to combine them more often than the newspaper vendors.

All interviews for the newspaper sellers were carried out in the vicinity of the work site, the school children were interviewed within the school premises, whereas the newspaper sellers were interviewed both at the work site and in their homes. Interview sites for the working population were neither noise-free nor distraction-free. Though efforts were made to find a quiet spot, it was necessarily in a public area, where curious passers by would often stop to observe or ask what we were doing. Subjects were comfortably seated and some paper and a pencil was provided to every subject with the instructions that they could use it if they so desired. Interactions with the school subjects were carried on in a relatively quieter environment, usually an empty classroom. Written records as well as audiotapes of the interviews were maintained.

Preliminary Interview

General Information

This was done in two parts: the first consisted of a set of autobiographical questions pertaining to each subject . The second part consisted of questions related to the subjects level of participation within his or her activity.(Appendix 1)

Counting

Subjects were asked to count up to 500. This was used to determine familiarity with numbers and knowledge of the conventional number system. If a subject hesitated she was encouraged to go on. If and when subjects stated that they couldn't count any more having stopped at a particular number, an attempt was made to uncover any non-conventional systems that were being used for e.g. if a subject stopped at 30, the experimenter would ask "How much is 30 and 1?" etc. The number counted up to, and the system of counting was noted for each subject.

Recognition of written numerals

During the preliminary interviews an effort was made to assess each subject's knowledge of the orthography of the conventional base ten system. Subjects were required to identify the following numbers presented on cards measuring 2" * 2" :

a. numbers from 1 to 10.

b. four multiples of 10, and four multiples of 5 picked at random from among numbers between 10 and 100.

c. Ten numbers between 10 and 500 other than multiples of 5 and 10.

A strictly standardized system was not followed, as some subjects were well versed with the system and could read and write numbers with ease whereas others had difficulty recognizing numbers beyond 10. Responses were classified on the basis of whether subjects could recognize numbers up to 10, 50, a 100 or 500. Some subjects who could not read all numbers fluently, nevertheless had no problem recognizing 10's and 100's, or sometimes multiples of 5's. Larger numbers were introduced on the basis of competence with smaller numbers.

Currency Identification

Formulated on the model of the currency identification task used by Saxe (1990), subjects were asked to identify common denominations of coins and bills. The coins used were 10p, 20p, 25p, 50p and the 1 rupee coin. Bills consisted of 2, 5, 10, 20 and 50 rupee notes.

Final Interview:

A final interview with each subject was conducted, where the set of experimental tasks was presented. Two research assistants, both psychology graduates from Delhi university assisted the main experimenter in this phase of data collection. All the interviews were conducted in Hindustani. A verbatim report of subjects' responses was recorded. Behaviours related to problem solution and any use of paper-pencil, other paraphernalia or finger counting were recorded as well. Verbal responses were audiotaped only when it was not possible to keep track of them in writing. All problems were orally presented to the subject, and except for the math facts, the following procedure was followed: Subjects could ask for any clarifications, just as they could ask for the question or any part of it to be repeated. No time limits were set for each problem, and the next problem was tackled when the subject gave an answer or expressed her or his inability to tackle the question and did not want to deal with it even after some encouragement from the experimenter. Subjects were encouraged to talk out the solution to the problem and if they were unable to do so, were asked to explain what they thought of, while finding the solution.

Math Facts: (APPENDIX 2)

Studies carried out in the U.S. often use math facts as an indicator of mathematical practice since it is a common feature of schooling in the U.S.; the only equivalent of this kind of activity which is required of children in schools in Delhi is the use of the multiplication tables.

However, in observations of the working children it was noted that frequency of working with a set number of prices and denominations of money allowed them to retain certain computations as math facts. Accordingly, a total of 66 problems were constructed: 22 addition, 24 subtraction and 20 multiplication. For each operation, problems contained either single digits or double digit numbers, which either did or did not correspond to a monetary denomination. Division problems were excluded as these could not be conveniently phrased in Hindustani, and therefore gave the subject ample time for working out, which made it difficult to categorize as math fact.

Problems were orally posed, and correct responses within 3 seconds were given a score of 1. The score for each operation is the total of correct responses. Therefore possible maximum and minimum scores are as follows:

Addition -	Maximum:22, Minimum:0
Subtraction -	Maximum:24, Minimum:0
Multiplication -	Maximum:20, Minimum:0

<u>The Four Arithmetic Operations.</u> (APPENDIXES 3a TO 3d)

These consisted of word problems within the four arithmetic operations of addition, subtraction, multiplication and division. For each operation eight word problems were presented, each of which were phrased in the language which was common to some school textbooks and textbooks designed for non-formal educational programs for out-of-school learning. The use of these problems in non-formal education implies that both the language for phrasing the problems and the contexts and the situations are fairly common to the lives of children in or out of school.

There was a total of 32 problems for the four operations. For each operation a set of 4 `familiar' number problems and a set of 4 `unfamiliar' number problems was presented in an order of increasing difficulty. The familiarity- unfamiliarity dimension was determined on the basis of the observations and interviews from the first phase. Numbers were rated as familiar if they corresponded to a commonly used monetary denomination since both groups of working children were continuously dealing with these. Numbers frequently used by the newspaper sellers would be used by the paanwallahs but not vice versa, therefore numbers considered familiar for the first group were the ones used in the construction of the problems. In the school situation all numbers are equally privileged in which case this dimension does not in principle hold for the school context. However, since the currency is decimal based, an understanding of the workings of the decimal system should render these numbers more easily manipulable to the school children as well.

REPHRASING: (APPENDIX 4)

A second level of familiarity was introduced in the multiplication and division problems, when quantities were rephrased in terms of money, newspapers or cigarettes etc.

Responses to each problem were scored as follows:

2 = Correct,

1 = Partially correct, and,

0 = Incorrect.

I. A response was scored correct (2) in the following cases:

1. The question was posed, the subject worked it out and gave the correct response.

2. The subject gave an incorrect answer, but spontaneously corrected it.

3. The subject, in explaining the procedure, spontaneously realized the mistake and corrected it, and,

4. The subject had an incorrect representation of any of the numbers, the experimenter repeated the correct numbers and consequently the subject realized the mistake and

corrected it. However if after a repetition, the subject did not make a correction, the problem was not scored 'correct'.

II. A score of 1 i.e. partially correct was given when:

1. The subject could carry out at least part of the computations correctly for e.g. in adding 102 + 145 + 224 if the subject responded with 102 + 145 = 247, and 247 + 124 = 371.

2. In the case of a multiplication problem of the following kind: 12 * 8 the subject responded by '..12+12 is 24, 24+24 is 48, ...well 4 times 12 is 48, it has to be added but I can't do any more. If the subject started adding 12's and gave up halfway through without explicitly stating either what the procedure was, or the partial solution the problem was scored as incorrect.

III. A problem received a score of 0 when the subject:

a. gave an incorrect answer, and made no attempt to correct it even in the course of explaining the procedure.

b. made some attempt to solve the problem but gave up without attempting to arrive at the solution and could not explain the procedure, and

c. made no attempt to solve the problem with or without any explanation of the reason for abandoning it.

<u>STRATEGY ANALYSIS:</u> (APPENDIXES 5a to 5d.)

Strategy here is used according to the definition proposed by Siegler, as ``any procedure that is nonobligatory and goal directed" (1989, p.11) and distinguished from procedures in that they represent a single way to achieve a goal. Research in various areas of problem solving indicates that children use multiple strategies (Reder,1987; Siegler,1988) and that decisions about efficient strategy use comes more from past strategy use rather than any cognitive metaassessment of the usefulness of strategies (Siegler 1988). Not only children but adults exhibit a marked contrast in the ease and efficiency with which strategies are selected for a familiar problem as compared to an unfamiliar problem (Siegler,1989).

Having established the accuracy scores, a further analysis was carried out to observe the strategies children use for the solutions of problems spanning the four arithmetic operations of addition, subtraction, multiplication and division. Given that similar levels of cognitive functioning may be attained as a result of varying experiences, the strategies that children use would also be expected to vary depending on the particular practices that they engage in. The categories used for the analyses are derived from Pettito (1979). This was followed by an analysis of errors made by subjects in the three groups (Appendix 6).

Combined Operations involving change: (APPENDIX 7)

Vending activity characteristically involves the use of more than one operation in both the buying and selling phases. When a customer approaches a paanwalla for instance, and asks for `one paan and one four square cigarette' the paanwallahs calculations would have to take the following course:

- the cost of 1 paan is 1 rupee,
- the cost of the cigarette is 60 paise,
- 1 + 60 adds up to 1 rupee 60 paise,
- the customer gives me 2 rupees,
- 2-1.60 = 40 paise.

This simple interaction involves determining the price of the two items, adding them up, subtracting that from a larger amount and calculating the result. The newspaper sellers are not called upon to do this very often, but for the paanwallahs it is a routine interaction. Problems involving combined operations are also part of the school curriculum. Examples of problems from a Class V textbook are given below:

1. Subtract the difference of 2.49 and 8.436 from the sum of 12.3 and 21.97.

2. A small bottle of jam holds 0.750 kg. of jam. How much jam will there be in 20 such bottles?

This task differed for all three groups, since problems were posed in terms of prices of items and the change to be returned. The problems posed to the paanwallahs were posed in terms of different brands of cigarettes, for the newspaper sellers in terms of prices of different newspapers and for the schoolchildren in terms of items familiar to them for e.g. school supplies, ice-cream etc.

While problems in this domain were presented to the two vending groups orally, the school children were presented with a written list of prices to be worked upon. This was done to reduce the memory load on the school children, since the working groups already knew the prices of the items asked for. For example while a newspaper seller does not need to be reminded of the price of a `Midday' when asked to calculate the price of 3 middays, a school child asked for the price of 3 notebooks would be at a loss, unless the price of each is specified.

The task consisted of 3 problems, again of increasing difficulty. The first problem simply asked for the total of the prices of 3 different items, but the next 2 problems involved calculating the prices of more than 1 item and making change.

Scoring was done as follows:

2 = correct

1 = partially correct, and

0 = incorrect.

A score of 2 was given if all computations were correctly executed, for e.g. if the subject calculated the price of the several items correctly, gave the final addition and calculated the correct change to be returned.

A subject received a score of 1 if part of the computation was correct for e.g. if the subject added up the prices correctly but failed to give the correct change, and

A score of 0 was given if the subject failed to carry out any of the above.

Profit and loss: (APPENDIX 8)

This included a set of 5 standard problems for all three groups. On the first two problems subjects were given a cost price and selling price and they were required to calculate the profit. The last three problems had an added step in that unit prices were given but the profit to be calculated involved a larger quantity. Problems were scored as follows:

2 = Correct

1 = partially correct, and

0 = incorrect.

A problem was scored correct when all steps of the problem were correctly solved, and partially correct if at least the profit was correctly calculated but the final summing up was incorrect. A score of 0 indicates that the subject could not solve any part of the problem correctly.

Proportions: (APPENDIX 9)

Given the price of a larger quantity subjects were required to calculate the prices of 4 different proportions of the total. Although in both the vending practices item prices are not calculated by the vendor they do buy quantities in bulk and the possibility of their making an attempt to calculate unit prices and making comparisons does exist. This was an attempt to explore the possibility of their understanding of the concept of proportion. In the school setting children are required to deal with proportions in the course of their learning of mathematics. Each of the 4 questions was given a score of 1 for correct and 0 for incorrect. Scores therefore vary from a maximum of 4 to a minimum of 0.

CHAPTER VII

PRELIMINARY TASKS

KNOWLEDGE OF THE NUMBER SYSTEMS.

Ginsburg (1977, 1982), proposed a 3 system classification of mathematical knowledge based on how and where it is acquired. As stated earlier system 1 develops outside school and is termed informal. At the same time, because it is seen to develop universally, it is also categorized as natural. System 2 which involves the use of counting, and depends on cultural transmission, is termed cultural, but it remains informal because it develops outside of school. System 3 is defined as both cultural and formal because it involves written symbols and other characteristics of a formal and systematized body of cultural knowledge. An attempt is made in the present study to observe differences, if any, among the three population groups on some aspects of these systems.

Preliminary observation with some amount of systematic probing was used to assess the knowledge of number systems whether conventional or non-conventional, that the subjects are using in the practice of their arithmetical activity in school or outside. The areas tapped for this information were: subjects' knowledge of counting, recognizing orthographic representations of the formal number system, recognizing common units of currency, and the knowledge of math facts.

Counting.

The counting task was used to assess what level of familiarity non-schoolgoing children have of the uses of the conventional order and nomenclature of a formal system. It was not meant to assess children's understanding of the number concept and the principles of counting as enumerated by Gelman and Gallistel (1978), for it was amply clear that all subjects in this study had a clear understanding of such principles. Rather, we sought to determine whether they have in the course of their dealings with numbers, internalized the conventional number names that formal mathematics works with. Predictably, all the 18 school children could count up to 500. Of the 14 cigarette sellers 13 counted up to 500 fluently and 1 could count only up to 50, whereas for the 16 newspaper sellers, the breakup was as follows: 5 of them were able to count up to 500, 1 was familiar with number names up to 50, 9 of them could use the conventional number names up to 40, and 1 up to 20 only. This would qualify as Ginsburg's system 3 since what is involved is the knowledge of a formal system of conventional number names.

Enumerative processes are a feature of not only virtually every cultural group but appears to be a universal feature of young children's arithmetic thinking (Klein & Starkey, 1988). Therefore it is only to be expected that all three population groups included in this study possess either a formal or an informal system of enumeration. It is most conspicuously the school group which has a mastery of the conventional enumeration system as this is the basic tool that is imparted to all school children when they embark on the project of learning a formal system of school mathematics. Given that any enumerative system is basically a symbolic vehicle which allows its bearer to execute arithmetical problem solving,, it is only natural that all three groups have devised some form or another of symbolically representing numbers as an aid to solving number problems.

The school children, expectedly fare better than the other two groups, since one of the tasks that schooling undertakes is the imparting of formal and conventional systems of identifying numbers. However all the subjects in the three population groups were capable of formulating a system of counting, which made use of unconventional representation systems. For e.g. when asked `what comes after 50?' the answer would be `50 and 1', or when asked `how much is 70 and 6' the likely response is `75 and 1'. It should be made clear that when a subject is reported to be able to count up to 50 it indicates that she is able to enumerate every single number up to 50 but not beyond, though it may very well be the case that she can name several number names beyond 50, but not each number consecutively. For e.g. the counting system could go as follows - 50 and 1, 50 and 2, 50 and 3, 1 less than 55, 55, 56, 55 and 2, 55 and 3, 1 less than 60, 60, and so on. In fact a majority of the newspaper sellers whose knowledge of the number system is fairly limited use this system of counting. Though most of the non-schoolgoing children could not elaborate all the number names up to a 100, they all had the tens and fives readily available and which they used as anchor points onto which the rest of the counting was hinged.

Recognition of written numerals.

To assess recognition of standard orthographic symbols, subjects were presented with cards with numbers ranging from 1 to 500 in a random order and asked to read them. These included numbers 1 to 10 and a random selection of numbers between 10 and 500. A grading of the subjects was ordered on the basis of whether or not they could read correctly all the numbers up to 10, 20, 50 100 and 500.

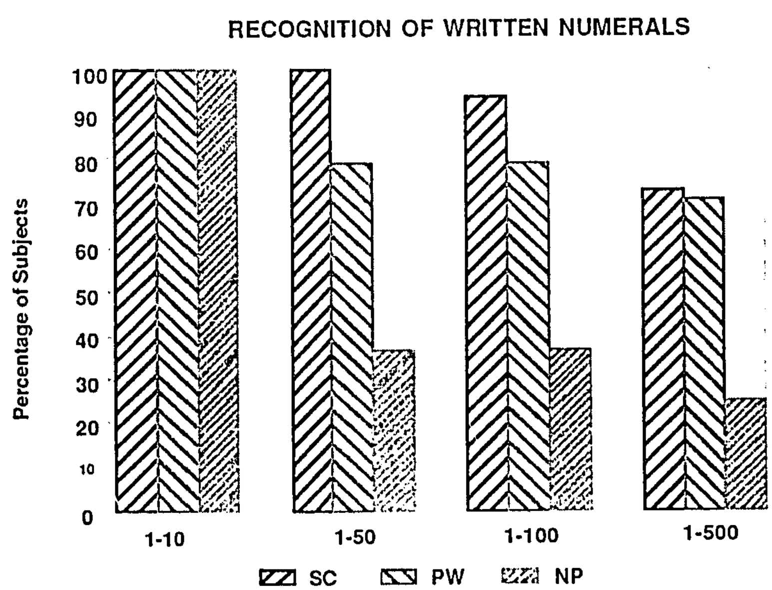

Figure 1 : Comparison between the three population groups on the recognition of written numerals

A category was included wherein subjects could recognize correctly the round numbers such as fives and tens although they had difficulties with other numbers, for e.g. children could read numbers such as 90, 100 and 200 but had difficulty recognizing numbers such as 34, 78 etc. This could be due to the fact that their familiarity and practice of the conventional system comes from use of the currency that they are forced to handle and the system of pricing that they work with, and that these units of currency are typically represented in multiples of tens and fives. Figure 1 shows the extent of knowledge of written numerals of the three population groups. A conventional orthographic representation of numbers is available through some cultural agency usually of a formal kind. Schooling is one such institution and, it is to be expected that the school children would have an edge over the other two groups. Of the 14 cigarette sellers 11 can recognize written numerals up to 500, 2 up to 50, and only the one unschooled child has problems recognizing numbers beyond 10. All but this one subject have had some minimum school experience and we could conclude that working with numbers has enabled them to retain this knowledge that was imparted at school.

There is a larger number of unschooled newspaper sellers, and we see that only 4 of them are able to cope with numbers beyond 10 with any great ease. It is remarkable that all 16 of these subjects, some with no schooling at all, can read numbers even if it is only up to 10. When questioned about where they had picked up this information, they admitted to having made a special effort to have someone teach them how to read and write these numbers. However, the activity they are involved in, namely selling newspapers, does not require them to have this knowledge, since they hardly ever use the orthography to determine the prices. They have learned to distinguish each paper on the basis of its appearance and accordingly remember the price of each. Since the variety they deal with is fairly limited, remembering the prices does not pose a big problem, neither is it necessary to have a knowledge of the orthographic system.

Knowledge of currency denominations

All 48 children were able to recognize all denominations of the coins and bills used for this task.

Children's knowledge of Math Facts.

All three population groups were assessed on sets of addition, subtraction and multiplication math facts. In the school system from which the present sample was selected, and in the Indian school system in general, learning of multiplication tables is a necessary and important part of the curriculum, but there is no such "math fact" learning for the other three operations of addition, subtraction and division. The two groups of vendors, on the other hand were seen to be working consistently with certain monetary denominations and some fairly stable item pricing within which a repertoire of remembered facts would be an advantage for their daily selling and buying practices. On the basis of these assumptions differences were expected to be observed between the three groups. The subjects were therefore tested on a total of 22 addition, 24 subtraction and 20 multiplication items.

Oneway analyses revealed significant differences between the three groups for both addition as well as subtraction math facts, but no significant difference for multiplication. For the addition problems ($F(2,45) = 16.77$, $p < .001$), the Duncan's Multiple Range Test indicates that both the groups of working children perform significantly better than the school group ($p. < .05$). Significant differences were observed for the subtraction facts ($F(2,45) = 14.37$, $p < .001$) and Duncan's Multiple Range Test reveals a significantly better performance by both the newspaper vendors and the cigarette sellers as compared to the school group ($p. < .05$).

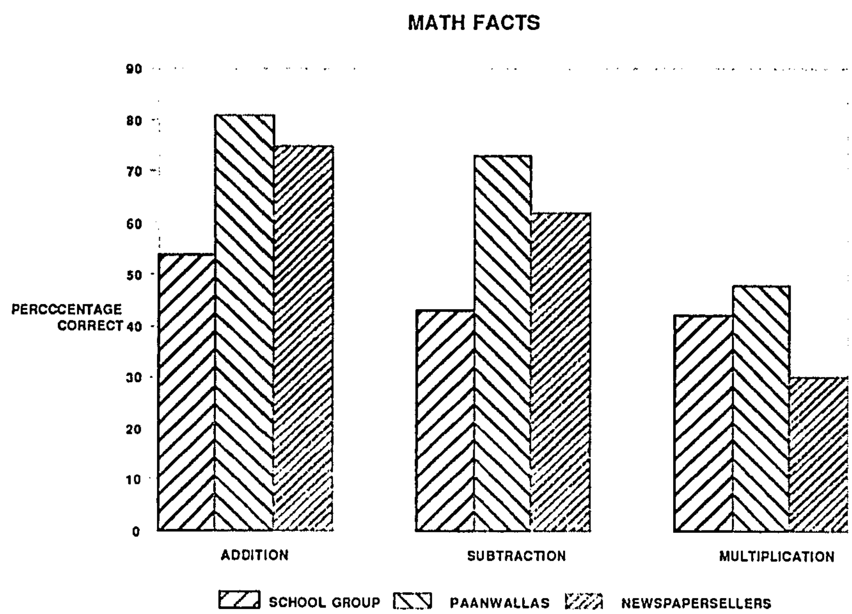

Figure 2: Comparison between the three population groups on addition subtraction and multiplication Math Facts

To analyze practice related differences among the three groups, the math facts within each operation were further categorized as follows:

Category 1: Math Facts involving numbers from 1 to 10, as numbers representing a low memory load. For the multiplication subgroup, this category consisted of numbers between 1 and 3 only. Since all of them possess a minimum working experience with numbers, no differences were expected in this category.

Category 2: Numbers corresponding to monetary denominations, which are necessarily multiples of fives or tens. For the working children these are the numbers on which a large part of their computation hinges. For the school children an advantage with these numbers should arise from their familiarity of working within a base ten system.

Category 3: Numbers other than those based on monetary denominations, which do not give the working children any advantage.

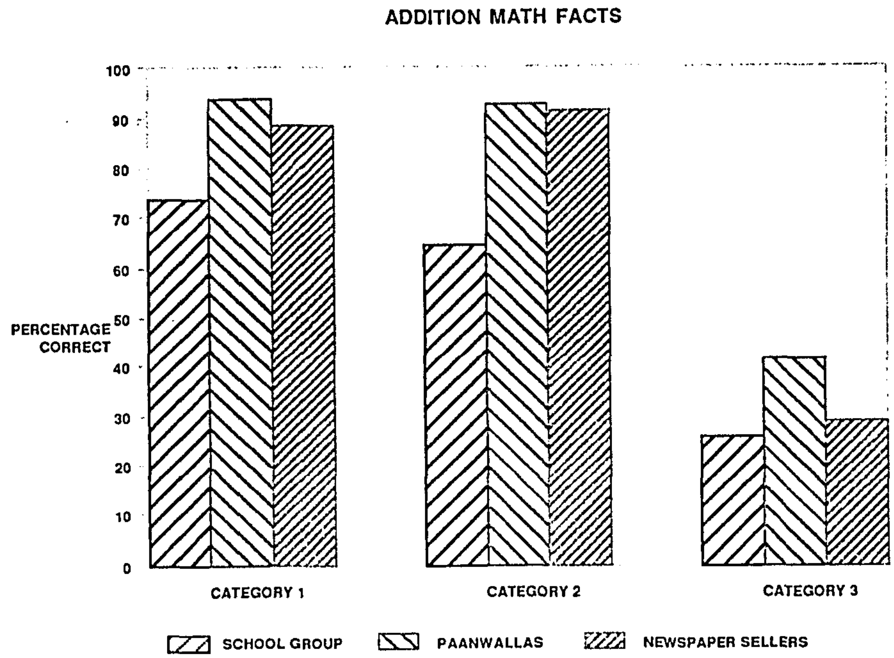

Table 3 : Comparison of the three population groups on the three categories of addition math facts

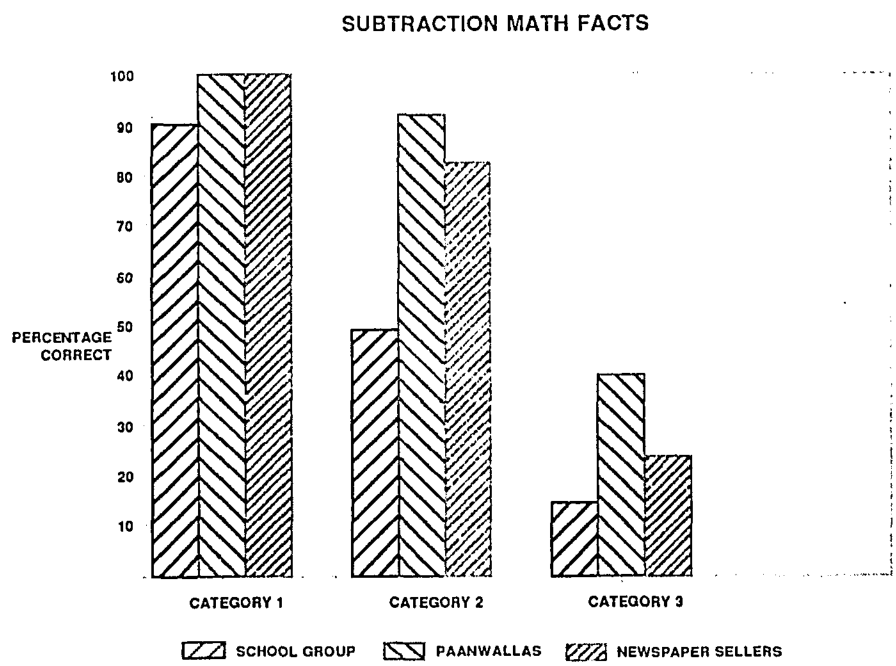

Figure 4 : Comparison of the three population groups on the three categories of subtraction math facts

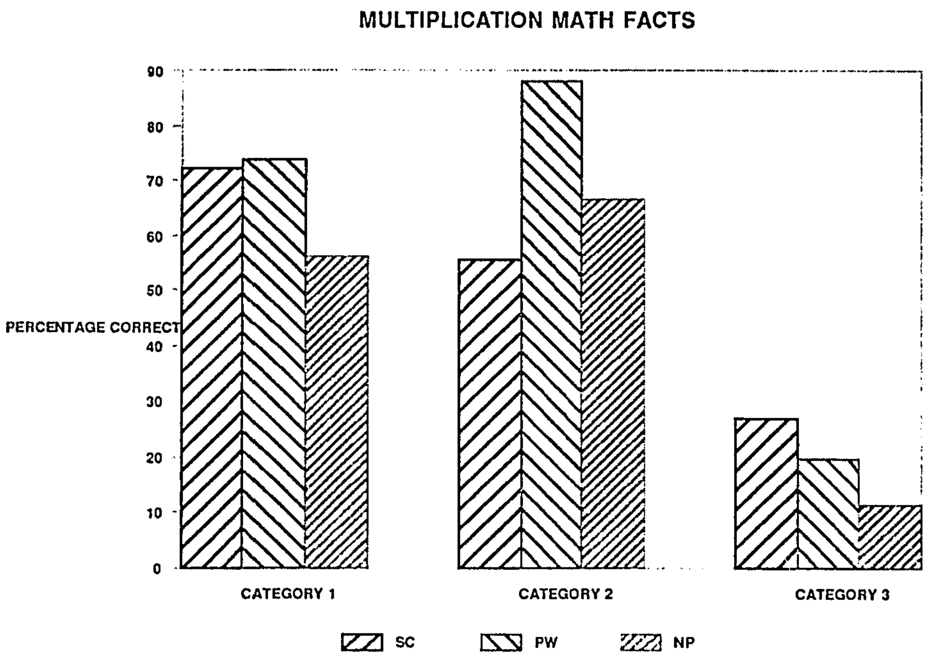

Figure 5 : Comparison of the three population groups on the three categories of multiplication math facts

We see that the performance for all three groups is lowest on category 3 for all three operations. On both addition and subtraction math facts the performance of the paanwallas and the newspaper sellers is better than that of the school children. On the multiplication math facts the school children had better scores than the two other groups for the unfamiliar numbers (category 3), and better scores than the newspaper sellers on category 1, whereas on category 2, the two working groups did better. As stated earlier, multiplication tables are learnt in school and this could account for the advantage of the school group here, though performance of all three groups is better on categories 1 and 2 than on category 3. The school group shows a steady decline an all three operations from category 1 through category 3. They are better able to deal with numbers below ten, the performance declines on multiples of five, and goes down further when dealing with the third category. The paanwallas and the newspaper sellers perform equally well on the first two categories for addition facts, show a marginal advantage on category 1 for the subtraction math facts and have a larger repertoire of multiplication math facts in the second category i.e. multiples of 5 and 10, than those in the 1st. category which consists of problems involving numbers 1 to 3.

CHAPTER 8

Children's Performance on Arithmetic Word Problems Involving the Four Operations of Addition, Subtraction, Multiplication and Division on Two Levels of Familiarity.

To investigate the arithmetical competence of the three population groups the four basic arithmetic operations of addition, subtraction, multiplication and division were used. These operations were examined in relation to the practices that children engage in, in the course of their work and/or school activity. They were also examined as a basic arithmetical ability on which more complex forms of arithmetical problem solving could be based. The school syllabus introduces the four operations in the first two years of the math curriculum, and well into the fourth or fifth year of school these operations are the focus of learning, with a shift from smaller numbers to larger ones, and to more complex uses, such as addition, subtraction, multiplication and division of fractions, decimals and so on. The school curriculum moves from straightforward operations of numbers such as $2 + 2 = ?$ or $84 / 4 = ?$ to word problems involving these operations, where a problem is presented and the operation to be used is not necessarily evident.

For both the groups of working children, it is the goals rather than the methods that form the focus of the vending activity. Number knowledge and operating with the numbers becomes a necessary requisite of solving the problems of buying, selling, calculating prices and handing back change. This involves the use of at least the two operations of addition and subtraction on a fairly routine basis. The operations of multiplication and division are less obviously required of the newspaper sellers, though the process of buying newspapers from the wholesalers does call for such operations. In sharp contrast to the newspaper selling the paanwallas deal with a number of items and a number of units of each item. The smallest of the paan shops stock at least 4 to 5 varieties of cigarettes and 2 to 3 kinds of paans, each of which is priced differently. Each brand of cigarettes moreover may come in different sizes and can be sold in packs of tens and twenties, or, as singles. The need to apply multiplication and division in the computation of prices and handling money arises often enough. The four operations, it was felt, would provide a fair measure of the competence with which the subjects understand and deal with numbers and number problems.

Subjects in the three population groups were compared on accuracy scores on 8 word problems for each of the four operations, under two conditions of familiarity. A repeated measures analysis of variance was carried out to compare accuracy of performance on the four operations and two levels of familiarity for the three population groups with age as a covariate.

The 3 (population group) by 4 (operation, repeated) by 2 (familiarity) repeated measures anova with age as covariate (since all three groups varied on age), revealed significant main effects for group ($F(1,44)=3.22$ $p = .04$), for operations ($F(3,135)=51.46$ $p=.0001$) and for familiarity ($F(1,45)=9.42$ $p=.004$). The group by operation interaction was highly significant ($F(6,135)=4.32$ $p=.001$) as was the group by familiarity interaction ($F(2,45)=3.66$ $p=.03$) and the operation by familiarity ($F(3,135)=18.65$ $p=.0001$) The three way interaction of group by condition by operation was also statistically significant ($F(6,135)=2.81$ $p= .013$).

These main effects indicate that the groups differ from each other whether it is on the overall score for all the operations, whether it is for each of the operations or whether it is for levels of familiarity across all four operations. The significant interactions are evidence of the complexity of these differences and need to be discussed in detail.

To begin with we have the overall difference in the accuracy scores of the three groups. This difference is significant and the paanwallas perform better than both the other groups. Duncan's multiple Range Test revealed that cigarette sellers fared significantly better than both the school children and the newspaper sellers ($ps < .05$), but that no such difference exists between the newspaper sellers and the school children. Table 2 shows a comparison of the means for the three groups.

TABLE 2
Mean Accuracy Scores of the Three Groups Across the Four Arithmetic Operations.

SC	PW	NP
M=38.55 SD=20.19	M=52.14 SD=9.73	M=37.81 SD=11.48

The superiority of the cigarette-sellers is in keeping with the hypothesis that greater practice and a flexible use of numbers and operations would contribute significantly to overall performance on number-related tasks. The paansellers deal with a large variety of prices and currency denominations as compared to the newspaper sellers, whose experience is limited to a narrowly set range of prices, fewer and simpler transactions and consequently a more limited use of all four operations. The school children, who in the course of their school mathematics deal with both a large variety of numbers and any number of hypothetical word problems involving both numbers and the four operations, should have been able to deal with these routine textbook-like problems with a greater competence. Their performance was no better than the newspaper group.

Despite similarities between the overall scores of the newspaper sellers and the school children, the performance is not identical and this is what we shall focus on, in the next section. Taking the lead from main effects for operations and familiarity and the significant interactions, oneway analyses of the data were carried out to analyze and understand these differences.

The analysis and discussion will focus first on each of the four operations along with an analysis of the strategies. The familiarity effect will be discussed in the context of each of the four operations and lastly we shall look at the effects of rephrasing on the operations of multiplication and division.

TABLE 3.
Comparison of the Three Population Groups on Each of
The Four Arithmetic Operations.

GROUPS	ADD.	SUB	MULT	DIV.
SC (N=18)	M=11.83 SD=4.55	M=10.61 SD=5.66	M=8.50 SD=6.37	M=7.61 SD=6.47
PW (N=14)	M=14.64 SD=1.94	M=15.50 SD=1.66	M=10.43 SD=3.69	M=11.57 SD=4.21
NP (N=16)	M=12.13 SD=3.24	M=13.69 SD=2.52	M=6.00 SD=3.72	M=6.00 SD=3.84

SC=school group, PW=paanwallas, NP=newspaper vendors. ADD=addition, SUB=subtraction, MULT=multiplication & DIV=division.

1.ADDITION

a. Accuracy: The mean accuracy score for each population group on the addition word problems is presented in table 4. The performance of the cigarette sellers is near perfect with a mean of 14.64 out of a possible score of 16. The accuracy scores of the other two groups are fairly high though not on par with the paanwallas. The F-ratio for difference between population groups for addition word problems across the familiarity condition was not significant, but Duncan's Multiple Range Test revealed that the cigarette sellers performed significantly better than the school population group ($ps < .05$). No significant differences were found between the cigarette sellers and the newspaper sellers or between the school group and the newspaper sellers.

However, when we look at the means for the familiarity condition and the unfamiliarity conditions separately, we see a slightly different picture. Oneway analyses revealed significant differences on the familiar problems ($F(2,45) = 2.78$, $p < .005$) but not on the unfamiliar problems. On the familiar problems, the cigarette and newspaper sellers both performed significantly better than the school group (Duncan's procedure $ps < .05$). The F-ratio for the comparisons in the unfamiliar condition was not significant, but the cigarette sellers had significantly higher accuracy scores than the newspaper sellers (Duncan's procedure ps <.05).

TABLE 4.
Mean Accuracy Scores of the Three Population Groups
On the Addition Word Problems

	SC	PW	NP
ADDITION	11.83	14.64	12.13
ADDITION FAMILIAR	5.78	7.64	7.13
ADDITION UNFAMILIAR	6.06	7.00	5.00

b.Strategies used for problem solutions: (Appendix 10a) An analysis of the strategies for correct as well as incorrect problems revealed further differences between the three population groups, not necessarily of the same order as the accuracy scores.

The first two categories i.e. repeats or writes are seen as attentional and attitudinal indicators. Observations in the first phase revealed that the paanwallas and the school children entered each interviewing session with a seriousness that was not present in the interactions with the newspaper sellers. Whereas the two former groups listened attentively to questions, asking for clarifications when necessary, and trying to answer the questions seriously and faithfully, interactions with the newspaper vendors took on a playful character. They repeatedly interrupted sessions with questions about the experimenter, about the tape recorder that I carried, and other personal questions unrelated to either the math activity or the immediate context. More than one newspaper vendor interrupted the examiner with questions like "why are you asking all this? ...Oh I don't know, but it doesn't matter." Consequently, it was used as a category in the analysis to evaluate group differences and its effect on the performance.

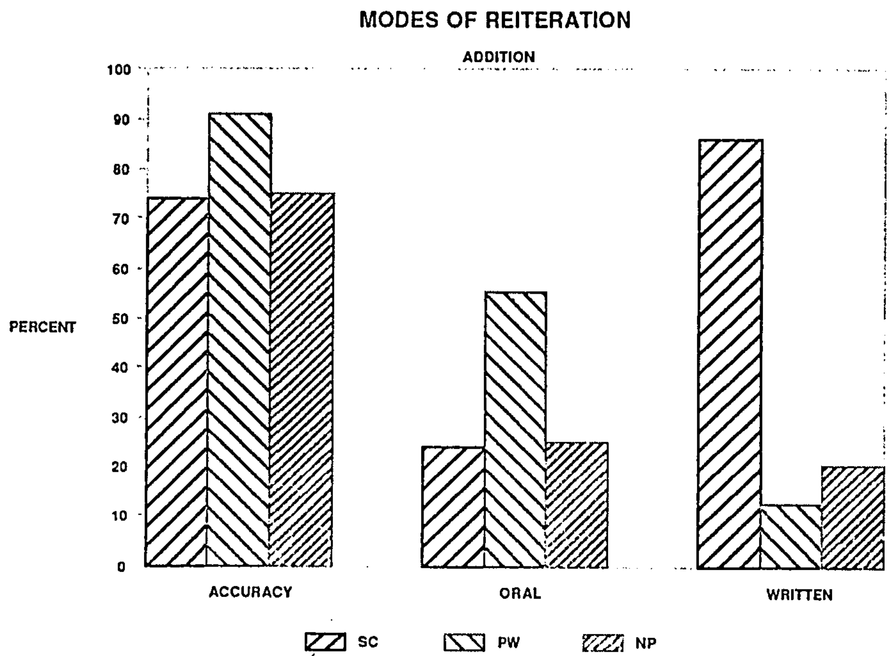

Figure 6 : Modes of reiteration used by the three population groups for the operation of addition

Differences were noticed among the three population groups at this level, both in the mode and the amount of re-iteration. Both the school children and the paanwallas either repeated the numbers or wrote them down before proceeding to work on them on a larger scale than did the newspaper sellers. As for the mode of representation, as seen in fig. 6, the school group made most use of writing, whereas both the other groups show a preference for oral repetition. The difference between the two modes is marked for the paanwallas, and not so marked for the newspaper vendors. Of this group, the written strategy was used by children who are currently in school rather than those with prior schooling.

As for the actual working out of the problems, the two working groups again lean heavily on out-of-school strategies as compared to school procedures which are overwhelmingly employed by the school group. The cigarette sellers solved 87% of the problems orally, drawing on their memory (23%) and using breakdown of numbers for 64% of the problems. The newspaper sellers similarly show an overwhelming preference for oral, non-school strategies in contrast to school-like solutions. This group takes recourse to memory and breakdown for 70% of the problems, whereas school algorithmic solutions were used for 14% of the problems. In contrast to the two working groups the school group used school algorithmic solutions for 85% of the problems, of which 86% were solved using the written mode. Memory and breakdown solutions were employed for a mere 4% of the problems. Predictably, the use of memory for problem solutions is much greater for the familiar problems than for the unfamiliar ones for both the cigarette sellers as well as the newspaper sellers.

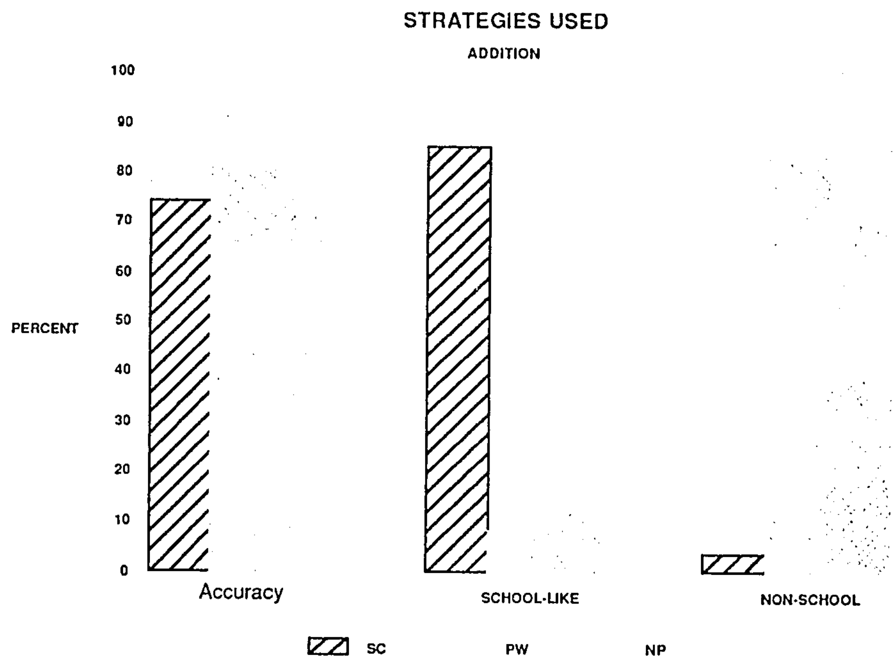

Figure 7 : Strategies used by the three population groups for the operation of addition.

The category of count-on, which is common to both school-like as well as non school-like solutions and therefore not definitively categorizable as either was used by all three groups, though minimally.

It is however interesting to note the differences in the breakdown of numbers as used by the working children, in contrast to the few occasions when the school children make use of it. Whereas all 4 examples where the school group used breakdown of numbers into what one supposes are easier and more familiar units, the variety within this procedure was far more limited than it was in the case of the working groups. For example:

Y.K. (school group), age 15:

Problem 1: 50 + 75.

Solution: 50 and 50 make 100, and 25 more makes it 125.

J.A. (paanwalla), age 12:

Problem: 25 + 35 + 40.

Solution: 5 from 25 added to the 35 makes it 40, 40 plus 40 makes 80. Take the 5 back and we have 75, so 75 and 25 is a 100.

R.D. (newspaper seller), age 12.

1. Problem: 74 + 52.

Solution: Add 1 to the 74 and make it 75, that leaves 50 and 1, 75 and 25 makes 125, add 1 more - it's 126.

2. Problem: 24 + 16 + 38.

Solution: Add 1 to 24 from 16, that makes it 25 and 15. That makes 40 plus 35 and 3....... 70 and 8, or again,

3. Problem: 102 + 224 +145:

Solution: 224 + 1 is 225, 225 and 145 makes 370. 370 and a 100 = 470 + 1 is 471.

K. (newspaper seller),age 11.

Problem: 74 + 52:

Solution: Add 1 to 74 and make it 75, that leaves 50 and 1, that makes 125 and 1.

For the school group the rare manifestation of regrouping was resorted to, in the case of simple problems where the oral solution seemed a quicker way out - in all 4 cases it was the same problem - 50+ 75 which was solved without the use of the school algorithm. In fact, for the subset of unfamiliar problems, there was not a single instance where this strategy was used, irrespective of whether solutions were correct or incorrect. In the case of the two groups of working children as is evident from the table, this was the strategy of choice and the breakdown was not simply a redistribution of units, tens and hundreds but centred very obviously on the multiples of fives, which corresponds to the currency denominations and the numbers that are the significant markers in their day to day activity. It is also interesting to note that school-like strategies among the newspaper and cigarette sellers are used more often by subjects who are currently in school rather than those who have had some schooling but are not presently in school.

c. Errors related to strategy: (Appendix 11a)

There is an overall tendency for the school group to resort to school procedures for solving the problems, and that too overwhelmingly in the written mode. In addition and subtraction problems numbers are aligned by units, tens and hundreds as prescribed by the school algorithm and working on them proceeds from units to tens and hundreds. An analysis of the procedures indicates that for the problems involving the operations of addition and subtraction, the school children can identify the operation required for solving the problem. The errors for this group arise out of a wrong application of the algorithm, or what are designated as bugs. Of the 23 problems in the addition subgroup, that are solved using the written school algorithm, only 7 errors were due to miscalculation, whereas 15 problems were incorrectly solved because of bugs in the procedure such as not carrying over, wrong alignment of numbers and so on.

For the cigarette sellers, who had a high success rate on addition problems, errors arose from miscalculation when numbers were misrepresented in the course of the calculation. Of the

10 erroneous answers 8 were oral miscalculations and 2 were abandoned with the explicit statement that the numbers were too large.

The newspaper sellers too had no problem identifying the operation required, but had problems dealing with the numbers. Of the 32 problems, only in the case of 7 problems was there an attempt at working through the whole problem, whereas 21 were abandoned after a cursory and ineffective attempt or no attempt at all. 13 of these problems were abandoned with the explicit statement that the numbers were too large to deal with.

Correlation with addition math facts:

Table 5.
Correlations between addition math facts and accuracy scores on addition word problems.

SC	PW	NP
.715 ($p<.001$)	.251 ($p=.193$)	.605 ($p=.006$)

For the school children and the newspaper sellers correlations between addition math facts and accuracy scores on word problems were high. The scores of the paanwallas on both sets were high and there was very little variability, which accounts for the lower coefficients. Breaking down of the numbers by the two working groups is done precisely to reduce them to familiar quantities, combinations of which may be available as math facts. The correlation for the school group similarly indicates that performance on the word problems is related to their repertoire of math facts.

d. Summary.

The phrasing used for addition word problems makes the operation evident and the link between the operation and the problem is a transparent one. The performance of all three groups accordingly reflects this facility, and though the accuracy scores of the school group and the newspaper vendors fell short of the paanwallas, all three groups displayed adequate efficiency in solving addition problems (Out of a maximum possible of 16, the lowest score was 11.83).

The paanwallas scores were near perfect for word problems that require the use of addition. Their performance on the familiar problems was marginally better than that on the unfamiliar ones, though the difference was not significant. The operation of addition is routinely performed by the paanwallas in the course of their selling and buying, and they have no difficulty in handling either the numbers or the operation. 91% of the familiar problems and 82% of the unfamiliar problems use either the strategies of memory or breakdown. Use of the memory strategy indicates that the subject draws upon math fact and gives an immediate answer. The majority of the problems using the breakdown strategy also make use of math facts in combination with other strategies. Therefore for solutions of these problems the subjects are drawing upon a fund of facts that is at their disposal, and have the capability to map it correctly and successfully to the problems presented to them. The major cause of errors for this group was miscalculation, when the numbers were large and after the breaking up, they missed adding back all the original numbers. Errors were also recorded when problems were not attempted at all. The unschooled subject on this group was the only one making this error, and he is recorded as stating that the numbers were too large for him to deal with. This subject had neither an adequate knowledge of the number system nor of its orthographic representation.

This inadequacy of a knowledge of conventional number names and an orthographic system is what seems to be the crucial source of errors for the newspaper vendors as well. They performed significantly better on the familiar problem set than they did on the unfamiliar ones, again with an overwhelming dependence on memory and math facts. While dealing with unfamiliar numbers they had to consistently depend on a non-conventional but inconvenient enumeration strategy which made working with 2 or more numbers exceedingly cumbersome. A number like 50 represents a 50 paisa coin, it is a number these children use continually in the course of their selling and some form of mental representation of this number seems existent, whereas when confronted by a number like 73, 9 out of the 16 subjects broke it down to 70 and 3, which increases the memory load as two numbers instead of one have to be retained. This puts an added strain on the capacity needed for calculations and consequently gives rise to miscalculations. In fact, for 40% of the problems that they failed to solve correctly, subjects in this group gave up after admitting that the numbers were too large. A large number of the problems were abandoned when subjects attempted them with the use of correct procedures, but could not keep track of the numbers. This is supported by the fact that on the familiar number set, for which they had adequate number names, the performance was significantly better. Again, as in the case of the paanwallas, strategies for correct solution relied heavily on math facts and memory. No difficulties were observed in the understanding or application of the correct operation.

If the school children failed it was not for want of mapping on the right operation but as a result of miscalculations and bugs in their use of procedures. They performed equally well in both familiarity conditions, therefore the characteristics of the numbers did not seem to have a deleterious effect when the operation was one they were familiar with and for which they were at least familiar with the algorithm. There is a certain competence with the algorithmic procedure taught to them in school, and if they have difficulty with carrying over or borrowing, this is not limited to the familiar numbers but is in evidence where carrying over is necessitated. The focus is on applying the right procedure, even though the results then are conceptually contradictory. For e.g. a school child seems to have no problem adding 75 and 25 to get an answer of 910 as a result of adding the two 5's to make 10, and the 7 + 2 which makes 9, whereas this would disturb the newspaper seller or the paanwalla. The maximum number of errors for this group were due to bugs in application of the school algorithm for addition.

Viewed in the context of Vygotsky's zone of proximal development, the nature of the vending activity here acts as a cultural and inter-psychological bridge between the actual and potential levels of development, whereby a knowledge of a culturally devised system of counting, number names and an orthographic representation of numbers is acquired by this group, which then becomes a stock-in-trade for efficient functioning within this activity. 13 of the 14 paanwallas were able to count fluently up to 500, and the one paanwalla who did not have a command of the number system, gave a dismal performance. The paanwallas therefore have the dual advantage of possessing knowledge of a sign system which allows them to represent all denominations of numbers along with a procedural and conceptual understanding of the operations they are called upon to perform.

2. SUBTRACTION

a. Accuracy.

One way analyses revealed significant differences on subtraction problems amongst the three population groups ($F(2,45) = 6.74$ $p = .002$). Duncan's Multiple Range Test revealed that both groups of working children performed significantly better than the school group ($ps < .05$). Analysis of the familiar and the unfamiliar conditions for subtraction revealed significant differences for both conditions ($F(2,45) = 9.74$, $p < .0003$) and ($F(2,45) = 4.14$, $p < .02$) respectively. Though both groups of working children performed better on the familiar subtraction problems, the significant differences on the unfamiliar problems were between the cigarette sellers and the school group, the former obtaining higher scores (Duncan's Multiple Range Test $p < .05$).

Table 6.
Mean accuracy scores for the three population groups on subtraction word problems.

	SC	PW	NP
SUBTRACTION	10.61	15.50	13.69
SUBTRACTION FAMILIAR	5.67	8.00	7.88
SUBTRACTION UNFAMILIAR	4.94	7.50	5.81

b. Strategies used for problem solutions (Appendix 10b)

The pattern of reiteration is similar to that for addition problems. The school group and the paanwallas use reiteration to a greater extent than the newspaper sellers, and all three groups use it more often in the case of the unfamiliar numbers than the familiar numbers. Again both working groups repeat numbers orally whereas the school group writes them down.

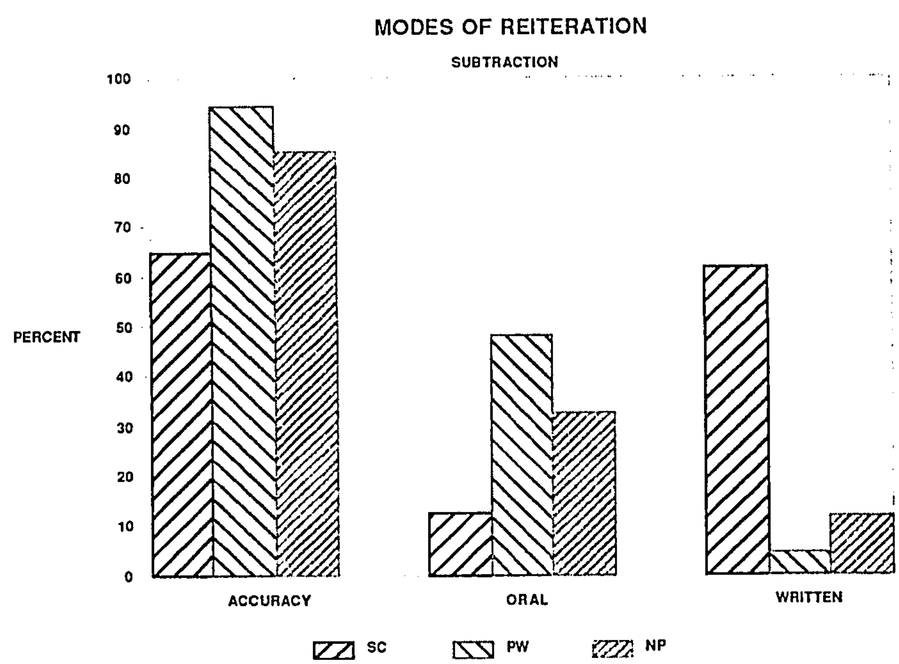

Figure 8 : Modes of reiteration used by the three groups for the operation of subtraction

For working out the problems the pattern for this subset is slightly different. The familiar problems for subtraction are solved orally to a much larger extent by all three population groups.

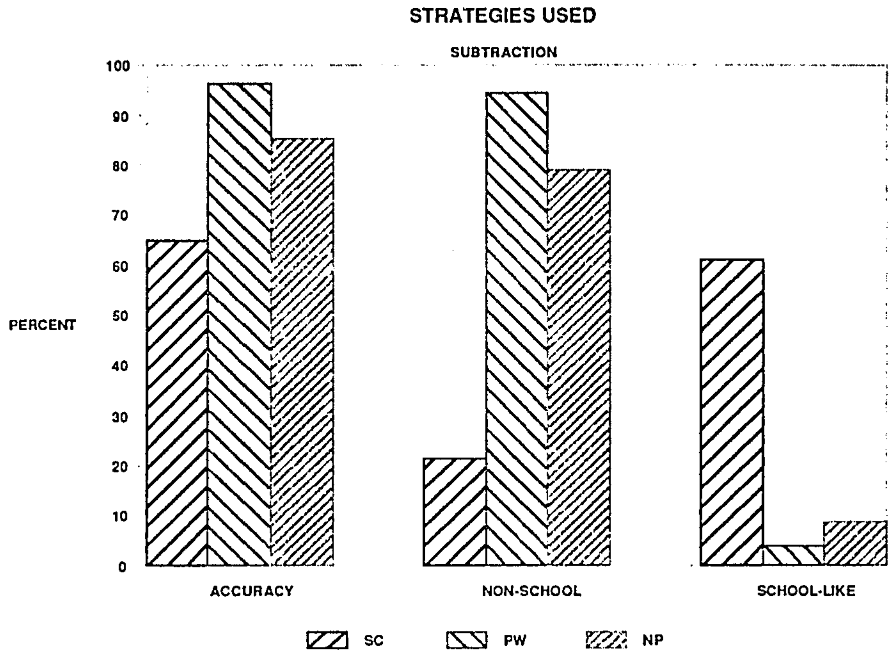

Figure 9 : Strategies used by the three groups for problem solution for the operation of subtraction

The school group resorts to memory more often for the familiar problems, though solutions for unfamiliar problems revert back to the school procedures. They use the prescribed school algorithm for subtraction, and though there are some instances of using the algorithm orally, the majority of the problems use the written strategy. The cigarette sellers use solutions from memory for 87% of the familiar problems and the newspaper sellers for 67%. The unfamiliar problems are largely solved by breakdown procedures by both these groups (87% and 61% respectively), which again is a-non-school strategy in the oral mode.

The overall use of school algorithm, whether in the written or the oral mode as compared to strategies of memory and breakdown of numbers for the set of subtraction problems irrespective of the levels of familiarity is similar to that seen for the addition problems with the school group indicating a definite preference for the former and the two working groups making greater use of memory and breakdown procedures.

The school children use regrouping strategies for a mere 3% of the problems, the rest being tackled by memory or school learned procedures. Both the newspaper vendors and cigarette sellers solve the familiar subset using math facts only, but revert to regrouping and subsequently the use of math facts where unfamiliar numbers are involved. The numbers again tend to get grouped into multiples of 5's and 10's as was the case in the addition problems:

J.A. (paanwalla), age 12:

Problem: 190 - 73:

Solution: 73 and 2 makes 75... 75 + 15 is 90... that makes 17 and a 100 is 117. Therefore the 73 is first subtracted from 75, this is subtracted from 90 and then the 100 is added on to it.

S. (newspaper seller), age 13:

Problem: 44 - 12:

Solution: Take 10 away from 44, that leaves 34, take away the 2 and that's 32.

d. Errors related to strategy. (Appendix 11b)

All three population groups gave no indication of any difficulties in understanding the problem or the operation that was needed for the solution. Though errors for all three groups were the lowest on the subtraction problems they provide some useful insights. In contrast to their strategy use on the problems solved correctly, the school group did not indicate the use of math facts or number breakdown in any of the problems which could not be correctly solved. Errors arose mainly on the use of the school algorithm, and 24 of the 31 problems were erroneously solved because of bugs in the application of the procedure.

The paanwallas had very few errors, and of the 4 unsuccessful solutions 2 were miscalculations, where subjects lost track of the numbers in counting off and 2 were not attempted at all, and this again by the one subject who had problems with number names.

The newspaper sellers too were highly successful in their solution of the subtraction problems. Of the problems they were not able to solve, 44% were not attempted at all, and subjects stated that the numbers were too difficult for them to handle, and 22% were abandoned after an initial attempt because subjects lost track of the numbers.

Correlations.

Table 7.
Correlations between subtraction math facts and subtraction word problems.

SC	PW	NP
.686 (P=.001)	.098 (P=.368)	.656 (P=.003)

The relationships are similar to those found for the operation of addition. In fact as the strategy use shows, math facts were extensively used for the familiar subtraction problems by all three groups. The school group drew upon math facts for 50% of the problems that they solved correctly. The paanwallas had near perfect scores on the word problems and therefore the correlation cannot be interpreted.

d. Summary.

The differences between the groups were more pronounced here than they were on the addition problems. Both the working groups improved their accuracy scores on this operation, and their performance was significantly better than the school group. Differences in the accuracy scores as a function of the familiarity level was most marked for the newspaper sellers. Both working groups had higher accuracy scores than the school group on the familiar set, but only the cigarette sellers score over the school group on the unfamiliar problem set.

The correlation with math facts is significant and the strategy analysis reveals that all three groups used math facts and memory to arrive at the solutions. Added to this is the fact that each subtraction problem involved the use of two numbers only, which reduces the memory load and thereby provides an advantage to subjects who do not have access to the orthographic system. That both working groups had their best scores on the subtraction subset, can be explained by their practice linked functioning. Of all four arithmetic operations the one that is called upon the most in both kinds of vending i.e. selling newspapers or selling the items that a paanshop stocks, is that of subtraction. To go back to the two vending activities, we observed that the newspaper selling can be divided into roughly three processes: buying of the newspapers, selling the newspapers and after-sale calculations and preparing for the next day.

The buying phase, as described earlier, in actual fact is rendered fairly simple as a predetermined number of papers is purchased depending upon the amount of money to be spent. Numerical calculations at this stage can moreover, be delegated to the agents who sell the newspapers to the vendors. The major chunk of time and effort is spent in making numerical calculations in the actual selling. During this phase the vendor is asked for a newspaper and handed a sum of money, and if necessary, has to hand back change to the customer. The one operation this oft-repeated transaction involves is subtraction. The vendor gets a sum of money, takes away from it the price of the paper, and hands back to the customer what is left over. This is also the one operation that necessarily needs to be done without any external aids, because when a sum of money is received for which change is to be handed back, it is necessarily in the guise of a denomination which cannot be physically broken up for e.g. a note of Rs. 2, 5 or 10. The vendor then has to mentally calculate how much remains if the price of the paper is taken away and hand back the rest. Similarly in the case of the paanwallas, calculating prices and giving back the required change is largely what occupies their working time. For them however this involves more than subtraction alone, because purchases made at the paan shop often involve the sale of more than one article, and therefore the cigarette seller has to add up the prices of two or more items, take that away from the sum received and then hand back the change. Therefore subtraction is the dominant operation that the two working groups employ in the course of their selling activity, whereas for the school group it is one among the four operations, and scores over multiplication and division in that it sequentially precedes them within the school curriculum.

3. MULTIPLICATION:

a. Accuracy:

Subjects in the three population groups differed significantly on scores for the multiplication problems ($F(2,45) = 3.10$, $p = .05$). The Duncan's Multiple Range Test revealed that the paanwallas performed significantly better than the newspaper sellers but that the performance of the school group was not significantly different ($ps < .05$). The results were identical for the familiar condition ($F(2,45) = 3.80$, $p = .02$) and no significant differences were found for the unfamiliar condition.

Table 8.
Mean accuracy scores of the three population groups on multiplication word problems.

	SC	PW	NP
MULTIPLICATION	8.50	10.43	6.00
MULTIPLICATION FAMILIAR	3.72	4.93	2.13
MULTIPLICATION UNFAMILIAR	4.78	5.50	3.88

b. Strategy use.(Appendix10c)

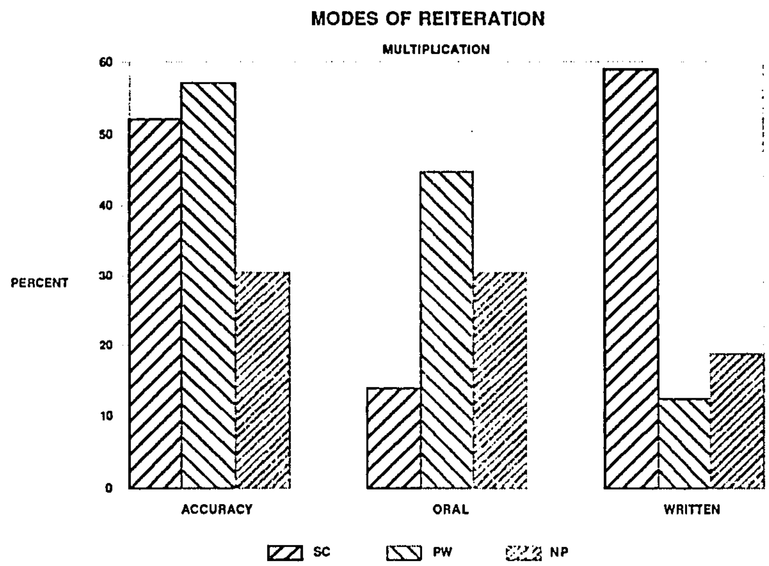

Figure 10 : Modes of reiteration used by the three population groups for the operation of multiplication.

The success rate on this set of problems is considerably lower than the addition and subtraction problems for all three groups. There is a higher amount of reiteration by the school group and the paanwallas, than by the newspaper sellers, for which the school group depends largely on the written mode (59%). The cigarette sellers use oral repetition for 45% of the problems, whereas writing down of numbers is used for 13% of the problems. For the newspaper sellers the trend is reversed for this one operation in that writing down of numbers is employed for 19% of the problems whereas repetition is used for 9% of the problems only. These subjects use very little reiteration on all four operations, and the analysis indicates that as accuracy goes down, and problems are seen as more difficult, the proportion of reiteration falls dramatically. It is the school going vendors from among this population group which persist with the reiteration and therefore the rise in the proportion of written reiteration.

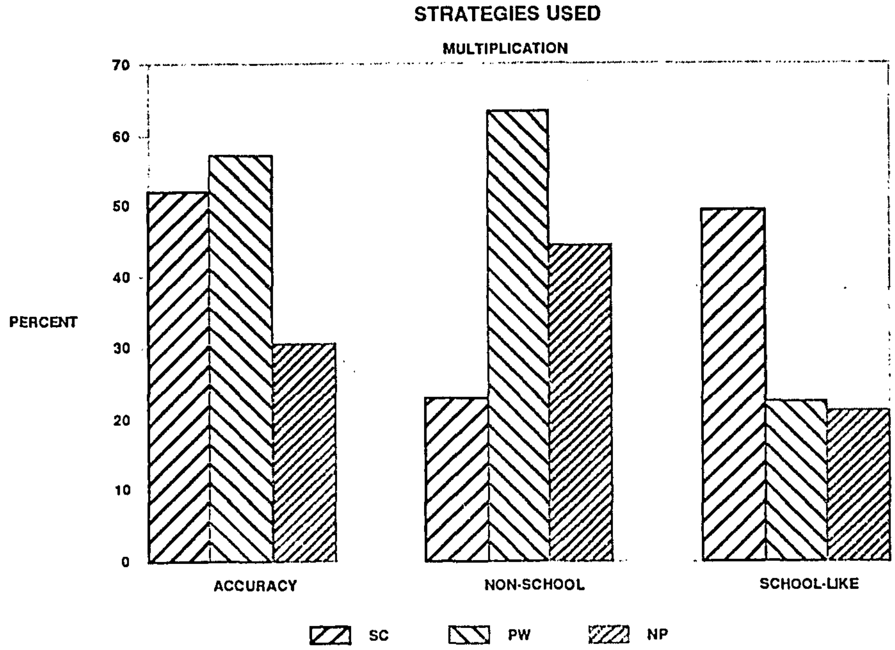

Figure 11 : Strategies used by the three population groups for the solution of multiplication problems

Strategies for solution confirm the earlier trends for all three groups. The school going children made use of multiplication tables, when confronted with the multiplication problems. The rest of the sample tends to resort to successive addition, and abandon it midway since the memory load becomes too heavy when the numbers are large. This becomes apparent if the strategies used for aborted solutions are taken into account, where the use of oral non-school strategies outweighs the school-like strategies.

49% of the problems are solved by the use of school-like strategies by the school group and 23% by the use of non-school strategies which include successive addition, associativity, and distributivity using the oral mode of functioning. The choice of strategy for the two working groups confirms the earlier pattern of functioning and non-school strategies dominate their problem solutions. The paanwallas used multiplication tables (characterized as oral school algorithm) for 16% of the problems.

In fact this group displays a variety and range of strategies, which is indicative of a flexibility of thinking about numbers and manipulating them in a variety of ways to arrive at a solution. An interesting strategy, categorized as optimizing, was used by a number of the working children and in 1 instance also by a school child. This entailed the use of a larger but more familiar number for carrying out the operation, and then subtracting the additional sum from the answer. This strategy was particularly noticed in the following problem: 24 * 4, where subjects multiplied 25 by 4 to get a 100 and then subtracted 4 from a 100 (3 of the paanwallas, 5 of the newspaper sellers and 1 school child used it).

Another example:

R.R. (paanwalla) age 16,

Problem: 50 * 30.

Solution: 30 into a 100 is 3000, half of that is 1500.

and again, 75 * 30 was solved in the following manner:

- 30 * 100 = 3000
- 30 * 25 = 750
- 3000 - 750.

<u>c. Errors related to strategy</u> (Appendix 11c)

Contrary to the first two operations of addition and subtraction, word problems involving operations of multiplication and division are more difficult to decipher. School children in the course of doing math often master the algorithms for multiplication and division but have difficulties identifying the needed operation when it is presented as a word problem.

The school group has problems identifying the operation to be applied for the given problems. This is already apparent for the multiplication problems and is magnified in the case of the division problems. Of the 69 multiplication problems which did not yield a correct solution for the school group, 21 are completely abandoned. Another 8 are attempted but the appropriate operation i.e. multiplication is not applied, and 17 are dropped with the explicit statement that they do not know which operation to use. Again, of the problems which are attempted only 5 use the correct school procedure for multiplication, and 17 are tackled using the strategy of repeated addition. Since the school procedure of solving multiplication problems involves the use of multiplication tables, this is an indication that subjects do not have these tables handy and some of the children explicitly stated this.

The paanwallas on the other hand apply the right algorithms, but make mistakes in computation. The algorithm varies from repeated addition (52%) to associativity or distributivity (69%) or the school algorithm (12%). In fact this group displays a variety and range of strategies, which is indicative of a flexibility of thinking about numbers and manipulating them in a variety of ways to arrive at a solution. The newspaper sellers have considerable difficulty with computations involving multiplication. Out of a total of 88 problems that they are unable to complete or solve correctly, they give up on a 54%(48). For a sizable number of the problems (21) subjects were aware of a solution strategy but made no attempt to apply it, whereas for another 10 they explicitly state that the numbers are too large for them to cope with. 50% of the problems were attempted using the right strategies, predominantly oral and non-schoollike, but with errors in computation. The lack of a conventional number naming system hinders their performance to a large extent and though they are able to recognize the procedure required, namely, that of successive addition, they are not able to mentally carry out such operations.

Two points become clear in these observations - one, that the newspaper sellers find it increasingly difficult to identify the familiar numbers when they are presented in an unfamiliar setting, especially as they come to operations which are less frequently used in their practices, and secondly, that they seem more aware of their own limitations in solving the problems presented. They are therefore able to analyze their own abilities and to state that they cannot deal with certain numbers. This meta-analysis is seen also in the case of the school children, who are willing to admit that they either do not know the necessary multiplication tables, and that they do not know how to tackle the problem and therefore give up, as opposed to the two previous operations where most subjects are able to apply the correct operation but not able to give the correct answer because of problems associated with bugs in the procedure. The school children did resort to non school-like solutions - mainly repeated addition, which was applied with a fair degree of success (25% of the unfamiliar problems and 12% of the familiar multiplication problems were solved by this strategy by the school group) which confirms the fact that if the problem is viewed as meaningful rather than merely mathematical, solutions are more easily forthcoming.

Correlations:

Table 9.
Correlations between multiplication math facts and word problems.

SC	PW	NP
.552 (P=.009)	.478 (P=.042)	.667 (P=.002)

Correlations are significant here for all three groups. The school group made use of multiplication tables where school algorithm is indicated in the strategy analysis, and so did the paanwallas, who draw upon their school learnt math when necessary. The performance of the newspaper sellers was not very good, since a large number of problems were not completed. Nevertheless the correlation is an indication of their use of whatever related knowledge that they posses and which consequently helps them in the solution of problems.

d.Summary.

On the multiplication problems the accuracy of all three groups drops considerably. The wording of the problems does not directly indicate a particular operation. In fact problems involving multiplication are in essence asking for a repeated addition, of which multiplication is a more efficient substitute.

School children, accustomed to using formulas find it more difficult to zero in on the right algorithm, in the absence of a clear and transparent demand for multiplication. They therefore have problems finding the "correct" algorithm, or having found it, of applying it correctly. The multiplication algorithm in the school context also requires a basic competence of multiplication tables if the algorithm is to be mastered. The lack of such a competence in itself becomes cause for abandoning the problems, which is what a number of the school children end up doing.

The paanwallas who once again solve more problems than the other two groups, indicate a better understanding of the problems as well as the strategies that can be used in achieving this end. The variety of strategies used by these subjects indicates an understanding of the numbers and the operation at a conceptual level. They are able to bring together their knowledge and understanding of the operations of addition and subtraction and apply it adequately for the purposes of multiplication. Paan selling activity requires the use of this operation often enough because of the need to calculate the prices of items which are bought in numbers of two or more, whether they use multiplication in the school format or simply as repeated addition. A number of paanwallas did make use of multiplication tables even though it was more often done orally.

The newspaper vendors have the most difficulty dealing with these problems, and 50% of the success rates are from subjects who are enrolled in school. In a large number of cases subjects make an attempt to solve the problem using adequate procedures, but give up midway because they cannot keep track of the numbers. The absence of a conventional representation system for larger numbers, whether orthographic or not, becomes a stumbling block for this group and leads to a poor success rate. The newspaper sellers could need to apply this operation if required to calculate the price of more than one paper when selling and especially when calculating the purchasing prices. In actual fact they do not, and as stated earlier, this is a culturally distributed activity and not always expected of the individual seller unless he or she is totally capable and willing to take it on independently. Nevertheless the sellers keep at least a rough account of the amount of newspapers sold and consequently the corresponding sums of money which they are accountable for.

Of the three groups those most easily willing to give up are the newspaper sellers, whereas both the paanwallas - who persevere and succeed considerably, and the school children who use their tried and tested methods but very often not successfully, make an attempt at the solution as far as possible.

All three groups however had higher success rates with the unfamiliar problems than with the familiar ones. A pertinent observation that needs to be made here is that all four problems involving familiar numbers consisted of 2 digit numbers as multiplier, since the units of currency which occur commonly in vending transactions are multiples of 5's and more often 25's - the commonest of which are the 25 and 50 paisa coins. Three of the four `unfamiliar' problems on the other hand had single digit multipliers. When these problems were tackled orally the memory load is vastly reduced if a successive addition is to be performed less than 10 times as opposed to a successive addition of over 20 times. This can be one of the reasons then that allowed the newspaper sellers who use the successive addition strategy to have a higher success rate with the unfamiliar problems than with the familiar ones. Similarly since more children are competent with multiplication tables of up to 10, the single digit multipliers are easier to work with. The multiplication algorithm in this case involves less steps and reduces the potential for making computational or procedural mistakes.

When problems were rephrased for the two working groups there was a dramatic and significant improvement in the accuracy of solutions for both groups - 92% of the rephrased problems were correctly solved by the paanwallas, and 82% by the newspaper sellers. The number in a concrete and familiar context is no longer an abstract symbol, but a manipulable entity as seen in the following examples:

F. (paanwalla), age 15:

Problem: If 1 carton contains 25 eggs, how many eggs in 40 cartons?

Solution: 4 cartons will have a 100... 8 will have 200... 200+ 200 = 400, how many cartons? 40?.. it's too much... (gives up).

When the problem is rephrased as: If one egg costs 25 paise, what is the price of 40 eggs?

Solution: Spontaneously converts the problem to cigarettes and gives the following solution: If 1 cigarette is 25p. 1 packet will be 2Rs. 50p. That makes it 10 Rs. for 4 packets...so 40 cigarettes will be 10 rupees.

S. (newspaper seller), age 13:

Problem: If 1 necklace has 50 beads how many beads would 30 necklaces have?

Initial attempt: 50 + 50 is 100, 3 times is 300.... it's too much, I can't do it.

When the problem is rephrased as `If one bead costs 50 paise, how much will 30 beads cost?

Solution: It will be 1 rupee for 2, which makes 5 rupees for 10...so 15 rupees for 30 beads.

4. DIVISION:

a. Accuracy:

There were significant differences between the three population groups ($F(2,45) = 4.67$, $p = .01$). The cigarette sellers performed significantly better than the school group and the newspaper seller group as revealed by the Duncan's Multiple Range Test ($ps < .05$). Differences between the newspaper sellers and the school group were not significant. Identical results were obtained for the familiar condition ($F(2,45) = 3.88$, $p = .02$) and in the unfamiliar condition the paanwallas performed significantly better than the newspaper sellers ($F(2,45) = 5.17$, $p < .009$).

Table 10.
Mean accuracy scores of the three population groups
on the division word problems.

	SC	PW	NP
DIVISION	7.61	11.57	6.00
DIVISION FAMILIAR	4.17	6.57	4.50
DIVISION UNFAMILIAR	3.44	5.00	1.50

The performance on this set of problems is closer to that of the multiplication problems and significantly worse than problems in the addition and subtraction subgroups. Though all three groups have better scores on the familiar problems than on the unfamiliar ones this difference is most marked for the newspaper sellers.

b. Strategies used for problem solution. (Appendix 10d)

The patterns of strategy use in the division problems confirm the earlier trends and both the paanwallas and school children use reiteration more often than the newspaper sellers. While the school group leans heavily on the written mode (95%), the paanwallas use oral reiteration of numbers more often. The newspaper sellers use reiteration for only a small proportion either in the written form (8%) or in the oral form (6%).

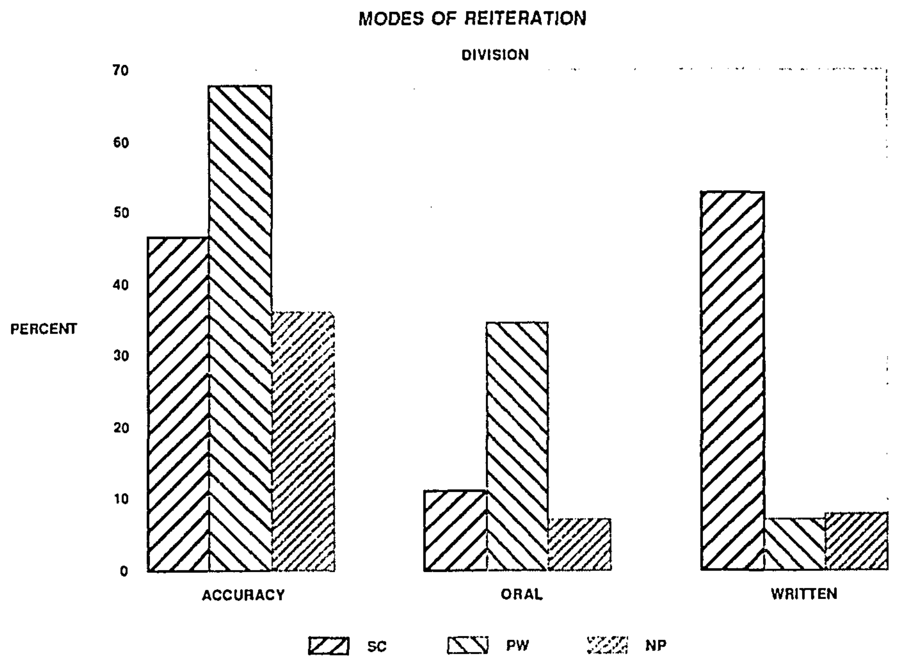

Figure 12 : Modes of reiteration used by the three population groups for the operation of division

As for the strategies used in solution of problems, the school group uses both written and oral school algorithms for division for 48% of the problems with a preference for the written form and successive approximations for another 10%. The two working groups use oral non-school strategies to a much larger extent and make a minimum use of school strategies. Both these groups use the written school procedure for division only in the case of unfamiliar problems.

The category of 'justification by answer' was applied when subjects were asked to explain the strategy they used and they responded by doing the operation in reverse to prove that the answer was correct for e.g. when asked how a problem like 100/25 was solved, the explanation is likely to be - 25, 25, 25 and 25 makes 100, so it 4 times 25 is a 100.

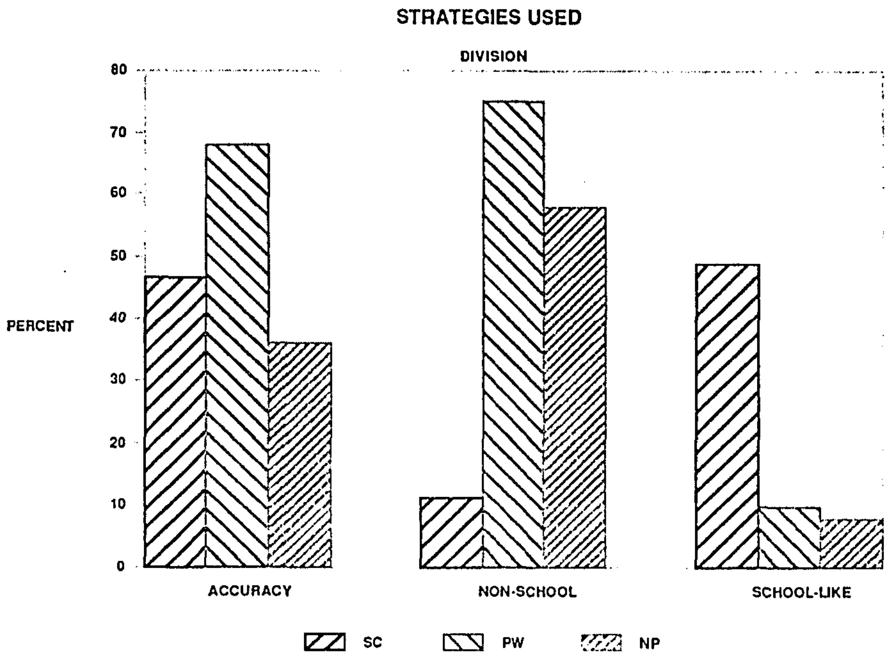

Figure 13 : Strategies used by the three population groups for the operation of division

This category is observed only in the two vendor groups and is taken as an indication of the inability to give a verbal explanation of a mental process, which has often been reported in unschooled subjects.

<u>d. Errors related to strategy.</u> (Appendix 11d)

The errors and reasons for inability of solution for this set of problems again approximates the multiplication problems. The mapping on of the appropriate operation itself is a problem, and the school children for a total of 77 problems use either a wrong operation (12%), do not know what operation to use (47%) or give up in perplexity (19%).

The paanwallas have a fairly good idea of the strategies involved but lose out in the oral calculation (53%). They use successive approximations most often, but tend to make computational errors and to lose track of the numbers.

The newspaper sellers perform poorly on these problems, and there is a significant difference in their scores on the familiar problems as compared to the unfamiliar ones. Of a total of 82 problems to which correct solutions were not given, they completely abandon 23, stating that they don't know what to do (12), or that numbers are too big (7), and trying their hand at successive approximations (31), and school algorithms (6), but coming up with computational errors here.

Correlations:

Since subjects were not assessed for division math facts, correlations between addition, subtraction and multiplication math facts and accuracy scores on division word problems were computed.

Table 11.
Correlations between accuracy scores
on division word problems and multiplication math facts.

SC	PW	NP
.709 (P=.000)	.534 (P=.025)	.440 (P=.044)

Correlations between the multiplication math facts and division accuracy scores were high for all three groups. Math facts of a multiplicative nature, whether in the form of tables or as alternative substitutes, were used to a large extent whether to buttress the school algorithm or the method of repeated addition.

d. Summary

On the division problems the paanwallas performance is significantly better than both the other groups and this holds for the subset of familiar problems. On the unfamiliar problems they perform better than the newspaper sellers but not significantly better than the school children.

Dividing is an operation which is theoretically applicable in both the work situations but in actual fact can be totally avoided by the newspaper sellers and to a large extent by the paanwallas. The school children on the other hand are required to learn the applications of this operation over the routine progression of the math syllabus, though it is the operation that is introduced last in the sequence and would normally be introduced to children at about ages 8 to 10 in grade 3. Subsequently this group would have least experience of dealing with this operation in the school context. That their performance peters out as they come to the division problems is not surprising.

5. REPHRASING.

A second order of analysis was carried out for the familiar group of word problems for the operations of multiplication and division. The problems were rephrased using the same numbers but were presented in a form which is directly mappable onto concrete perceptual objects they are used to working with. This was done to answer the following question: If the representation of numbers for the children who learn to deal with them through the monetary system hinges on common monetary denominations, then does it become easier for them to operate with numbers which can be mapped on to such figurative representations?

These problems had been rephrased to render familiar not only the numbers but also the content of the problems. In the original format, numbers with which the working groups had a greater familiarity were presented in word problems where the numbers were familiar but the content was neutral for all three population groups. For e.g. the number 50 was used in the following problem: If one necklace has 50 beads, how many beads would 30 necklaces have? Here the number 50, which as a monetary denomination is commonly used in vending transactions, remains an abstract number. When the same number is presented as 50 paise, in a rephrased form such as: If one bead costs 50 paise, how much will 30 beads cost?, it takes on a contextual significance and a representational form that can be directly mapped on to everyday dealings of the working children. A rephrasing of these two sets was done on this basis with the numbers rendered as monetary denominations.

The results were then analyzed to ascertain the degree to which it actually helped each of the three population groups. Table 12 compares the groups and indicates the proportion of problems that required rephrasing as a consequence of the inability to solve it on the first representation, and the proportion of problems subjects are able to solve, as a result of rephrasing.

TABLE 12.

Proportion of multiplication and division word problems solved as a function of rephrasing.

	MULTIPLICATION		DIVISION	
	Initially Incorrect	Rephrased& correct	initially incorrect	Rephrased& correct
SC	.55	.125	.50	0
PW	.50	.92	.21	.75
NP	.81	.82	.47	.43

A one way analysis between groups of the extent to which rephrasing helps indicates highly significant differences ($F(2,45)=23.87$, p, <.001). The Duncan's Multiple Range Test shows that the newspaper vendors benefitted most from the rephrasing, and that for the school group the rephrasing did not make any difference. For the cigarette sellers too rephrasing did help but not to the same extent as it did the newspaper sellers, even if this arises from the fact that the initial performance of this group was better.

6. Effects of familiarity:

TABLE 13.
Comparison of the three groups on the two levels of familiarity across the four operations.

	PROBLEMS	
GROUPS	FAMILIAR	UNFAMILIAR
SC	M=19.33 SD=9.87	M=19.22 SD=11.23
PW	M=27.14 SD=3.77	M=25.00 SD=6.58
NP	M=21.62 SD=4.95	M=16.18 SD=7.72

The significant differences analyzed by the Duncan's Multiple Range Test were in the following direction: the cigarette sellers' scores were significantly higher than those of the school group and the newspaper sellers (ps .05). For the unfamiliar problem set, the differences were significant at the .03 level. The intergroup differences however were significant only between the newspaper sellers and the cigarette sellers (Duncan's Multiple Range Test, ps .05).

Although there are no statistically significant differences between the newspaper sellers and the school group on either the familiar or the unfamiliar problems across all four operations, a look at the means indicates an interesting trend. The newspaper sellers perform marginally better than the school children on the familiar set of problems but on the unfamiliar set their performance is worse. Related to this is the finding that here the newspaper sellers differ from the other two groups when within group differences on the two conditions of familiarity are taken into account. On these within-group differences the school children and the paanwallas present a similar picture. The school group gains no special advantage from the familiarity factor since it was based on the use of the monetary denominations, which is not the locus of identification for them. The cigarette sellers had better scores on the familiar problem set but the difference is not statistically significant. Because of their extensive and varied use of numbers, they seem to have canceled out any advantage that numbers corresponding to monetary denominations should hold for them. They resemble the school group on differences between familiarity levels, although their performance is much better on both. The newspaper sellers perform significantly better on the familiar as opposed to the unfamiliar problems. ($F(1,30) = 5.62$, $p = .02$). We can conclude then that the cigarette sellers, because of their flexible use and variation of number combination, are able to cross the unfamiliarity barrier and to deal with these numbers with almost as much ease as they do the mor familiar numbers. The newspaper sellers on the other hand because of their more constricted use of numbers are able to work within the familiar domain with more ease and efficiency than within the unfamiliar domain.

7. **Within Group Comparisons.**

A relative comparison of performance within each group on the four operations and the two familiarity conditions which was subsequently carried out will be useful in understanding these results.

For the school group the Duncan's Multiple Range Test indicated a significant difference between the addition and the division scores ($p \leq .05$). Table 3 indicates a gradual decrease in the scores, with a mean of 11.83 on the addition problems and a mean of 7.61 on the division problems. This is consistent with the rationale of the school math syllabus, which assigns a hierarchical ranking to the four operations on an order of difficulty and therefore also introduces them into the work schedule of school children in this same order.

The cigarette sellers' performance does not conform to this order. A one way analysis revealed significant differences within the group for performance between the operations (F (3,52) = 8.97, p=.001). The Duncan's Multiple Range Test revealed that accuracy scores for addition and subtraction were higher than scores on multiplication and division. Though these significant differences are in the predicted order, a look at the means gives a slightly different picture. The addition and the subtraction problems clubbed together showed significantly higher scores than the multiplication and division problems. However, within both subsets, the means for the supposedly more difficult operation are higher for this population group. The mean for the subtraction problems is 15.50 as compared to a mean of 14.64 for the addition problems. Similarly, a mean of 11.57 on the division problems is higher than the mean of 10.43 on the multiplication problems.

The pattern of performance of the newspaper sellers approximates that of the paansellers rather than the school children, whereas the level of performance is closer to that of the school children and lower than that of the cigarette sellers. A one way anova revealed highly significant differences between the two subsets (F (3,60) = 22.84 p< .001). The Duncan's Multiple Range Test revealed that performance on both the addition and subtraction problems was significantly better than their performance on the multiplication and division problems. (ps .05). Differences between addition and subtraction and between multiplication and division were not significant, but as in the case of the cigarette sellers these differences were not in the predicted direction. The performance of this group is again marginally better for subtraction than for addition - the mean for subtraction is 13.69 as compared to the mean for addition which is 12.24. The means for multiplication and division are exactly alike - 6.00 for both operations with standard deviations of 3.72 and 3.84 respectively.

The standard deviations across the operations within each group are also worth noting. Although all three population groups have the highest standard deviations on the division problems the school population group has larger standard deviations for all four operations than the other two population groups. Standard deviations for the school group range between 4.55 for addition to 6.47 for division, for the cigarette sellers between 1.66 for subtraction and 4.21 for division problems and for the newspaper vendor group the range is between 2.52 for subtraction and 3.84 for the division problems, which suggests that the school group is less uniform in its performance than the two working groups.

8. Effects of age, schooling and years of experience.

Contributions of age to the accuracy levels were computed by a regression analysis across all three groups, and a significant amount of variance in the scores is accounted for by this factor (R square = .23, F=13.52, p = .0006). Age, therefore is a significant predictor of success, and this factor was controlled for in the earlier analyses for differences as a function of population groups.

Regression analyses were also carried out for the two working groups to evaluate the contributions within these groups of age, experience and schooling. The variance contributed by these three factors is considerable (R square = .36, F=7.62, p = .002). However though the contributions of years of schooling (t=2.28, p=.03) and of age (t=2.07, p=.04) were significant, years of experience did not contribute significantly. This could be explained by the fact that it is the quality of experience rather than its duration that makes an impact on the arithmetic ability of the subjects. Therefore a basic participation within each activity ensures an understanding of arithmetical relationships, which does not necessarily transform with years of practice. That the nature of the activity contributes to these understandings is brought out by the very significant differences between groups as a function of the nature of the vending practice.

9. Comparison on the basis of sex.

Though the sample for this study was selected on the assumption that there are no inherent differences in performance on arithmetic tasks on the basis of sex, an analysis was eventually carried out to ascertain any such differences that may have been manifested by the subjects of the two groups which did include female subjects. Independent sample t-tests were carried out for each of the two groups separately, but neither the school group nor the newspaper sellers showed any significant differences in performance on the basis of sex.

Summary: A vocabulary of a language for mathematics.

To sum up the performance on the four operations, we see that the paansellers are more proficient than the other two groups on all four operations. Differences and similarities between the three groups were seen at levels other than the overall accuracy scores.

The school children have their best scores on the addition problems, and subsequently there is a steady decrease over subtraction, multiplication and division. There was no indication of differences between their performance on the familiar number problems and the unfamiliar number problems on any of the four operations. When multiplication and division problems were rephrased in monetary denominations no significant changes were recorded in the accuracy of answers. These findings can be interpreted in the context of the practice of schooling as described in chapter 5, based on the ethnographic observations of this practice. The school curriculum for mathematics begins with familiarizing children with the conventional sequence of number names and their use in counting. Children are at the same time taught to recognize and begin to write the orthographic symbols of this sequence. Schedules are set annually and whether or not children understand the concept of number in relation to this conventional system, they are expected to master it. The next step is to introduce the four arithmetic operations in the prescribed order of addition, subtraction, multiplication and division. Each operation carries with it a prescribed method or what we call the school algorithm. These operations are initially employed in computational exercises and later on as embedded in word problems. Observations of the situations within which the participants of this study came from, revealed that school settings and the math schedules focus much more on the curriculum than on the children who are to acquire an understanding of the curriculum. Teachers are keen that students learn the algorithms and great importance is attached to correct answers.

The strategies used by the children and the kinds of errors seen in their solutions reflect the forms of learning and interaction of their number related practices. The immediate response of the school child to the experimenter's questions was to start writing, even though the questions were posed orally. The strategy analysis reveals that for this group, the mapping on of the operations is easier in the case of addition and subtraction than it is for the problems involving multiplication and division. operations. A lack of understanding of the place value system is exhibited, when routine procedures are applied and no concern is registered in the case of anomalous answers. This is brought out also by the fact that this group shows no effect of the condition of familiarity. Though problems in the familiar subgroup were presumed to have a higher familiarity rating for the two working groups by virtue of having been based on the monetary system, they should by the very rationale of a base ten system, be more accessible to the school population as well. *But since the priority seems to be granted to the algorithm rather than to the numbers in the context of the word problems, this advantage is lost in the process of the actual working out of the problem.* In fact the word problems for this group are seen as a challenge to discover the appropriate operation rather than a numerical problem within a meaningful context. A fair number of the respondents commented on this aspect for example, "I should do addition here, isn't it?", or, "Can you tell me whether to use multiplication or division for this problem?" or again, "If you tell me what operation to use I can do it. " The number symbols and the prescribed procedures to work with these symbols become so predominantly the focus in this setting that the implications of wider relationships to any meaningful contexts seem to get obliterated in the process. The classroom context of "doing" arithmetic as a decontextualized activity seems to place limits on its application Understanding of the numerical relations and operations, which should form a basis of learning in school, would make the task of progression from one operation to another easier, and is the principle on which the sequential introduction of the operations is based. Consequently a knowledge of properties of addition, for example, should make the reverse operation of subtraction that much easier to incorporate, as also the property of repeated addition which is implicit in the operation of multiplication. The practice of arithmetic in the classroom does not make such an understanding obligatory. The means of evaluation in the classroom is a correct answer, which can be arrived at simply by applying the correct procedure whether or not the student understands the relationship between the problem and the procedure. The negative consequence of committing errors are likely to be, initially, rebuke from the teacher, and subsequently failure in the examinations. In any case the margin of error is large since with a minimum of thirty percent marks the child is declared successful in a subject. An incorrect solution does not entail any economic losses, as it would in the case of the working children.

Although the newspaper sellers did not have significantly better overall scores than the school group, their performance on the familiar addition and subtraction problems was significantly better than the latter. Overall scores for familiar problems across operations were higher for this group than they were for the school group, and accuracy scores across the unfamiliar set were lower, though neither of the two were statistically significant. A comparison of their performance between operations indicates a marked difference between addition and subtraction on the one hand and the multiplication and division problems on the other. However, in contrast to the school children, but in consonance with the performance of the paanwallas, subtraction accuracy scores were better than the addition scores, and the means for multiplication and division were identical. Again, unlike the school group, their performance on the familiar number tasks was significantly better than for the unfamiliar ones. When multiplication and division problems were rephrased in terms of monetary denominations, a highly significant improvement was evident in the accuracy scores. Accuracy scores of these two groups are an indicator of their similarities, but do not form the complete picture; the differences are indicated by the quality and practice of their functioning.

The selling of newspapers involves arithmetical activity in which counting (of newspapers or money), recognition of monetary denominations and the operations of addition and subtraction are necessary and sufficient skills. More complex numerical skills are an asset but not strictly necessary for efficient functioning. Performance for this group, when measured across the four operations, not taking the familiarity dimension into account, was equivalent to that of the school group, but significantly less accurate than that of the paanwallas. Performance on the subtraction problems, and on the "familiar" addition problems was significantly better than the school group. Therefore the school experience and the newspaper selling experience though disparate, lead to a similar level of mathematical cognition. The differences within the group on each of the four operations and the two levels of familiarity are also indicative of the their engagement within the practice. These results reveal significant differences for their performance on the first two as compared to the last two operations. Multiplication and division are operations rarely used in the practice of their trade, and though their competence of working with these procedures is limited, their conceptual understanding of the relationships espoused by these problems enables them to solve successfully a portion of the problems. The methods they used were unconventional, namely repeated addition for the multiplication problems and successive approximations for the division problems. Across the board, the problems that this group found difficult to solve were those involving large numbers. However, when rephrasing in terms of currency denominations was undertaken this group showed the most dramatic improvement in performance. For example, when the following multiplication problem, "If one packet contains 25 eggs, how many eggs will 40 packets contain?" was posed only 1 out of the 16 subjects had a correct answer, though another 4 had attempted it but lost count the numbers. When the same problem was rephrased as "If one egg costs 25 paisa, how much will 40 eggs cost?" 13 of the subjects solved it successfully. Strategies ranged from "If one egg is 25 paise, 10 eggs will be 2 rupees 50 paise, 40 is 4 times 10, so 4 times 2.50 will be 10 rupees" to "4 eggs will cost 1 rupee, 10 times that will be 10 rupees". Similarly, the difference in performance between the familiar and the unfamiliar problems is significant only for this group.

The inaccessibility of a conventional and formal system of counting and representing numbers puts constraints on this group and becomes a limiting factor in their ability to operate with numbers. This inability gets magnified as numbers get larger and farther removed from a familiar domain. Contextualizing the numbers within an understandable vocabulary partly overcomes this constraint as is obvious from the results obtained with rephrasing. Given the fairly limited range of numbers in their daily practice, the possibilities of delegating computational responsibility and the lack of motivation for engaging in mental exercises of a numerical kind, the performance of this group is remarkable in that it averages the accuracy level of the school children. This group has the maximum number of unschooled and illiterate subjects with little opportunity to acquire the knowledge of a conventional number system. The knowledge of number names extends only up to 40 for more than 50% of them, knowledge of the orthographic system being even more limited, and though some unconventional forms of enumeration and number representation have been devised by these subjects, it is basically for the purpose of dealing with a limited range within which their number involvements function, and therefore does not extend comfortably to larger numbers or unfamiliar ones.

Of the three groups, the paanwallas have the highest accuracy scores on all four sets of problems whether they involve familiar numbers or unfamiliar ones. Although their performance on the familiar problem set is better than that on the unfamiliar problems, the difference is not statistically significant. Again, when the multiplication and division problems are rephrased in terms of monetary denominations their scores show a significant improvement. The performance of this group is superior to that of both the school group and the newspaper sellers across all four operations and on the familiar problem set. For the unfamiliar problems the equations change and the difference between the cigarette sellers and the school group ceases to be significant whereas that between the two working groups remains so. This is because the performance of the school group is no different for the unfamiliar problems than it is for the familiar ones, since they tackle all problems and numbers in a standard school-like manner, whereas a drop in the scores of the unfamiliar problems for the paanwallas bridges the gap between these two groups to some extent.

The ability of the paanwallas to transcend the familiarity context can be related to their versatile and varied use of numbers as currency and as quantities. Their knowledge of math facts supports this hypothesis, where facts for small numbers and "familiar" numbers far exceeds their store of math facts for "unfamiliar" numbers, and yet they succeed to use them to advantage in dealing with unfamiliar numbers as well. This is seen in their use of math facts in dealing with unfamiliar numbers after they are broken down into more familiar units.

CHAPTER IX.

Related Mathematical Tasks.

Combined Operations and Profit and Loss.

The two sub-tasks of Combined operations and the Profit and Loss problems were included as more advanced mathematical problems which all three population groups encounter in the course of their practices. There is a difference however in the ways they encounter these problems and the degree to which they may or may not actually engage with them. Of the two working groups the cigarette sellers deal with a much larger variety of goods as well as denominations of notes and coins. The very nature of paanselling involves the use of more than one operation for a majority of their transactions. A steady stream of customers each making a purchase which varies in price and quantity, necessitates computations of this nature.

As for the concepts of profit and loss, these are computations the sample included here does not necessarily have to deal with, on a daily basis. The very organization of the activities and their feasability depends on some form of profitability. In the case of the paanwallas, it is the owner who make decisions about buying, selling and pricing and therefore calculations of profits and losses as well. However, the assistance rendered by the subjects in our sample in keeping accounts, dealing with wholesalers and taking stock of sales etc. does give them an exposure to this aspect of the activity as well.

For the newspaper sellers the opportunities for using a combination of operations arises less often, since the newspapers are almost always sold in quantities of one, where prices are fixed and there is not always need to return change. Opportunities for the calculations of profit and loss do arise, since sales for the day need to be accordingly oriented. However, as observed in the ethnographic enquiry, children keep track of the amount initially invested and strive to cross that mark in their sales. There is no conscious effort of calculations of profit and loss on each item or on an everyday basis.

The school children encounter word problems involving computation of combined operations, profit and loss and proportion in the course of their school mathematics curriculum, and these are introduced after the basic operations are considered to have been mastered although this is not necessarily true in practice and there is no indication that children have indeed mastered these operations and understood the principles which would enable them to proceed to the next stage. The syllabus is set and introduced according to grade level, whether or not a child is ready for it, and word problems involving combined operations are introduced by class 4, whereas profit and loss problems enter the syllabus in the 6th year of school. Table 14 compares means of the three population groups on these sub-tasks.

TABLE 14.
Comparisons of the Three Groups on Combined Operations
And Profit and Loss Problems.

	SC	PW	NP
COMBINED OPERATIONS	M=3.61 SD=2.74	M=7.87 SD=1.40	M=6.12 SD=2.33
PROFIT & LOSS	M=5.00 SD=4.61	M=12.14 SD=3.08	M=7.37 SD=4.84

Significant differences were observed for the three population groups on the task involving combined operations ($F (2,45) = 13.98$, $p < .001$). Duncan's Range Multiple Tests revealed that both the newspaper sellers and the cigarette sellers scored higher than the school group, and that the cigarette sellers scored higher than the newspaper sellers (ps .05).

The profit and loss problems also revealed significant differences between the groups ($F(2,45)=10.95$, $p.<.001$). The paanwallas performed better than both the school children and the newspaper sellers (Duncan's Multiple Range Test, ps .05). Though the newspaper sellers had a higher overall score than the school group the difference is not statistically significant.

Proportions Sub-task:

Both vending activities i.e., cigarette and newspaper selling, require some amount of proportional calculations, and the school curriculum introduces such problems in grade 6 when children are 11 to 12 years old. School children fared badly on this task, and the newspaper vendors fared marginally better (Table 15).

TABLE 15.
Comparisons of the Three Population Groups
On the Proportions Sub Task.

	SC	PW	NP
PROPORTION SUB-TASK	M=.166 SD=.383	M=1.85 SD=1.70	M=.812 SD=1.16

The differences were significant (F(2,45)=8.38, p<<001) and the cigarette sellers performed better than both the newspaper sellers and the school children (Duncan's Multiple Range Test ps .05). The newspaper sellers' performance was better than that of the school group, but not at a statistically significant level.

Summary:

The performance on these tasks supports the earlier findings that the number computations and arithmetic reasoning abilities of the three population groups are in consonance with the cultural practices within which they function. School children are less competent with tasks that according to the school syllabus itself are graded as more advanced and consequently introduced later in the curriculum. Competence on these tasks requires an understanding of the operations or atleast a basic familiarity with them. The results support this hypothesis and performance of the three groups is in consonance with their performance on the earlier word problems. Both groups of working children displayed more competence than the school group on all three tasks.

The paanwallas had a high percentage of correct solutions on both the combined operations and the profit and loss problems. Their performance on the proportions problem was better than that of the other two groups, though all three groups fared badly on this subset. The facility of the paanwallas with the combined operations task is explained by the extensive use of this kind of computation in the course of their vending added to their competence with the arithmetic operations.

That the newspaper sellers have higher scores on the combined operations task is further confirmation of their understanding and subsequent facility if the numbers are not unmanageable. A large part of their difficulties in the operations arose from their inability to retain the numbers which were too large or for which they did not cryptic labels in the form of number names. Their system of enumeration is a cumbersome one , which increases the load on memory. The use of prices allows them to break free of this constraintand to focus on the problem and its computation, and as the results indicate they do it remarkably well. In fact for the two working groups these two tasks are more grounded in the context of their practices than the word problems representing the four operations.

The findings in this study therefore are in keeping with the research findings reviewed earlier. That the computations and calculations of the vendors can be described as mathematical activity has been well brought out by Nunes, Schliemann and Carraher (1993). They define mathematical activity as:

> ... not concerned with observation, experimentation, or causation but with deduction. In

> other words, mathematical activity is not carried out in order to discover relationships about empirical events but is an exploration of relationships between representations. It is a process of making inferences that starts with representations that make possible the use of formalization (p.128).

and go on to demonstrate how the definition is applicable to street mathematics in as much as transactions carried on in street markets are regulated by both social as well as logical rules, which are not synonymous with empirical laws but mutually recognized obligations to behave in consistent but not inevitable ways. That the subjects in our study were able to respond to problems at a theoretical level is obvious from the very formulation of the problems which are posed theoretically and in contexts that do not duplicate the contexts of practice. At the same time the mathematical knowledge is deeply influenced by the social context within which it was acquired. This is demonstrated by the modes of representation, the representational signs and the strategies of dealing with mathematical problems.

Children in the vending groups show a preference for oral modes of problem solving, and representations are symbolized as much by the conventional number system as by the monetary denominations through which their interactions with a number system are abstracted. Vendors in this study obtain higher accuracy scores when problems are formulated in terms of currency denominations, whereas children in school do not gain from this form of representation. Not only does the rephrasing help, but subjects from among these groups sometimes spontaneously switch to this form of representation, for example, F., paanwalla, aged 15, when confronted with the problem of dividing 240 mangoes into 12 baskets, proceeds in the following manner: "...120 will be 10 each , packets of 20 will be double, so if you had 12 packets of 20, it will be 240. 12 packets will be 20 each". This is not to say that the representations concretize the situations, since the problems are ultimately removed from the concrete vending experiences.

Similarly, children whose practice is embedded in the oral mode rely heavily on this mode for problem solving than do children who predominantly practice their mathematics in school settings. Such findings have been reported by research on street vending and establishes the socio-cultural context of mathematical activity (Saxe, 1991; Nunes, Schliemann and Carraher, 1993). That learning in school or out of school is linked to specific practices within each "arena" as she terms it, is established by Lave's research with tailors in Liberia (Lave and Reed, 1979), with grocery shoppers in California (1988) as much as it is by most of the research programs cited earlier (Scribner &Cole, 1981; Posner, 1979; Saxe, 1991). This study confirms their findings and both groups of vendors are better able to deal with addition and subtraction than they are with multiplication and division, whereas the practice of schooling gives rise to a different sequence. That combined operations are better handled by the sellers than they are by the school group is a confirmation of this fact just as much as the abity of the two working groups to deal with subtraction problems with higher efficiency than the addition problems as a consequence of the practice of their activity.

Observations of the practice of mathematics located in the everyday activities of the participants have been admirably conducted by Lave and her coworkers. The disparity of success on arithmetical problems in the course of the activity (supermarket and best-buy problems) and in a test performance in the same group of subjects is considerable and indicates the significance of the setting and the level of involvement as facilitators of cognitive functioning (Lave, 1988). In the idea of apprenticeship or learning in practice, she states,

> ...the child's understanding (giving significance to, and critical analysis of relations of the subject to other aspects of the life world) encompasses and gives meaning and value to the subject matter, the process of learning it, and its relations with the learners life and activity more generally. (Lave, 1990, p.325)

The settings of the work situations provide its members with a variety of external aids which facilitate the mathematical problem solving just as school procedures are designed to assist its participants in their problem solving activities. It is precisely this infrastructure inhabited by people and objects that guarantees the smooth and successful functioning of the transactions that take place in each work setting. Unfortunately, in the present research context, the accuracy of mathematical problem solving in the course of working could not be empirically demonstrated and documented due to unavoidable constraints, though questions pertaining to the practice were asked, and interviews with the paanshop owners in the case of the paanwallas, and with co-workers and the adults in the case of the newspaper sellers confirmed that the commercial transactions were carried out by our subjects with a high degree of efficiency and accuracy.

The practices of paanselling and newspaper vending demand minimal levels of efficiency of mathematical problem solving which make the activities viable at a commercial level. This efficiency is expected of all participants, though not necessarily at an individual level. The out-of-school activities and their socio-cultural organization provide settings in which participants can draw upon resources outside of themselves but critically implicated in the outcome of their cognitive functioning. The practice of schooling on the other hand provides tools of mathematical functioning which need to be necessarily appropriated by the individual, since the very system of assessments, examinations and evaluations is directed to an individual and as far as possible at an abstract and decontextualized level of functioning. The classroom as social setting provides a context where activities are segregated rather than linked, and strict rules of functioning are externally imposed upon the participants. Unlike the street settings, mathematics is an academic discipline which is consciously separatefrom the social or the personal. The teacher is an authority figure and it is she or he who initiates and directs any interaction.

Saxe, in his work with sellers in Brazil, documents the social support system that creates a context within which techniques of functioning lend effectiveness and competence to their mathematical understanding. For younger sellers, complex problem solutions like ratio comparisons and wholesale-retail price translations are accomplished by relatives, peers and store clerks or simply avoided by equally effective means. He proposes a three component approach within which form-function shifts in cognitive development play an important part in linking cultural practices to cognitive development. He defines cultural forms as

> historically elaborated constructions like number systems, currency systems, and social conventions. In daily life these forms become cognitive ones as they are acquired and used by individuals to accomplish various cognitive functions, functions like counting and arithmetic. (Saxe, 1991, p. 19)

In his observations of differences between schooled non-sellers and unschooled sellers, he finds that children construct different kinds of mathematical knowledge in the process of structuring forms to serve functions linked to the activity contexts. Thus schooled children use number orthography in an important way, whereas unschooled sellers rely on knowledge of numerical representations linked to the currency system. These differences were observed in the present study in the school children's reliance on orthographic and algorithmic forms, and the vendors' use of currency systems, units of merchandise and prices of the units etc. The settings for conceptualizing the problems are created by the participants and are closely linked to the settings within which their mathematical functioning is practiced.

CHAPTER X.

Discussion

The motivating force behind this research has been a strong desire to understand the cultural component of cognitive functioning. Some of the pioneering work in bridging the culture cognition gap was cited in the review of literature in chapter 3. This formidable body of research within the area of cognitive psychology has gradually shifted the focus of investigation from the study of psychological subjects, as functioning in an isolated mental space without reference to their personal or cultural histories, to locations where cognitive functioning itself can be observed in ways that underlines its social and cultural nature and subjects do not remain isolated.

The cognitive activity chosen as the object of study here was a fairly routine and mundane one - that of arithmetical reasoning; and the settings were both academic and non-academic. This was done with the express purpose of observing the manifestations of this form of cognitive reasoning within what are generally characterized as formal and informal modes of cultural transmission and to highlight the functional equivalence of varying cultural experiences. Three different settings which include arithmetical practices as an integral part of their activity, were the focus of this research. Subjects from within these three activities of schooling, paanselling and newspaper selling were asked to solve word problems involving the four arithmetic operations, and subsequently tasks involving combined operations, profit and loss problems and a proportions problem. Differences amongst the three population groups were hypothesized and observed, and explanations were sought within the cultural practices of each of the groups.

The results which have already been discussed in some detail reveal that the paansellers combine a body of number knowledge and experiences which gives them an edge both over the school children and the other group involved in a vending activity - the newspaper sellers.

Quantitative and qualitative differences observed in the functioning of the three groups provides an understanding of areas of overlap rather than clear cut differences that divide the activities in any irreconcilable way. The nature and presentation of the experimental tasks, which were an amalgam of work related and school related experiences, transcend the practice levels of all three groups to some extent, while remaining grounded in situations that all three groups are likely to encounter. The shift from familiar to unfamiliar numbers and from more familiar to less familiar functions were included to arrive at exactly such an understanding of how and where the boundaries between these activities merge.

The ethnographic observations of the three practices reveals that neither "vending" nor "schooling" are clearly demarcated and well defined activities in some decontextualized manner. Each activity is defined by the participants and their motivations as much as it is by the larger social and economic context within which it operates. This is clearly brought out by the experience of schooling observed here. The schools and school children described in this study work very much within the larger educational infrastructure provided in this country, but the immediate context is redefined by the social class of the student population, the power relations between the parents and school authorities, and the immediate goals and motivations of both the students and the teachers in the mathematics classroom. As a result of all these factors, the classroom, which is generally defined as a site where mathematical concepts are scientifically imparted to the students with a theoretical and scientific understanding, in the present context imparts to the children a rote learning of the enumeration system, and a practice and drill method of working out operations without any sustained attempt of imparting either a theoretical or a practical understanding. Similarly, the vending activities differ according to the arena within which each operates. The physical site, the transactional structure, the position of the participant within a hierarchy of responsibilities and the level of involvement of each participant serve to identify the nature and consequently the practice of arithmetical functioning within each of these vending activities. Therefore it is in specific contexts that the three groups are defined here, and it is in these contexts that we can situate the levels and types of cognitive functioning revealed by the experimental tasks.

That the three groups are distinguished by their work or school activity is not to deny their membership in other activities related to number and computation. We know that all three groups varied on age and that subjects in the working groups also varied on levels of schooling. The differences observed on the basis of their participation in the above activities only confirms the influence of this kind of participation and gives us insights into the components of the practices that can point to specific characteristics of arithmetical problem solving abilities.

This research confirms that knowledge of the natural number system and enumerative processes are devised in the absence of any instruction or formal learning process. The interface with a world of objects necessitates some level of numerical understanding and the concept of conservation, which, according to Piaget, is a necessary condition for any mathematical understanding. Subsequent development does not follow a unique pattern, and our research demonstrates that arithmetical abilities and understandings manifest themselves in a variety of ways which we attribute to the cultural context within which each group functions and the arithmetic practices that evolve within each of these activities. That we observed differences in the accuracy scores, the strategies used for solving the arithmetical problems and the errors that each group committed on all the experimental tasks, is seen as evidence that each of these practices develops and functions within a given set of parameters which define the arithmetical competence of its participants. The two working groups engage with numbers in ways that are different to those of the school child. In school, children are introduced to numbers predominantly in a written and abstract mode as compared to the experiences with children in the two working groups, whose experience of number and operations with numbers are oral but predominantly in the actual presence of the quantities that they are dealing with. At the same time we have evidence of the fact that these interactions are capable of transcending the concrete availability of the objects. This is demonstrated by the ability of the participants to tackle word problems involving arithmetical computations and relationships in the absence of any concrete configurations of the objects. In fact, it is the paanwallas, and in some instances the newspaper sellers who are able to solve these problems with more ease than the school children. The sequence of number words becomes a representational tool for solving operations and it is through such a representational system that school children are initiated into operations.

For newspaper vendors, especially those with no schooling, the understanding of the concept of number is acquired largely through the use of physical manipulative materials. That they succeed in making the shift from the physical embodiments to a representational system based on these embodiments, is demonstrated by their facility with numbers that hinge on monetary denominations. But there is also evidence that the representational ability goes beyond this level, in that they are able to use them as abstract symbols of quantity and to employ them as mediators in the solution of numerical problems. It is this facility that enables them to solve the word problems, presented in a format which is suitably distanced from the context of their vending practice, with some degree of success.

We repeatedly see them fumbling with larger numbers, and losing track when the operations involve several steps, and subsequently, an overload on memory. Their understanding of the additive function enables them to tackle problems of a multiplicative nature as the strategy of successive addition is used to solve a fair number of the problems. the division problems pose greater difficulty in that the concept of unequal quantities is not viewed as problematic. Often the spontaneous response to dividing 105 among 3 people was: 30, 30 and 45, or 40 ,40 and 35. One of the more interesting explanations for this was from 13 year old Seth who explained it by `I usually end up selling less than my sisters, so I would give them 40 each and I could have 35.....you see I get bored with this hanging around, I like to make enough money to rush off for a movie!'

Our findings further demonstrate that formal school learning is not a necessary condition for the development of the understanding of arithmetical principles, while at the same time underlining the fact that a knowledge and mastery of the conventional and formal systems that have developed in the history of the cultural system called mathematics, becomes a powerful tool for efficient functioning in decontextualized settings.

The paanwallas' counting abilities, knowledge of counting and familiarity of the conventional orthography of numbers is comparable to that of the school children, whether it is acquired at school or out of school. Equipped therefore with a sign system i.e. the conventional number names and their orthography, these subjects enter a practice where computation is tied to a concrete world of money and objects which require mathematical operations. In the process of this working out the quantitative operations become decontextualized and consequently less dependent on the direct and immediate spatio-temporal context.

When the number ten can represent a packet of cigarettes, a bundle of packets of paan masala or a ten paisa coin and a ten rupee note, the number by itself becomes an abstraction and is capable of being represented independently of any concrete object. Yet the abstraction has to have a mediational representation which is available to the subject in the absence of a perceptual reality. This is a powerful support that is provided by a conventional number representation system and which becomes more important when bigger numbers need to be dealt with. This system is available to the cigarette sellers and to the school population group to a much larger extent than it is to the newspaper sellers which forces them to rely on a context of objects and artifacts that is available in their immediate environment. Despite this limitation, the competence of the newspaper sellers is not restricted by these physical objects and concrete quantities, but as the problems get further removed from the familiar content and context, the strategies begin to break down and the cognitive load in the absence of abbreviated mediational means becomes heavier and therefore more difficult to cope with. This is brought out by the similarities and differences between the three groups on the familiar and unfamiliar problems both in terms of operations and the content and context. That the cigarette sellers perform nearly as well on the familiar problems as they do on the unfamiliar ones is testimony to the fact that their ability to deal with numbers transcends the familiarity barrier. That the school children deal with both types of problems with the same efficiency and do not reveal major differences in performance similarly is indicative of their ability to treat numbers in a decontextualized fashion, though their efficiency in dealing with the computations is significantly inferior to that of the paanwallas. Since this facility is limited for the newspaper sellers, their performance on the problems using familiar numbers is significantly better than that on the problems using unfamiliar numbers.

On the other hand, the conventional rules for application of operations are no more available to the cigarette sellers than they are to the newspaper vendors, and their performance across operations reflects this. Both groups achieved more accurate scores on the addition and subtraction problems than they did on the multiplication and division problems. The school children reveal a different pattern: the accuracy declines progressively over the four operations. Their familiarity with the operations in accordance with the school syllabus would be highest for the operation of addition which is the first operation to be introduced in school, followed by subtraction, multiplication and division, each subsequent operation and procedure building up on an understanding of the earlier ones.

The paanwallas as it were, seem to combine a minimum number literacy with the advantages of the on-hands learning that the newspaper sellers also possess. Although all except one of these subjects have some amount of schooling they demonstrate an overwhelming preference for oral and non-school like solutions.

There is considerable evidence that children universally use computational procedures to determine the effects of transformational procedures on sets (Klein and Starkey, 1988). This ability however is limited and its development varies with socio-cultural settings. The paanwallas and the newspaper sellers in the course of their vending activity are called upon to perform transformations on concrete sets of objects which are physically available to them, for example, calculating the totals of sets of money, newspapers or cigarettes when the sets to be totalled are with them in concrete form and of course counting physically the sums of money they receive, or, from time to time, the stocks that are in their possession. The availability of the concrete objects performs an important function especially for children who have no schooling or familiarity with a conventional counting system. Units of currency or a pack of cigarettes take on the symbolic function of representing a numerical quantity and the presence of the concrete operations facilitates the formation of such a system. The school children have limited access to such aids, and though fingers and tally marks on paper are sometimes used, observations in the classrooms did not reveal encouragement of these forms of counting. They are initiated into arithmetic by way of the number names which are symbolic representations of quantity. All three groups however are capable of transcending this mode of functioning, which was necessitated in the experimental condition since numbers and objects of transformation used in the word problems were not available in any concrete form.

Some estimation of what system of representing numbers is possessed by each group is available from the counting and knowledge of the orthographic system tasks that were administered to all three groups. 13 of the 14 paanwallas have had some amount of schooling, and all except that one subject had no difficulty in counting up to 500. The knowledge of the orthographic system was less complete, but again all 13 could recognize multiples of 5's and 10's with ease, and could use a written system for their personalized use, though it did not correspond to the conventional codes, for e.g. 105 would be written as 1005, and served its purpose for the concerned subject. The school subjects' knowledge of the conventional number system, both as number names and their orthographic representation is comparable to that of the paanwallas. Except for the newspaper sellers that were in school, the knowledge of number names for this group was limited to numbers between 40 and 50, and recognition of written numerals was worse. The strategy and error analyses subsequently indicated that this is a substantial source of their difficulties in solving the word problems.

The competence, understanding and modes of tackling the word problems reveal the links between the practices of the three population groups and their understanding and operating with numbers. While all three practices are directly number related, the functioning within each varies in magnitude, variety and application. The problems were presented to children orally and not directly in the contexts of the settings within which they function. The verbal content was familiar to all the subjects and the numerical relationships were derived from forms and functions which arose in the contexts of their practices.

The school children are formally initiated into a system of mathematics where, within the first four years, they are acquainted with a conventional base ten enumerative system and its corresponding orthographic representation. The teaching schedule functions within predetermined steps and stages. The first step in this process is counting where children are familiarized with a conventional enumerative system, and an orthographic system of representing numbers. These are powerful tools that a number literate person possesses - a sign system that mediates numerical relationships. In the process of this familiarization they advance from smaller numbers to larger ones, and to the arithmetical and computational functions of the numbers. The operation of addition is the first one to be introduced, followed by subtraction, multiplication, and division. For each operation there is a formal algorithm, which the school children learn to master. There is ample evidence to show that children learn rules for written algorithms of addition and subtraction without understanding place value within the decimal system. They learn the procedure but not the rationale which makes this procedure sensible (Resnick, 1983). Brown and Burton (1978) have demonstrated that childrens errors, particularly in subtraction are a result of systematic application of wrong algorithms.

The four operations of addition, subtraction, multiplication and division are the basic tools for a host of other more complicated mathematical functioning. Children studying mathematics in school situations are introduced to these operations as soon as they become familiar with concepts of number. The setting in which the school children are introduced to numbers is a formal one. There is a schedule of learning with predetermined steps and stages. Teaching is done by experts, and the setting is that of the classroom. The familiarization and the incorporation of the principles of a conventional enumerative system, alongside with with an orthographic system of representing numbers become stepping stones to mathematical computation.

Whether it is the school, the paanshop or the more fluid setting in which the newspaper sellers vend their papers, each situation has its own characteristics which distinguishes it from the others. Each situation is is socially defined within it's parameters annd rules of functioning within which individuals have a limited opportunity to digress. Subsequently, each of these practices leaves a mark on the cognitive functioning of it's participants and organizes their particular forms of representing numbers and ways of operating with them.

The difference between the two contexts can be categorized in very general terms in

Vygotsky's formulation of the spontaneous vs. scientific distinction in concept formation. Work situations, by and large, demand a hands on learning, where concepts are imparted in a formal, well-defined manner and the process of acquisition takes a top-down route. The work situation provides the participant with particular instances, from which inductions are derived and generalities arrived at. School-like learning provides general principles and expects participants to derive particulars by a deductive process. The schooling that we observed provides neither the theoretical formulations in any well defined manner, nor the paraphernalia that children could learn to appropriate and use as materials for inductive reasoning.

The performance of the three groups repeatedly indicates that cognitive functioning is not entirely limited to the immediate experience of the participants and that rules and hypothetico-logical relationships are generated in the course of confronting the particular instances which can be and ARE applied in novel situations. That newspaper vendors and cigarette sellers formulate rules of multiplication and division based on their knowledge and experience of additive and subtractive properties of numbers, is a manifestation of this ability, just as school procedures, used for solving out-of-school problems establishes the ability of the school children to go beyond their immediate context.

Scribner's (1975) incisive analysis of solutions used for solving hypothetical problems by a group of unschooled adults of the Vai community in Liberia underlines the fact that though performance on tasks of abstract reasoning and thinking is deeply influenced by cultural practices of a particular group, neither abstract thinking nor reasoning is constrained or limited by such experiences. Studies of syllogistic reasoning in a variety of settings have demonstrated that adults from "traditional", nonschooled groups fare dismally on such tasks. She reanalyzed the results of one such study and found that performanceof the group differed sharply on the basis of whether subjects had used theoretical as opposed to empirical explanations. The investigation also focused on whether these subjects were unable to deal with theoretical reasoning, as the studies seemed to suggest. Not surprisingly she found a robust relationship between theoretical justifications and correct answers. A significant conclusion of these findings is that when a problem is dealt with as "formal" and "theoretical", nonschooled, nonliterate subjects display exactly the same logical capacity as adults and children exposed to western type schooling.

What this analysis, as the recent research on mathematical functioning in everyday contexts establishes, is that cultural contexts determine manifestations and forms of cognitive functioning within these contexts but that they do not determine the cognitive potential of the individuals concerned.. This is true as much of a concrete situation as it is of more formal, theoretical settings, and performance on a variety of reasoning and thinking and reasoning tasks is found to be context-sensitive, irrespective of educational levels or levels of technological development of the society (Wason, 1966; Johnson-Laird, Legrenzi & Legrenzi, 1972). The questions that need to concern researchers in psychology and education need to center on how theoretical and empirical contexts do and can come together. We also need to investigate the kinds of experiences within these contexts that can help us bridge this gap. It is hoped that the present research and other studies that delve into the details of functioning within such contexts can furnish pointers to where such possibilities are available.

It is precisely to understand these levels of functioning, that Vygotsky's socio-historical theory and the concept of activity form a useful framework which allows investigations into cognitive functioning to be viewed as dynamic and dialectical process within a socio-historical context. The cultural and social aspects of psychological functioning, the role of symbolic mediation, the concept of the zone of proximal development and the concept of activity as a unit of analysis offer a framework within which the possibilities of bridging the gap between subject and object, and between culture and cognition can be explored. This is broadly the framework within which recent work on mathematical thinking in socio-cultural settings has emerged, and views cognition as observed in everyday practices as "...distributed - stretched over, not divided among - mind, body, activity and cultural settings (which include other actors)." (Lave, 1988. p.1)

This research was as much an investigation of mathematical reasoning in children as of a different way of viewing the subject in cognitive psychology, not as functioning within a laboratory or a clinic, but in a world of historical, economic, social and cultural reality of which the individual is an active agent, with the hope that it will contribute in some small way to the educational enterprise in pointing out that psychological subjects construct themselves and are constructed within a socio-historical and a cultural context. Cognitive functioning emerges from within these contexts, and it is in reference to them that each individual's world acquires its meaning. Consequently, children groping with an understanding of mathemats and mathematical concepts needs to be viewed as existing within these relationships, just as the concepts that acquire they are linked to a world of other concepts. The routes to mathematical reasoning are diverse and an understanding of these diversities needs to be positively integrated into classroom teaching and learning.

The theoretical agenda of this project however goes beyond the observed differences and raises questions that the field of psychology needs to adress urgently. The classical paradigm in cognitive psychology starts with the concept of an "abstract" mind and implicitly makes the claim that this mind is universal, except for any local conditions (like culture) which gets in the way. This paradigm further assumes that the field and it's practitioners are making no a-priori value judgements in seeking for this universal mind. Research in cognitive development (with the tools available to it), however, in observing and analyzing this neutral territory discovers compelling differences of a hierarchical nature, which are repeatedly and convincingly verified. These differences unfortunately manifest themselves in a hierarchical manner and the groups in the privileged positions in this hierarchy invariably also happen to be privileged groups in the social order. The overarching dichotomy of abstract vs. concrete cuts across areas of cognition from language and verbal behavior to intelligence, memory and all forms of thinking that psychology concerns itself with. **Maybe it should worry us just a little that these distinctions map on so neatly with schooled vs. unschooled, modern vs. traditional, urban vs. rural, black vs. white, male vs. female and so on.**

The shift that occured as a reaction to this paradigm is summarized in the research on culture and cognition. These studies have demonstrated that not only are the concrete thinkers able to think in abstract ways but that given the right kinds of tasks, their performance is likely to supersede that of the traditionally more "abstract thinkers". This project therefore starts with the premise that psychology and the investigations of human cognition are necessarily situated within individuals who are products of a material and a socio-historical culture. This project, unlike the earlier one, is comfortable with recognizing that cognitive functioning is not uniform, that subjects manifest differences in their ways of thinking and behaving and that these differences do not follow a strict hierarchical order correlated in definite ways with a hierarchical social order. Nor is this project content to view differences as effects of variables which are treated as uniform and constant, and consequently which can be neatly controlled in laboratory experiments. Cognition, here, is viewed as a complex social phenomenon and therefore the attempt is to create an "outdoor psychology" (Geertz, 1993). Moving psychology from the laboratory to the field itself has expanded our horizons of understanding and consequently underlined the difficulties of viewing individuals as isolated subjects. The embeddedness of cognition in culture provides this project with a rich base of material which psychology needs to understand. But more importantly, situating the cognizing subject in an activity or focusing on the "person-in-practice", is a way of confronting issues of inequality, social diversity, conflict and hegemonizing political systems that create centres of power and knowledge which exclude and marginalize nations and peoples within nations alike.

Appendix 1

Biographical Questionnaire.

(All Groups)
Name:
Age:
First Language:
Other Languages:
Father's Occupation and educational qualifications:
Mother's Occupation and educational qualifications:
Place of origin:
Length of stay in Delhi (if migrated from another state):
Siblings: Age, Education and Occupation.
Do you go to school?
What class are you in?
Which schools have you been to?
Have you ever been to school?
Can you read numbers?
How did you learn to read numbers?
Can you write numbers?
How did you learn that?
Who do you live with?
Do you help with house work?
What kind of work do you help with?
What do you do after school (or work)?
What do you want to do when you're older?

b. Interview Schedule for details of number-related trade practices.(Newspaper Vendors)
How long have you been in the present trade?
Did you do any other work before this?
Who initiated you into the selling of newspapers?
From whom and how?
-did you learn to count?
-to read or write numbers?
-to count money?
How many of the daily papers do you sell?
How many copies of each newspaper do you buy on an average? (details regarding each paper).
Do you always buy the same amounts? When and why does it vary?
How much do you sell the "Evening Times" for?
Do you know how much it costs you?
How much do the papers cost you altogether?
How much money do you keep for the purchase of the "Midday"?
For the other 3 papers?
What do you do with the money at the end of the sales each day?
What is the total amount of papers that your family buys?

How many of these are given to you for selling?
How many do the other members get?
Do you get to keep any of the money?
What do you use it for?
Do you sell anything else? (Get details).

c. Interview Schedule for information on number related practice. (Cigarette Sellers)
How long have you been in the present trade?
Did you do any other work before this?
Who did you work with when you first started?
How long have you been doing this on your own?
How and from whom did you first learn to count?
-to read and write numbers?
-to handle money?
What were the first items you started selling?
Have you made any changes since then?
Where did the money for investment come from?
Do you find the trade profitable?
What are all the items you sell now?
How often do you do your purchasing?
Are the cost prices fixed?
Which are the items that can vary?
On what basis do you fix your selling prices?
How much money do you think you make?
-on a daily basis?
-on a weekly basis?
What do you do with the money?
Details of buying and selling prices of each item stocked.
What are your future plans?

Appendix 2

Math Facts

ADDITION	SUBTRACTION	MULTIPLICATION
2 + 2	3 - 1	2 * 2
2 + 4	4 - 2	4 * 2
4 + 4	8 - 4	3 * 3
5 + 5	10 - 5	4 * 5
7 + 3	12 - 8	6 * 6
6 + 3	15 - 10	7 * 5
9 + 4	15 - 5	8 * 6
10 + 5	25 - 10	9 * 7
10 + 10	25 - 5	10 * 2
15 + 15	24 - 5	11 * 3
5 + 15	24 - 12	12 * 4
25 + 25	22 - 11	13 * 6
25 + 5	75 - 50	14 * 5
50 + 25	75 - 25	15 * 6
50 + 50	70 - 34	20 * 2
12 + 12	100 - 50	25 * 2
14 + 13	100 - 75	25 * 4
20 + 12	30 - 10	50 * 2
22 + 24	32 - 21	50 * 3
75 + 75	100 - 24	24 * 5
75 + 25	90 - 25	
34 + 46	80 - 40	
	100 - 35	
	100 - 43	

Appendix 3a

Addition Problems (Familiar)

1. There are 50 eggs in 1 basket and 75 in a second one. How many eggs are there altogether?

2. There are 25 birds on one branch, 35 on a second one and 40 on the third one. How many birds is that altogether?

3. There are 3 buses carrying 30 passengers, 50 passengers and 20 passengers respectively. How many passengers does that make?

4. One school has 150 children, a second one has 175 and a third one has 125. How many children are there altogether?

Addition Problems (Unfamiliar).

1. There are 74 birds on one tree and 52 on another. How many birds are there altogether?

2. In a Basti there are 24 men, 16 women and 38 children. How many people in all?

3. There are 114 people living in one village and 172 in the neighbouring village. How many people are there altogether in the 2 villages?

4. Ramu, Shanti and Raju were picking mangoes. Ramu collected 102, Shanti has 224 and Raju has 145. How many mangoes do they have in all?

Appendix 3b.

Subtraction (Familiar).

1. If there are 50 mangoes in a basket and 25 are taken out, how many would be left over?

2. A child had 100 marbles out of which he lost 30. How many will he have left with him?

3. There were 175 eggs in a basket, out of which 50 fell down and broke. How many eggs will be left in the basket?

4. A shopkeeper had 200 hens out of which he sold 75. How many are there left with the shopkeeper?

Subtraction (Unfamiliar).

1. 44 children were playing in a park, out of which 12 went away. How many children are there left in the park?

2. A fruit seller had 90 bananas out of which he sold 32. How many bananas does he have left?

3. If you had a 170 rupees out of which you spent 54, how much would you have left over with you?

4. A park had 190 trees out of which 73 were cut off, how many trees are left in the park?

Appendix 3c

Multiplication (Familiar).

1. If one necklace has 50 beads, how many beads would 30 such necklaces have?

2. If one packet contains 25 eggs, how many eggs would there be in 40 such packets?

3. If there are 10 children in one class, how many children will there be in 30 classes?

4. If there are 75 chairs in one room, how many chairs will there be in 30 rooms?

Multiplication (Unfamiliar).

1. If 1 book costs 12 rupees, what will be the cost of 8 books?

2. If there are 24 children in 1 room, how many children will there be in 4 rooms?

3. If there are 14 pens in 1 box, how many will there be in 8 boxes?

4. If 1 pack has 22 toffees, how many will there be in 12 packets?

Appendix 3d

Division (Familiar).

1. If a 105 newspapers were to be equally divided between 3 children, how many will each child get?

2. If 75 apples have to be equally divided into 3 baskets, how many will there be in each basket?

3. If 300 toffees are to be equally divided between 6 children, how many would we give to each child?

4. If we want to divide 175 rupees amongst 7 people, how much would each person get?

Division (Unfamiliar).

1. 72 Laddus have to be distributed amongst 8 children. How many will we give to each child?

2. If I give 56 rupees to 7 children. how much will each child get?

3. 240 mangoes have to be equally divided into 12 baskets. How many will we put in each basket?

4. 252 pencils have to be packed into 12 boxes. How many will we put in each?

Appendix 4

Rephrased Word Problems: Multiplication

1. If the cost of 1 bead is 50 paise, what would 30 beads cost?

2. If 1 egg costs 25 paise what would be the cost of 40 eggs?

3. If 1 toffee costs 10 paise what will be the cost of 30 toffees?

4. If 1 cigarette costs 75 paise, what will be the price of 30 cigarettes?

Division

1. If 1 Re. 5 paise have to be distributed amongst 3 children, how much will each child get?

2. Can you distribute 75 paise equally between 3 children.

3. If you have to give 3 rupees to 6 children, how much would each child get?

4. And 1 rupee 75 paise between 7 children?

Appendix 5a

Strategy Analysis: Addition

1. Number correct:: Number of problems that received a score of 2.

2. Repeated: Subject repeated either all or some of the numbers that formed part of the problem to be solved, or, asked the examiner to repeat the numbers.

3. Writes: Subject writes down some or all of the numbers.

4. Memory: Subject solves the problem immediately, presumably using math facts which are immediately available without recourse to calculation.

5. Breakdown: Subject breaks larger numbers into smaller ones, either into units and tens, or more familiar numbers like multiples of fives and tens and subsequently works with them for e.g. 175 + 75 is 200, 200 +100 = 300.

6. Count On: Where the subject starts with a base number and counts up from that point onwards by 1's or some other regular some other regular intervals, e.g. 50 + 25 may be counted on as "50, 60, 70, 75." etc.

7. School Algorithm(written)
Subject uses a written school algorithmic procedure, which involves aligning units, tens, hundreds and then working from units to tens etc.

8. School algorithm(oral):
The subject uses a school algorithm, for example, adding from the right i.e. units, tens and hundreds with carry over, but the procedure is applied orally.

Appendix 5b

Strategy Analysis: Subtraction

1. Number correct:: Number of problems that received a score of 2.

2. Repeated: Subject repeated either all or some of the numbers that formed part of the problem to be solved, or, asked the examiner to repeat the numbers.

3. Writes: Subject writes down some or all of the numbers.

4. Memory: Subject solves the problem immediately, presumably using math facts which are immediately available without recourse to calculation.

5. Count off:: Using one of the numbers as a starting point, and counting off from that point the second number is subtracted by 1's or some other regular interval, e.g. 5's or 10's for example, 70-50 becomes 70, 60, 50 etc. 100-75 = 25+25 = 50.

6. Breakdown :Subjects break down larger numbers into either smaller or more familiar units and then carry out the operation in steps, for example, 125-75 becomes 100-75 = 25+25 = 50.

7. School algorithm(written):
The written school algorithm for subtraction is used.

8. School Algorithm(oral):
The school algorithm for subtraction isapplied orally.

Appendix 5c

Multiplication

1. No. correct: No. of problems that received a score of 2.

2. Repeated: Subject repeated either all or some of the numbers that formed part of the problem to be solved, or, asked the examiner to repeat the numbers.

3. Writes: Subject writes down some or all of the numbers.

4. Memory: Subject solves the problem immediately, presumably using math facts which are immediately available without recourse to calculation.

5. Repeated Addition: The number to be multiplied id added to itself the number of times specified by the multiplier, e.g. 25 * 4 is solved by adding 25 four times.

6. Associativity: The multiplier is broken down into a product of two numbers and applied to the multiplicand sequentially, for example, 50X6 = (50X3) + (50x3).

7. Distributivity: Multiplicand is broken down into a sum of 2 other numbers and multiplier is applied to each of the numbers separately, for example, 50X30 becomes (10X3) 5 times.

8. School Algorithm written: As for earlier operations

9. School Algorithm oral: As for earlier operations

10. Idiosyncratic: Subjects use an optimizing strategy where familiar numbers, which may be larger are used for computation and a calculation is then carried out to adjust for the difference, for example, 24X4 is solved as: 25X4 = 100, take away 4, and that's 96.

Appendix5d

Division

1. Number correct: Number of problems that received a score of 2.

2. Repeated: Subject repeated either all or some of the numbers that formed part of the problem to be solved, or, asked the examiner to repeat the numbers.

3. Writes: Subject writes down some or all of the numbers.

4. Memory: Subject solves the problem immediately, presumably using math facts which are immediately available without recourse to calculation.

5.Successive Approximation:
Subject starts by partitioning out components of the numbers into the required units and successively adding onto them until remainder is zero, for example, 75/3 becomes 20+20+20 is 60, that leaves 15, so 5 more in each place makes it 25.

6.Associativity: The divisor is broken down into a product of 2 numbers and applied to the divident sequentially, for example, 300/6 = 300/3 = 100/2 = 50.

7.Distributivity: The divident is broken down into a sum of two numbers, the divisor is applied to each of them separately and then the two resulting quotients are added together.

8.School Algorithm written:
As for the earlier operations.

9.School Algorithm oral:
As for the earlier operations.

Appendix 6.

Categories for error analysis.

1. School algorithm: The prescribed school procedure is used for solving the problem.

2. Guesses: The subject makes a guess without any attempt to calculate, to arrive at an incorrect answer. There may be some attempt at estimatio, or a wild guess. Subjects either state explicitly that they guesssed or having given an immediate incorrect answer are unable to explain how they arrived at it.

3. Wrong operation: Subjects use a school algorithm but the operation used is inappropriate, for example, when required to divide 75 by 3, the operation of multiplication is employed.

4. Bugs: The school algorithm is applied and subjects use a systematic routine that produces wrong answers, for example, in addition, numbers carried over are not added on, or , in subtraction all numbers subtracted from zero equal zero.

5. Miscalculation: When the procedure, whether school-like or otherwisse, is correct, but the answer is wrong due to a miscalculation, for example, in adding the numbes 9 and 5, subject comes up with 13 instead of 14.

6. Loses count: When subject starts a procedure that should arrive at the correct solution but loses count of the numbers, for example, 120 + 145 is attempted in the following manner: 120 +100 is 220, 220 + 30 is 250... (cannot remember the numbers any more), or, in the case of multiplication of 30 by 8 subject starts repeated additionof 30s, but having proceeded halfway, forgets how many more times it needs to be done.

7. Doesn't know operation: Subjects explicitly state that they don't know which operation is needed to solve the problem

8. Abandons: Subject does not even begin to make an attempt at a solution.

9. Breakdown: Subject uses strategy of breaking down numbers as in the strategy analysis but does not arrive at the correct solution.

10. Other: This category was used for any strategies which do not fall in the above categories and are difficult to classify, for example, the subject takes time arriving at an answer but is not able to give an explanation.

Appendix 7

Combined Operations for the three population groups:

(Brackets indicate the actual numbers involved, though it varied slightly around these figures, depending on the practices and stocks of each subject).

1. CIGARETTE-SELLERS

1. If I buy 1 goldflake cigarette, 1 Wills and 1 Charms, How much would I owe you? (Rs.1.50, Rs.1.25 and 60 paisa)

2. If I give you 10 rupees, and buy 2 Wills cigarettes, 2 Goldflakes and 3 Charms, how much change will I get back? (10-(1.50+3.00+1.50)).

3. If I give you 50 rupees and buy 1 packet GoldFlakes, 2 packs of Wills and 2 Four Squares, how much change will you give back to me?
(50-(13+20+9)).

2. NEWSPAPER VENDORS:

1.If I buy 2 Evening News, 2 Middays and 1 Veer Arjun, How much money do I have to pay you?(3.00 +3.00 + 1.50).

2. If I give you 10 rupees and purchase 2 Evening News, 1 Sondhya Times and 2 Middays, how much change will you give back to me? (10- (3.00 + 1.50 + 3.00)).

3. If I give you 20 rupees and purchase 5 Evening News, 2 Middays and 3 Sondhya Times, how much money will you return to me? (20- (7.50 + 3 + 4.50)).

3. SCHOOL CHILDREN:

1. If you go to the stationers and buy 1 notebook for Rs.2.50, 2 pencils for Rs.1.50 each and 1 sharpener for 3 rupees. How much do you have to pay the shopkeeper?

2. If you buy 2 ice-bars for 2 rupees each and a bread for Rs. 5.50, and pay the shopkeeper Rs.10, how much money does the shopkeeper have to return to you?

3. If you give 50 rupees to the shopkeeper and buy one book for 9 rupees, 2 notebooks for 4.50 each, and a pen for Rs. 15, how much money will the shopkeeper return to you?

Appendix 8

Profit and Loss Problems.

1. If the cost of 20 newspapers is 35 rupees and they are sold for Rs 40, how much profit does the seller make?

2. If a book is bought for Rs. 1.25 and sold for Rs.1.40, how much is the profit on it?

3. A shopkeeper buys a packet of cigarettes for Rs. 8 and sells it for Rs 8. 75 paise, what would be the shopkeepers profit if he sells 50 packets?

4. If the cost of a toy is Rs.6.50 paise and it is sold for Rs. 7, what would be the profit if 9 toys are sold?

5. A shop that sells shoes buys them at Rs. 23.50 paise a pair and sells them for Rs. 25 each. What is the profit if 15 pairs are sold?

Appendix 9

Proportion Task

A box of toffees contains 50 toffees and the price of this whole box is Rs. 75,

a) Can you calculate the price of 25 toffees?

b) Price of 10 toffees?

c) The price of 5 toffees?

Appendix 10a

Strategies used for addition problems.

Strategy	SC		PW		NP	
	F	UF	F	UF	F	UF
Total Correct.	52 72	54 .75	53 .95	49 .87	57 .88	39 .61
Repeats	21 .29	13 .18	29 .52	33 .59	12 .19	20 .31
Writes	61 .61	63 .87	1 .2	13 .23	8 .12	18 .28
Memory	1 .01	0 .0	22 .39	3 .05	23 .36	0 .0
Breakdown	4 .06	0 0	29 .52	43 .77	30 .47	36 .56
School algorithm (written)	56 .78	61 .85	1 .02	8 .14	4 .06	14 .22
School algorithm (oral) .	3 04	2 .03	0 0	0 0	0 0	0 0
Count on	7 .09	4 .06	4 .07	0 .0	3 .05	0 .00

Appendix 10 b

Strategies Used for Subtraction Problems.

Strategy	SC F	SC UF	PW F	PW UF	NP F	NP UF
Total	51 .71	44 .61	56 1.0	52 .93	63 .98	46 .72
Repeats	7 .10	11 .15	14 .25	40 .71	9 .14	12 .19
Writes	34 .47	55 .76	0 0	5 .09	2 .03	13 .20
Memory	23 .31	3 .04	49 .87	1 .02	43 .67	0 0
Breakdown	3 .04	2 .03	7 .12	49 .87	19 .30	39 .61
School Algorithm (written)	27 .37	51 .71	0 0	4 .07	0 0	11 .17
School algorithm	5 .07	5 .07	0 0	0 0	0 0	0 0
Count off	9 .12	3 .04	0 0	1 .02	0 0	0 0

Appendix 10c

Strategies Used Multiplication Problems

Strategy	group 1 F	group 1 UF	group 2 F	group 2 UF	group 3 F	group 3 UF
Total	32 .44	43 .59	28 .50	36 .64	12 .18	28 .43
Repeats	10 .28	10 .20	32 .60	18 .25	7 .08	4 .11
Writes	41 .90	44 .81	9 .21	5 .08	11 .50	13 .39
Successive addition	9 .09	21 .23	20 .21	25 .39	22 .50	26 .35
Ass& Distr	1 .01	1 .01	10 .18	14 .20	0 0	4 .06
Idiosync.	0 0	1 .01	2 .04	3 .05	5 .08	0 0
Algorithm	32 .44	34 .47	6 .11	1 .02	9 .14	12 .19
Algorithm (oral)	3 .04	2 .03	8 .14	10 .18	2 .03	4 .06

Appendix 10d

Strategies Used for Division Problems.

Strategy	group 1		group 2		group 3	
	F	UF	F	UF	F	UF
Total	36 .50	31 .43	44 .78	32 .57	35 .54	11 .17
Repeats	6 .08	10 .14	17 .30	22 .39	4 .06	4 .06
Writes	42 .58	34 .47	1 .02	7 .12	3 .05	7 .17
Successive Approximation	15 .21	1 .01	27 .48	30 .54	29 .45	29 .45
Association & distribution	1 .01	0 0	14 .25	5 .09	4 .06	0 0
Justification by answer	0 0	0 0	5 .09	0 0	12 .19	0 0
Algorithm (written)	32 .44	36 .50	0 0	3 .05	1 .02	3 .05
Algorithm (oral)	1 .01	1 .01	0 0	8 .14	1 .02	5 .08

Appendix 11a

ADDITION

ERROR TYPE	SC	PW	NP
TOTAL	38	10	32
SCHOOL ALG	25	2	2
WRONG OPER	1	0	0
BUGS	15	0	0
MISCALCULATION	7	2	2
OTHER	2	0	0
ADD ON (LOSES COUNT)	7	1	0
GIVES UP	6	2	18
DOES'NT KNOW OPER	6	0	2
NUMBERS TOO LARGE	0	2	13
OTHER	0	0	3
BREAKDOWN	0	5	12

Appendix 11b

SUBTRACTION

ERROR TYPE	SC	PW	NP
TOTAL	49	4	19
SCHOOL ALG	31	1	2
WRONG OPER	5	0	0
BUGS	24	0	2
MISCALCULATION	2	0	0
OTHER	0	1	0
GIVES UP	12	2	9
DOES'NT KNOW OPER	4	0	0
NUMBERS TOO LARGE	0	2	7
ABANDONS	8	0	2
BREAKDOWN	0	1	4
MISCALCULATION	6	0	0
GUESSES	0	0	4

Appendix 11c

MULTIPLICATION

ERROR TYPE	SC	PW	NP
TOTAL	69	48	88
SCHOOL ALG	13	7	7
WRONG OPER	8	2	0
BUGS	2	4	5
MISCALCULATION	3	0	2
OTHER	0	1	0
GIVES UP	50	32	77
DOES'NT KNOW OPER	17	0	4
AFTER SUCC ADD.	12	23	41
ABANDONED	21	9	21
OTHER	0	0	1
NUMB TOO LARGE	0	0	10
SUCC. ADDITION	5	2	4
MISCALCULATION	1	4	0
GUESSES	0	3	0

Appendix 11d

ERROR TYPE	DIVISION SC	PW	NP
TOTAL	77	36	82
SCHOOL ALG	16	1	6
WRONG OPER	11	0	0
BUGS	0	1	2
MISCALCULATION	5	0	4
OTHER			
GIVES UP	56	17	42
DOES'NT KNOW OPER	36	0	12
AFTER SUCC ADD.	0	0	0
ABANDONED	15	0	23
OTHER	4	0	0
NUMB TOO LARGE	1	0	7
SUCC. APPROX.	5	17	31
MISCALCULATION	0	1	0
GUESSES	0	0	1
OTHER	0	0	2

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