

Studying Cognitive Development in Sociocultural Context:
The Development of a Practice-Based Approach

Geoffrey B. Saxe
UCLA

In A. Colby and D. Jessor (Eds.), Ethnographic Approaches to the Study of Human Development. Chicago: University of Chicago Press.

This chapter was prepared for the MacArthur Foundation Conference on Ethnographic Approaches to the Study of Human Development. Thanks to Maryl Gearhart for comments on an earlier draft of the manuscript. Support from the Spencer Foundation (#M890224) and the National Science Foundation (#MDR-8855643) during preparation of the manuscript is gratefully acknowledged. The opinions expressed in this chapter are my own and not necessarily those of the funding agencies.

Studying Cognitive Development in Sociocultural Context:
The Development of a Practice-Based Approach

Geoffrey B. Saxe

UCLA

In the late 1970s, Michael Cole and his colleagues at Laboratory of Comparative Human Cognition published two critical review papers, one intended for psychologists (LCHC, 1979) and the other for anthropologists (LCHC, 1978). Reflecting on the state of the art at that time, Cole and his associates concluded that psychology had offered only a superficial treatment of culture in cognitive functioning and that anthropology had lacked systematic empirical approaches to hard questions of culture-cognition relations.

The fields are changing. Increasingly investigators are using models in which constructivist views of cognition and development are wedded with social or cultural analyses (Cosaro, in press; Miller, in press). A general thrust in the new wave of work is to understand culture and cognition as intrinsically related, constituting one another in people's daily activities.

The active scholarly interest in culture-cognition relations has led to the development and/or re-emergence of a wide range of constructs like *cultural psychology* (Cole, 1990, 1991; Shweder & Sullivan, in press), *situated cognition* (Brown, Collins, & Duguid, 1989), *distributed intelligence* (Hutchins, 1991; Pea, 1994), and the *zone of proximal development* (Campione, Brown, Ferrara, & Bryant, 1984; Rogoff, 1990; Vygotsky, 1978, 1986; Wertsch, 1984). While in these efforts there is movement towards richer interpretations of culture in cognitive development, to date, the conceptual work is only beginning to seriously inform empirical analyses. In this chapter, I review the development of a heuristic method for the study of culture-cognition relations, focusing specifically on relations between frameworks and empirical techniques over the course of its development.

AN ORGANIZATIONAL NOTE ON METHOD: FRAMEWORKS AND TECHNIQUES

Discussions of method can take two forms. One is *technique-based*. Its purpose is to abstract classes of procedures, whether particular coding systems, like ones to represent social interaction, or particular data gathering techniques, like time sampling or more general ethnographic approaches to participant observation and

informant interview. Technique-based reviews point the reader to contexts in which particular procedures have born fruit and review the threats to validity and reliability to which they may be subject. The second approach is *framework-based*. With this approach, an effort is made to outline methodological approaches linked to general epistemological and/or psychological assumptions. The framework-based review provides a means of framing questions about a general class of phenomena.

Both approaches have their weaknesses. The technique-based approach suffers from its positivistic roots (Pepper, 1942). In large measure, the value of a particular technique should be gauged by how usefully it extends an interpretive framework into a field of study, not (solely) by how precisely and reliably the technique serves as a measurement instrument. At the same time, the framework-based approach may lack specificity, falling short on discussions of how conceptual approaches can be translated into particular techniques.

In the following pages, I make an effort to coordinate both approaches to review, focusing on the productive tensions between methodological frameworks and empirical techniques. To this end, I sketch four quite different empirical projects with which I have been engaged over the course of a 20 year period, projects that mirror some of the shifting values about what should be taken as core cultural phenomena in cognitive developmental research. I trace two developments over this body of work. First, I use the projects to explain the protracted development of a research framework that is geared for addressing core empirical and conceptual issues in current thinking about culture-cognition relations. Second, I use the projects to illustrate the shifting data gathering techniques that have extended the framework into empirical analyses and that have, in turn, led to its shifting form.

CULTURE IN CROSS-CULTURAL STUDIES OF MORAL DEVELOPMENT:

EARLY DISCONTENTS WITH METHOD

In 1969 as an undergraduate I spent a summer living in a small Eskimo village in sub-Arctic Alaska. One purpose of my stay was to extend Kohlberg's framework for the study of moral reasoning (Kohlberg, 1969) to cultures that were dissimilar from our own. I had adapted Kohlberg's moral dilemmas into versions that I thought would be relevant to village life and I interviewed village children and adults.

As an interested and concerned 21-year-old, I returned from the field with a wealth of feelings about the community, ones that were not well reflected in my documentation of only the first three of Kohlberg's six stages. My efforts to reconcile my experience of village life with the representation of development yielded by the interview techniques were disconcerting and the tension that emerged foreshadowed a methodological concern that became a major theme in my later work.

I had two principal reactions to the three-stage results. First, I saw the reduction as one that reflected the wisdom of thoughtful scholars. Indeed, I was (and continue to be) fascinated by the elegance and insight that structural-developmental treatments of cognition can offer (Langer, 1969; Kohlberg, 1962; Piaget, 1970). The representation of development as a form building process through commerce with an environment that individuals are structuring was both elegant and in tune with an epistemology that I was growing to deeply appreciate.

Second, I was uneasy. While perhaps strong as an epigenetic treatment of ethics, Kohlberg's six stage model seemed weak as a means of elucidating complex relations between culture and the ethical thinking of individuals. The concern to document universal stages hid the complex strands of relations between the moral life as lived by these people, the social structure of the community, and the historical circumstances that were shaping social change in this part of the world.

The methods that I used in Alaska reflected a prominent paradigm of the times: A researcher, seeking to garner supportive evidence that a framework-based stage sequence was universal, sampled divergent communities using a more or less standard set of interview tasks developed in research with Western children (e.g., conservation, classification, moral dilemmas) and coded the interviews with pre-established schemes. The results of such investigations were often similar to those I had produced in Alaska: Researchers reported confirmation of behaviors that indexed the existence of a posited set of stages and lack of documentation of behaviors that indexed the highest of those stages. I came to believe that not only did my own work fail to represent well some critical dynamics of culture-cognition interactions, but the same critique could be made more generally of cognitive developmental research.

The dilemma for me was how to preserve the strong developmentalist orientation to cognition while creating techniques that allowed for greater insight into culture-cognition relations. It seemed that the very focus on universal stages precluded the analysis of cultural specificity in development.

Another concern that grew out of this early work concerned the status of ethnography in studies of the cognitive development of individuals. On the one hand, I was a participant observer in the Eskimo community (naive of his ethnographic task) -- bathing with elders, attending ceremonies, and developing friendships. On the other hand, I was conducting a confirmatory study of moral development stages in which I scheduled interviews with residents, much like the norm in cross-cultural research in developmental psychology at the time. In my mind, and very much in tune with the psychological research literature of the times, these two activities were not aspects of the same research enterprise. Context was to serve only as a backdrop for confirmatory social scientific enterprise with which I was engaged. I ended with a reduction of moral development of villagers into three, age related stages.

REPRESENTING CULTURE IN PRACTICE:

MATHEMATICS IN THE OKSAPMIN OF PAPUA NEW GUINEA

Methodological frameworks for representing culture in cognitive development remained limited in the 1970s. Indeed, the thrust of developmental research concerned age-related shifts in universal structures of intelligence. My graduate training was very much in tune with such conceptual and methodological frameworks, most notably Piaget's genetic epistemology.

In 1978 and again in 1980, I experienced again the tensions between the representation of culture and the representation of the cognitions of individuals that had emerged in my early venture into cross-cultural research in Alaska. The occasion was an opportunity to extend my dissertation research on the early development of numerical cognition in a series of studies with a remote cultural group in Papua New Guinea, the Oksapmin. Now, the tension foregrounded rather than emerged from the fieldwork.

I entered the Oksapmin community with a loosely structured plan that reflected extant methodological frameworks. I was to begin with a study of the more traditional confirmatory variety that extended my

dissertation research on number development in Western populations, focusing on relations between the development of children's use of counting and the formation of Piagetian concepts of number conservation. I reasoned that, like my early experience in Alaska, techniques associated with confirmatory efforts depended minimally upon on-site efforts to design tasks; therefore, if I had pre-formulated tasks and general questions that bore on issues of universality, I would have "insurance" that the visit to these groups would satisfy productivity commitments to funding sources, allowing me some opportunity to devote efforts to my second, more challenging concern.

It was the second part of the plan that was more ambitious, breaking from the mold of research paradigms of the times. I had followed the writings and thinking of various authors who had pointed to cultural practices as a fruitful context for study of culture-cognition relations. For instance, early in this century, Franz Boas (1911) argued that people generate intellectual skills in the context of the practices with which they are engaged. In his work with native Americans, he pointed out that cultural practices vary in complexity both within and across groups, and the character of people's knowledge varies accordingly. In the 1960s and 1970s, the focus on cognition and practices re-emerged in the work of psychologists. In Piagetian-based studies, researchers had documented that certain practices, economic exchange (Posner, 1982) seemed to favor the emergence of Piagetian cognitive structures (e.g., pottery making (Price-Williams, Gordon, & Ramirez, 1967). In work that reflected more contextual frameworks for understanding cognition, researchers had shown how practices created important contexts for culture-specific intellectual growth (Cole, Gay, Glick, & Sharp, 1971; Cole & Scribner, 1974; Gay & Cole, 1965; Lave, 1977). For instance, in studies with Kpelle rice farmers, Cole et al. pointed to culture-specific measurement practices that rice farmers displayed marked proficiency. As a whole, the empirical work associated with Piagetian and contextual frameworks was quite consistent with Boas' early observations. People's intellectual adaptations were related to the cultural practices in which they were participants.

For me, the focus on practices had promise, though that promise was far from being fully realized as a method of study. The existing research studies did not reveal much of the dynamics of cognitive work that was accomplished in practices nor how that work created context for novel cognitive developments. Indeed, the

Piagetian-linked developmental research largely was concerned with documenting either universals in cognitive structures or relative retardation or accelerations of these structures across practices and/or cultures. While the contextually oriented research seemed more revealing about culture-cognition relations (see, for instance, Cole & Scribner, 1974), the approach did not satisfy my own commitments towards elevating culture more centrally in structural-developmental analyses of cognition.

I went to Papua New Guinea with two commitments as a part of the second part of my plan: (1) a commitment to a developmental perspective, and (2) a commitment to using cultural practices as a focus for framing questions about culture and cognitive development. I went with few tools. Like the comparative methods in cognitive development at the time, the techniques that I had used in my own prior research were based on interviews organized around tasks designed to provide insight into general cognitive developmental structures, not to reveal the dynamics of culture-cognition interactions nor the cultural specificity of cognitive developments.

Some Preliminaries

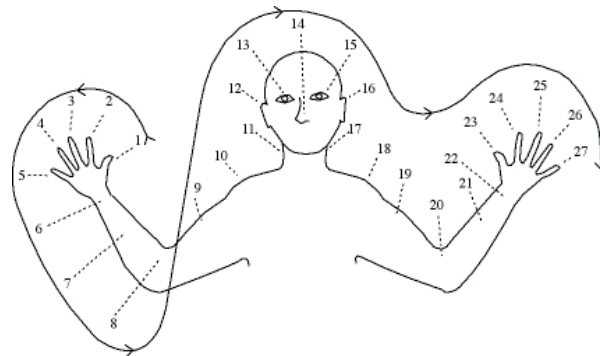
My research on mathematics in Oksapmin was aided greatly by two linguistic anthropologists, Tom Moylan and Virginia Guilford who were engaged in their own dissertation research. It was through their already established friendships with people and progress in learning the Oksapmin language that I was afforded access to important informants and gained knowledge of the community. In addition to help from Tom and Virginia, I had the benefit of support from the Indigenous Mathematics Project of the Papua New Guinea Ministry of Education, an affiliation that provided me access to the government bush school and helped in establishing rapport with teachers. The Ministry affiliation also gave me an entry into talking with adults about number.

Oksapmin and Number, Part I: Confirmatory Studies

I first learned about the Oksapmin number system through Tom and Virginia. Later, I apprenticed myself to others (Oksapmin adults and children) and through my additional confirmatory studies on counting/conservation relations in Oksapmin children (Saxe, 1983), I had an opportunity to learn much about how the system was used by children.

The standard Oksapmin system is based upon body parts. To count as Oksapmin do, one begins with the thumb on one hand and enumerates 27 places around the upper periphery of the body, ending on the little finger of the opposite hand. If one needs to count further, one can continue back up to the wrist of the second hand and progress back upward on the body (see Figure 1). In discussions and observations with others, I learned various functions for the system in everyday activities. For example, aside from using the system to count (pigs, currency, etc.), people also use it to denote the ordinal position of an element in a series of elements (the ordinal position of a hamlet in a series of hamlets on a path), or in basic measurement operations (as a means of measuring and representing the length of string bags, a common cultural artifact). Procedures for computation are not used in traditional life; however, there are some analogs of a computational process. For instance, in traditional economic exchanges, Oksapmin traded goods directly in one-for-one or one-for-many exchanges (bows for leaves of salt, axes for bows). In general, such analogs lack a representational solution procedure in which an answer can be determined in the absence of the objects.

Figure 1. Oksapmin body part counting system.



In my first set of studies, I focused on age-related shifts in children's counting and its relation to children's understanding of a Piagetian construct, number conservation (Saxe, 1981, 1983). Some of these studies served to support my dissertation findings concerning the developmental relation between counting and conservation and revealed the increasingly common finding that people in remote groups develop understandings of conservation, but at later ages than their Western counterparts. Others provided insight into the way the

organization of a numeration system leads children to different conceptual hurdles in its acquisition (Saxe, 1981).

The second part of my plan for the Oksapmin work took form as I learned more about practices with which individuals were engaged. I focused my attention on the way number was used in two selected practices in an effort to better understand how culture is interwoven with cognitive development.

Oksapmin and Number, Part II: Elevating Culture More Centrally in Cognitive Developmental Analyses

The timing of my two stays in the Oksapmin area (1978 and 1980) was quite favorable for a study of cultural practices and cognitive development. The Oksapmin people were just experiencing contact with Westerners in the 1960s and 1970s, resulting in the emergence of novel practices that involved number. Two practices -- economic exchange with currency and Western-styled schooling in arithmetic -- became central targets of my work. It took some time for me to identify and then realize that these were ripe contexts for analyses in which I might be able to integrate cultural and developmental analyses in a study of cognition in these practices and some time to understand how I might begin to proceed.

Economic exchange. Western currency had entered the Oksapmin community through a number of routes. Some Oksapmin men earned about 200 kina (the equivalent, at the time, of about \$300 in purchasing value) from 2-year stints of labor on copra and tea plantations. These men typically returned to the Oksapmin community; some built tiny trade stores, having brought with them bags of rice and tinned fish to sell to people in their hamlets. Many of the other plantation returnees were principal customers at the tradestores.

I saw the new practice of economic exchange as one in which people were accomplishing problems that were novel in their own social history. I needed a framework and techniques from which to ask questions about cognitive development linked to the practice. I saw little utility in the kind of information that Piagetian-practice based study or a contextual study would provide.

Seeds for a framework came from two formative books in my own development, one by A.R. Luria (1978) and the other by B. Kaplan and H. Werner (1962). In structuring a study on cognitive developments linked to the practice of economic exchange, I drew on

these works, finding that both could be adapted and reformulated to capture what emerged as the remarkable developments occurring in the Oksapmin community.

1. Luria's study. In his seminal study conducted in the early 1930s in a remote part of post-revolutionary Russia, Luria (1978) was concerned with documenting a shift in the organization of thinking that he argued would be related to dramatic changes in the organization of people's daily practices, changes from feudal to collectivist forms of social and economic organization. Luria argued that what characterized the shift in groups was the emergence of "new motives for action and also new forms of access to a technological culture and mastery of mechanisms such as literacy and other new forms of knowledge. The transition to a socialist economy brought along new forms of social relations and, with them, new life principles (p. 15)." Following Vygotsky, Luria argued that with the new motives, people would be shifting from "graphically oriented" or unmediated forms of thinking towards mediated forms of thinking. To this end, Luria sampled individuals from five groups that reflected the societal movement. At one extreme were Ichakari women "who were illiterate and not involved in any modern social activities;" at the other extreme were women students admitted to a teachers' school. To document the expected shifts in thinking, Luria engaged villagers in conversation and gradually introduced standard tasks that contained problems involving perception, generalization and abstraction, deduction and inference, reasoning and problem solving, imagination, and self analysis.

In Luria's sampling method -- choosing population groups that reflected a projected shift in forms of social organization -- I found a valuable technique, applicable to issues of economic exchange in Oksapmin. Indeed, I could use an analogous procedure by sampling individuals with varying levels of participation in the money economy and then study the nature of their arithmetical problem solving.

I was less inspired by Luria's methods for studying cognition. The tasks used to assess categories of knowledge were divorced from the targeted practices that Luria was studying. Like the Piagetian analyses of cognitive development, I found problematic the reduction of knowledge into pre-formulated categories that bore little relation to targeted practices and little in the way of an epigenetic analysis of how one form of knowledge might be generated from another in practice.

2. Werner and Kaplan's treatment of symbol formation. Where Luria's analysis weak, I saw strength in Werner and Kaplan's form-function analysis of symbol formation. Though Werner and Kaplan created their treatment in analyses of early language development, I saw their treatment as potentially applicable to an analysis of cognitive development that more richly represented cultural processes.

In their analysis, Werner and Kaplan considered the effect that an emerging linguistic function, such as denotative reference, had on the children's generation of novel linguistic forms (syntactic, pragmatic, and morphological). Werner and Kaplan argued that during infancy, gestural and intonational forms -- early reaching, cooing, and babbling -- have prelinguistic functions (e.g., grasping and affective expression). With the emerging function of denotation in early childhood, children attempt to adapt their already acquired gestural and intonational forms (reaching and cooing) as means to accomplish goals associated with the new function (e.g., reaching while vocalizing to indicate that a parent attend to a particular object). Such prior forms are clearly limited in their ability to serve the purpose off the newly emerging denotative function, and children gradually structures novel forms of a function-specific character. The process of construction passes through various transitional phases, such as the generation of onomatopoeic forms (as in "choo-choo" for "train") and, later, the generation of more clearly specialized syntactic and morphological forms (as in such expressions as, "Look at the train"). Children's generation of new forms reciprocally creates conditions for the emergence of new functions and novel goals.

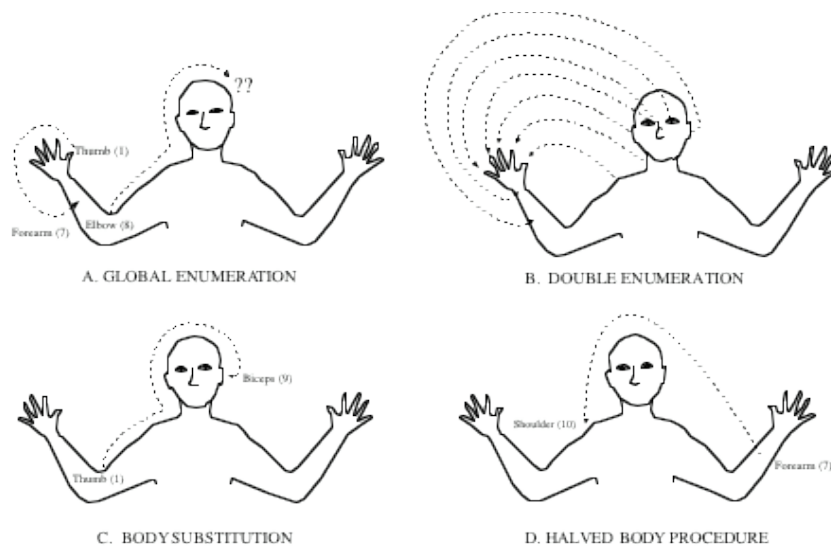
Unlike the analyses of cognition provided in Luria's work and more generally in the cross-cultural Piagetian tradition, the form-function analysis had promise as a means of understanding intrinsic relations between cultural and cognition in development, particularly if coupled with a strong treatment of cultural practices. Cognitive forms are often initially cultural forms, like the Oksapmin number system; further, the cognitive functions that forms serve are interwoven with the practices with which individuals are engaged.

A study on the development of arithmetic linked to the newly emerging practice of economic exchange. My efforts to bring forward Luria's and Werner and Kaplan's prior work were first realized in a study on economic exchange. Following Luria, I sampled adults who had different levels of experience with the money economy (Saxe, 1982). I

interviewed about 80 individuals from four population groups that had varying levels of participation with the new practice of economic exchange with currency. These groups included (1) trade store owners, (2) men who had returned from a period of work at a plantation, and groups of (3) younger adults who had never left the area but who had acquired minimal currency and (4) older adults who had little experience with economic exchange that involved currency.

Interview tasks were created that would allow for analyses of arithmetical reasoning. In a typical addition task, a subject was told, "You have 7 coins and are given 14 more. How many do you have altogether?" The results of the interviews revealed some dramatic differences among the four groups in the way Oksapmin used their body system to solve the tasks, differences that could be made intelligible in a developmental framework using the form-function model. Consider four approaches to the solution of $9+7$ coins that emerged with increasing participation in the money economy depicted in Figure 2.

Figure 2. Oksapmin arithmetical strategies.



Those Oksapmin people with only minimal participation in the money economy first attempted to extend the body-counting cognitive form as it is used to serve enumerative functions in traditional activities to accomplish arithmetical tasks that emerge in economic transactions. This direct extension, however, was not adequate to accomplish arithmetical solutions, and it was not even clear that Oksapmin with little experience treated the task as one that involved

the cognitive function of arithmetic. In these preliminary efforts, Oksapmin attempted to count the sum with a prior counting strategy linked to the body system. Figure 2a illustrates this "global enumeration strategy." In this strategy, an individual began with the first term (7) of the problem -- thumb (1) to forearm (7) -- and then continued to count the second term (9) from the elbow (8). Since the problem of nine coins plus seven coins seemed to be understood as an enumeration rather than an addition, individuals did not recognize the need to keep track of the addition of the second term on to the first term, and they typically produced an incorrect sum.

Oksapmin with greater experience in the money economy made a clumsy and labored effort to restructure their prior global counting strategy in such a way that one term is added on to the other (the "double enumeration strategy"). In one example of this strategic form (Figure 2b), individuals again enumerate the first term -- thumb (1) to forearm (7)-- but now, as they enumerate the second, they make efforts to keep track of their enumeration. Thus, the elbow (8) is paired with the thumb (1), the biceps (9) is paired with the index finger (2), and so on, until the ear-on-the-other side (16) is paired with the biceps (9), yielding the answer. Thus, in this initial extension of the body system to accomplish the arithmetical problem, the body parts begin to take on a new function of keeping track of the addition of one term onto another.

With higher levels in the sequence, we see the body-part-counting form progressively specialized into more sophisticated cognitive forms that serve distinctly arithmetical functions. Now, individuals, rather than establishing physical correspondences between body parts as they did previously, efficiently use the name of one body part to refer to another in a "body substitution strategy" (Fig 2c). To solve $7+9$, the elbow (8) is called the thumb (1), the biceps (9) is called the index finger (2), and so on, until the ear-on-the other-side (16) is called the biceps (9). The result is a more rapid computational process, one in which body-part names are differentiated from the names of body parts themselves.

Cognitive forms that are distinctively specialized to serve arithmetical and not enumerative functions were more frequently displayed by trade store owners who have the most experience with problems of arithmetic that emerge in economic transactions with currency. In their strategies, some trade store owners incorporated a

base-10 system linked to the currency as an aid in computation. With this strategic form (Figure 2d), individuals use the shoulder as a privileged value. In their computation of $9+7$, they may represent the 9 on one side of the body as biceps (9) and 7 on the other side of the body as forearm (7). To accomplish the problem, a trade store owner might simply "remove" the forearm from the second side (the seventh body part of 7) and transfer it to the first side where it becomes the shoulder (the 10th). He then "reads" the answer as $10+6$ or 16.

By incorporating elements of both Luria's and Werner & Kaplan's analytic frames, I was able to reveal some practice-specific developmental processes occurring in the Oksapmin community. In their efforts to accomplish goals that emerge in economic practices, Oksapmin appropriate practice-linked cognitive forms initially specialized to serve earlier emerging cognitive functions (enumeration) for new uses -- in this case, arithmetic. In the process of this appropriation and specialization, the function of the body system shifts and the original form used to accomplish enumerative functions undergoes a progressive development. In this process, Oksapmin were creating, over time, progressively more specialized and sophisticated uses of the indigenous number system, a process of specialization that is deeply interwoven with both developmental and cultural processes.

In an effort to further explore the cognitive developments as they emerged in individuals' participation in practices, I turned next to the analysis of Oksapmin children's mathematics learning in a new Western-styled bush school. The study was one that required the development of a new data gathering technique -- a systematic, though limited, observational coding scheme. It was also an occasion to push the form-function framework to see whether it would be useful applied to a different practice in Oksapmin.

A study on arithmetic linked to schooling. At school, Oksapmin children participate in a wide range of activities -- from formal school lessons to the building and maintenance of the school grounds. Children come to school with knowledge of the body system, speaking only the Oksapmin language. They are taught to use Western numeration and arithmetical procedures in English. I suspected that like adults engaged in economic practices, children might be appropriating the indigenous body system in an effort to make sense of their school math, and in a developmental process, show similar form-function shifts as the adults. I used two types of techniques to

analyze the development of arithmetical problem solving in the context of school.

My first concern was to document whether children spontaneously used the body system during arithmetical problem solving. To this end, I collaborated with teachers in structuring an arithmetic test to be used at 3 grade levels that would be administered during class time, a context in which we would be able to observe children solving mathematical problems in the course of an everyday classroom math routine. The observations revealed that many children used the conventional body part system during the test; though, the frequency with which children overtly used their bodies to solve the tasks declined over grade level.

Having documented children's use of the indigenous system in school, my second concern was to analyze developmental shifts in children's arithmetical understandings. To this end, children were interviewed individually about a variety of arithmetic problems. In addition, a group of nonschooled adolescents was interviewed to determine whether these inventions were attributable to the school experience or merely developed in the course of everyday activities.

Similar to the adults who had little experience with exchange involving currency, I found that Grade 2 children used strategies similar to the global enumeration procedure, using body parts to accomplish strictly enumerative functions. In contrast, Grade 4 and Grade 6 children tended to use strategies that resembled those of the adults who had experience with currency. The nonschooled contrast group of age-matched grade 6 children used strategies similar to the Grade 2 children. Thus, the form-function shifts documented in these Oksapmin children were linked to participation to school-based practices.

A Critique of the Research in Oksapmin

The Oksapmin studies of arithmetic in trade and in school illustrate well the way form-function analyses can represent the interplay between culture and cognitive development in the study of practice. In practices, individuals make use of cultural forms, tailoring them to serve particular, practice-linked cognitive functions. With use and specialization of these forms, often individuals create new functions for which there is again a process of specialization. The dialectic between form and function is thus a process whereby history

(as enduring cultural forms) and cognition become interwoven with one another in the developing understandings of the individual.¹

While the focus on form-function relations satisfied some of my early concerns about the representation of culture in analyses of cognitive development, I saw that I could have pushed harder in the Oksapmin work. Missing was a critical treatment of how environments emerged in the practices of economic exchange in the trade store and in the school. While in the Oksapmin fieldwork I had spent time observing social interactions in which arithmetical problems were generated and resolved in the trade store, I had not attempted systematic social interactional analyses. Lack of such analyses seemed, in hindsight, a critical omission for two reasons. First, emergent environments in practices themselves reflect socially and culturally organized cognitive work. *In situ* analyses of the environments would offer a window into the ways in which cultural and cognitive processes are constituting one another in the daily dynamics of people's activities. Second, the form-function model is based on the assumption that individuals are constructing goals and means to accomplish them in practices. Goals are not set by the structure of an activity; rather, they emerge as individuals motives and understandings are realized in practices.

DOCUMENTING EMERGENT GOALS THROUGH SOCIAL INTERACTIONAL ANALYSES:

A FINE-GRAINED STUDY OF PRACTICES

In subsequent work with colleagues in the United States (Saxe, Gearhart, & Guberman, 1985; Saxe, Guberman, & Gearhart, 1987), I turned my attention back to young Western children's understanding of number -- a focus of my dissertation research conducted five or six years earlier. In the new work on early number, I brought forward the focus on practices, the form-function framework, and now a focus on social interactions.

In the research literature on number development, various researchers had revealed that children at a young age show considerable knowledge (Fuson, 1978; Gelman & Gallistel, 1978; Saxe,

¹This analytic concern is similar to Vygotsky's target of study in his "method of double stimulation" (Vygotsky, 1962; 1978). Vygotsky, however, focused principally on the construct of "internalization" in his analysis of shifting relations between artifacts and cognition. Further, Vygotsky's research was principally lab based, with the principal exception of the study he supervised with Luria reviewed above.

1977, 1979); however, little attention had been addressed to the enculturating processes that supported children's number development. Were young children, like the Oksapmin, participating in everyday numerical practices in which they were constructing and accomplishing numerical goals linked to social and cultural processes? If so, could children's developments be understood in terms of shifting relations between cognitive forms and functions?

The research was set in a neighborhood in Brooklyn, New York. The neighborhood was largely Caucasian and contained families that were both working and middle class (as defined by standard indices). We sampled families that contained either 2 1/2-year-olds or 4-year-olds from each socioeconomic group.

Form-function analyses. Drawing upon prior work on early numerical understandings, my colleagues and I identified four principal functions for number words in young children's development, functions that had implications for children's construction of numerical goals (Saxe, Guberman, & Gearhart, 1987). These functions included: (1) nominal reference (using number words in naming activities), (2) cardinal/ordinal representations of single sets, (3) comparing and reproducing sets, and (4) arithmetical transformations of numerical values. We also identified a range of the strategic forms that children used to realize these functions, like strategies to achieve an accurate count, to represent cardinal values of a single set, or various strategies to compare or reproduce sets.

To document the way these forms and functions were realized in children's activities, we developed interview techniques that were used to elicit from mothers rich descriptions of the numerical practices with which her child was engaged with or without her direct support. We also elicited from mothers their retrospections and projections of prior and possible future practices. These descriptions were then analyzed with schemes that coded both the content (games of mothers' and children's own invention, store bought games, etc.), and more importantly, their goal structure complexity of the activities based upon our prior analysis of the cognitive functions involved in the activities. For instance, based on the form-function analysis, we identified activities in which goals were principally ones of nominal reference (e.g., identifying and pushing numbered elevator buttons (level 1)), representation of cardinal values (e.g., counting coins to determine their amount (level 2)), comparing the numerical values of

two collections (e.g., comparing two collections of pennies (level 3)), and arithmetical (e.g., adding and subtracting checkers to find their sum (level 4)).

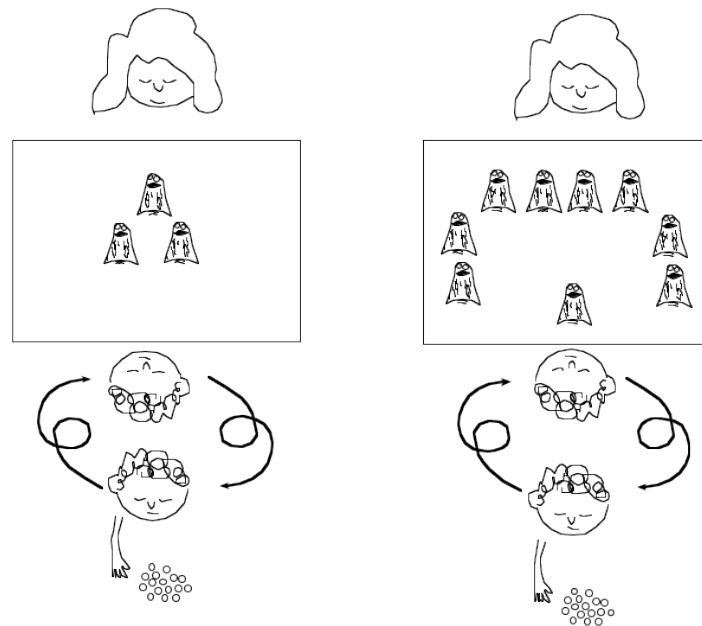
Our interviews with mothers revealed that, across our age and social class groups, children regularly participated in practices involving number, practices that had goal structures of varying levels of complexity. We found age differences in the goal structure complexity of home activities, differences that mirrored our developmental analyses of children's achievements: younger children tended to be engaged with activities of level 1 and 2 goal structures; older children, children who showed competence reflecting higher-level goals, tended to be engaged with activities with higher-level goal structures. Working-class 4-year-olds tended to be engaged with social activities of less complex goal structure than were their middle-class peers, again reflecting social class differences in children's numerical achievements. Thus, these analyses provided a window into children's numerical practices and the way form-function shifts in children's numerical cognition is interwoven with their practice participation.

Our next step was to ask how numerical goals emerged for children during play with their mothers and whether these emergent goals differed for younger and older children. To this end, we videotaped mother-child pairs during their engagement in two prototypical activities. One containing a goal structure that required a cardinal representation (level 2) and the other involving an activity with a numerical reproduction goal structure (level 3). We also videotaped children accomplishing the activity in solitary play.

We found that in our analyses of mother-child videotaped interactions, the goal structures took form and shifted over the course of activities regardless of children's age. Further, goal structures could best be understood as a product of mothers' and children's adjustments to one another. In the number reproduction activity, for instance, children were presented with a board containing pictures of either three or nine Cookie Monsters (a model set) and a cup. The child had to get just the same number of pennies from a collection about 5 feet away as there were Cookie Monsters in the picture (see Figure 3). We found that the mothers of the children who were older (and who performed at higher levels in their unassisted performances) attempted to structure the task at more

superordinate level goals and the mothers of 2 1/2-year-olds (and who demonstrated less ability in their unassisted performances) attempted to provide directives that supported children's construction of less complex goals. Further, it was possible to document the dynamics that led to different goal structures emerging for children. When mothers provided goal directives that the child was not successful in accomplishing, mothers tended to shift to a less complex numerical goal directive; in contrast, when children successfully accomplished a goal directive, mothers tended to shift to a more superordinate numerical goal directive. Reciprocally, children were also adjusting their own activities to their mothers. For instance, children who did not appropriately count one or both sets when unassisted (an important strategic component in the solution of the task) were likely to count with their mothers' assistance. Further, children who did not successfully complete the task on their own were likely to do so with their mothers.

Figure 3. Number reproduction activity with 3 and 9 Cookie Monsters.



The analyses of videotaped interactions provided a remarkable window into the emergence of goals in practices: Mothers were adjusting their goal-related directives to their children's understandings and task-related accomplishments and that children were adjusting their goal-directed activities to their mothers' efforts to organize the task. Further, as children's ability to produce numerical goals of different complexity levels changed with

development, they were afforded new opportunities for creating more complex numerical environments.

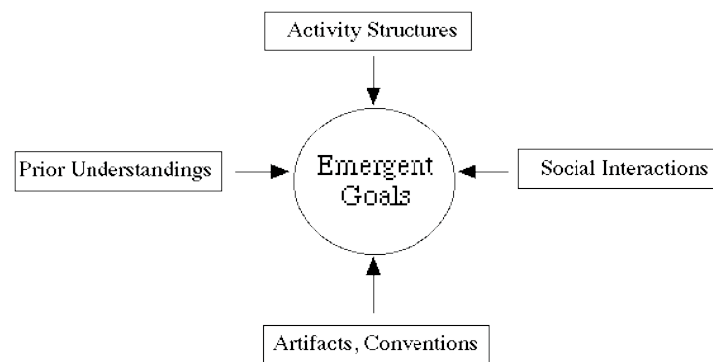
A PRACTICE-BASED RESEARCH FRAMEWORK

New efforts and ambitions to better represent the interplay between cultural practices and cognitive development led me to systematize a general research approach. The systematization took the form of a three component research framework.

Component 1: Emergent Goals

Central to my prior work in Oksapmin and Brooklyn was the thesis that children create cognitive developments in their efforts to accomplish numerical goals, goals that emerge in practices. The first component of the framework is geared for understanding the dynamics of goal formation in practices (see Figure 4). The focus is on the way artifacts (e.g., currency), social interactions (e.g., a mother's efforts to assist her child in face-to-face discourse), activity structures (e.g., the routine activities to make a purchase at a tradestore), and individual's own prior understandings (e.g., of arithmetic, counting) are interwoven with the goals that children construct.

Figure 4. Four parameter model.



Component 2: Form-Function Shifts

The second component brings forward an analysis of the interplay between form and function in analyses of cognitive development. The analyses of cognitive development in Oksapmin and Brooklyn demonstrated the utility of asking questions about cognitive development in terms of form-function relations: What cultural forms

has the child appropriated and specialized to accomplished emergent goals in practices and what cognitive functions are these forms serving? The focus on form-function analyses became central in systematizing data gathering and analytic techniques to understanding development in practices.

Component 3: The Interplay between Cognitive Developments Across Practices

In their daily activities individuals are engaged in multiple practices in which mathematical goals may emerge. The third component is concerned with questions of the interplay across practices: in what way do cognitive forms elaborated in one practice become appropriated and specialized to accomplish new functions in others?

THE PRACTICE-BASED APPROACH

APPLIED TO CANDY SELLING

The three components served to coordinate a wide ranging set of analyses in concerned with culture and cognition in relation to a single but pivotal construct to the analysis of development -- emergent goals. To illustrate the framework, I draw on research conducted in Brazil's Northeast.

At the invitation of Terezinha Nunes, Analucia Schliemann, and David Carraher at the Federal University of Pernambuco, I had taken a sabbatical leave and taken up residence in Recife, Brazil. I went with a Fullbright fellowship for teaching that put me in touch with graduate students at the Federal University and with a grant from the National Science Foundation to support research on the interplay between culture and cognitive development in urban and rural practices with which children were engaged. My search for practices to target for study was guided by five principal concerns, several of which had proved useful for organizing empirical studies in my prior work:

1. Targeted practices were to be ones that appeared to support the development of complex mathematical cognitions in children.
2. Children of various ages were participants (to allow for a study of age related shifts in children's understandings).
3. Children of considerable numbers had to be involved to insure that trends observed in children's mathematics were reliable.

4. A large number of participants in targeted practices should have little or no schooling; this would allow me to study mathematical understandings children construct with out the benefit of schooling.
5. A large number of participants in the targeted practices should be attending school to enable a study of the interplay between math learning at school and math learning in the streets.

Guided by these general constraints, I spent time with faculty colleagues and graduate students discussing and visiting various communities in the process of selecting sites for study. Two emerged that satisfied most criteria: candy selling in urban children and straw weaving in rural children. Below, I draw on research with candy sellers to explain the three component framework.

The candy selling practice² is set in the context of a major urban center in Brazil's Northeast in which there is a large informal sector. Due to a long history of an inflating economy, sellers must deal with very large numerical values in everyday transactions; many of these sellers have little or no schooling.

Component 1: Emergent Goals

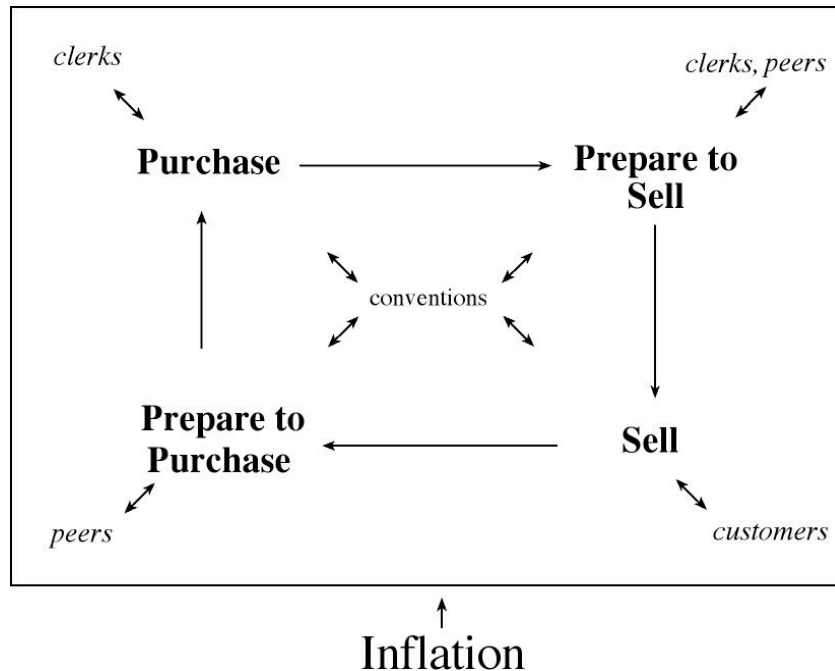
To document the arithmetical goals with which sellers were engaged, I organized analyses of sellers' practice with reference to each of the four parameters of the first component. Below, I point to the way these parameters are implicated in analyses of sellers' goals.

Activity structures. Activity structures consist of the general tasks that must be accomplished in a practice and the general motives for practice-participation. In the case of candy selling, the activity structure is an economic one (the inner rectangle in Figure 1). To accomplish their practice, sellers must purchase their boxes from wholesale stores during a *purchase phase*, price their candy for sale in a *prepare-to-sell phase*, sell their candy in the street in a *sell phase*, and then select new wholesale boxes for purchase in a *prepare-to-purchase phase*. The cycle then repeats back to the purchase phase. In selling candy, children generate mathematical goals that are linked to this cyclical activity structure to accomplish economic ends. For

²The interested reader can find a more complete rendering of these methods in Saxe, 1991).

instance, in the prepare-to-sell phase, one type of mathematical goal that typically emerges is the mark-up from wholesale to retail price.

Figure 5. Schematic of candy selling practice.



Social interactions. The social interactions that emerge in a practice, the second parameter, may simplify some goals and complicate others. During each phase in the practice, sellers typically interact with other people. For instance, in the purchase phase, sellers buy their boxes from wholesale store clerks. In these transactions, clerks may offer varied forms of assistance in helping children mark-up their boxes for retail sale. Sometimes this assistance may be merely in the form of telling children how much the box costs if sellers cannot read posted prices. Other times, clerks may accomplish the mark-up for children by telling them what an appropriate mark-up would be to sell on the streets. Regardless, an inherent property of these interactions is that practice-linked numerical goals emerge and are modified in social interactions. Often children who are less capable construct and accomplish less complex numerical goals, the more complex ones being structured and accomplished by the store clerk.

Cultural artifacts. The third parameter consists of the artifacts that are interwoven with the practice. Consider a pricing convention that has emerged over the history of the practice. In selling their

candy, sellers price their candy using a price ratio form. Children might offer their candy to customers for two prices, three packages for Cr\$500 or five for Cr\$1000. While this convention may reduce the complexity of arithmetical computations in making change, it may complicate others. For instance, a seller must mark-up a multi-unit wholesale box price in terms of a retail price ratio. The final selling ratio (the retail price) should reflect the wholesale box price plus a profit margin. Thus, the price ratio convention is interwoven with the mathematical goals that emerge as sellers address problems of mark-up.

Prior understandings. The prior understandings that sellers bring to bear on the practice--the fourth parameter--are fundamental to the kinds of goals that emerge in a practice. For instance, a seller who does not understand the relation between wholesale price and retail price does not generate mark-up goals--or at least, if he does, the mathematical goals in his computation will be quite different sort from the seller who does.

An eclectic set of techniques were used to gather information on sellers' mathematical goals in the practice. These included *in situ* observation and interview of principal participants in the candy selling practice (6- to 15-year-old candy sellers, store clerks, cashiers, and customers in the streets and on buses). Further, we recruited wholesale store clerks to keep records of their transactions with their child customers (the candy sellers) and asked them to note if they provided the sellers any assistance, and if so, what form. We also conducted systematic analyses of the exchanges that took place in wholesale stores. We analyzed the particular mathematical goals that sellers formed in their practice and the way children's goals shifted with sellers' ages.

Component 2: Form-function shifts in Development

We used observation and informal interview procedures to collect information on the development of sellers' mathematical understandings. We accompanied some sellers as they plied their trade, asking about their activities at opportune moments. We noted various ways in which children were making use of cultural forms to accomplish cognitive functions in sellers' practice and the shifting

relations between cognitive forms and functions that occurred over age.

Consider one strand in shifting relations between form and function in sellers' mathematics. All sellers made use of a price ratio convention (a cultural form) to offer goods to customers. Sellers, for instance, would sell candy for a specific number of units for Cr\$1000. Sellers would however make use of the price ratio in different ways in their computations. For the six-year-old seller, the price ratio served the cognitive function of mediating exchanges of candy for currency in seller-customer transactions: The child-seller exchanges, for instance, one Cr\$1000 bill for three candy bars. For the young seller, issues of price mark-up are taken care of by others.

As sellers take on more responsibility, we saw a shift in the cognitive functions the price ratio served. Rather than being solely used in the context of seller-customer transactions, sellers began to use the price ratio as a means to organize their mark-up computations. They began to use the ratio to determine a potential gross price for their boxes were they to use a particular ratio for a retail price ("what if?" computations). For instance, sellers would empty their boxes, replacing their candy in groups (e.g., 3 by 3, or 2 by 2), counting Cr\$1000 with each placement. Once they replaced all of their candy, they would have determined the gross value of the box if it were sold at the specified grouping ratio.

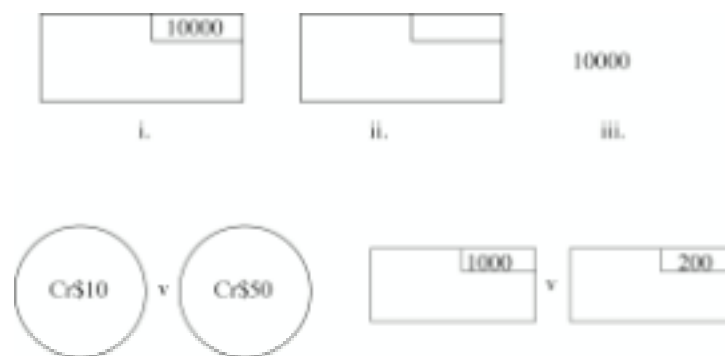
To collect systematic information on form-function shifts in sellers' mathematics, interview tasks were designed in the areas of mark-up, number representation, and arithmetic. We interviewed sellers, and, for comparison purposes, age matched urban and rural nonsellers; we paid children for the time they spent as interviewees.

Most sellers appeared rarely if ever to make use of our standard orthography for number. For instance, when sellers would enter wholesale stores to purchase boxes of candy rather than reading posted prices, they would often ask store clerks the price of boxes. Other times, sellers already knew the price of a box of a type of candy in a store from word of mouth provided by other sellers. Rarely were sellers observed using paper and pencil computations to accomplish arithmetical computations. I suspected that many sellers were using currency itself (a cultural form) as a means of identifying numerical values in transactions with customers. Bills were printed with different colors, and children seemed to be identifying the numerical

value of bills not by the printed numerals on them but by the figurative characteristics of bills. Further, with knowledge of ordinal and multiplicative relations between currency values, children could use as a representational system for number in their computations.

To investigate children's number representations, I developed tasks to determine sellers' abilities. For a standard orthography task, sellers were asked to read and compare 20 multidigit numerical values, values that were within the range that they addressed in their practice. To determine sellers' ability to use currency as an alternative system for large number representation, I constructed two types of additional tasks. First, in bill identification tasks, children were presented with 12 bills (or printed bill values) in each of three conditions (see Figure 6a): (a) standard bills, (b) bills with their numbers occluded by tape, and (c) photocopies of cutouts of the numbers. In each condition, children were required to identify the values of the bills or numbers. Second, in the currency comparison tasks, children were presented with 14 pairs of currency units and asked to tell which was the larger of the two (e.g., bills of Cr\$200 and Cr\$1000) as well as the multiplicative relations between units -- how many of the smaller units were equivalent to the larger unit (see Figure 6b). I reasoned that if sellers could identify currency units and compare them numerically, they have the basis for a representational system to manipulate large numerical values, a system that would serve them well in their everyday computations.

Figure 6. Currency Identification and Comparison Tasks



Analyses of the interviews revealed that sellers' develop a mathematics that differs from the mathematics that we have learned in school, and one that their nonselling peers do not construct. Further, the character of their mathematics becomes more powerful with age, displaying a shifting relation between the culturally linked

forms that sellers appropriate in their solutions (e.g., currency, the price ratio selling convention) and the functions that these forms serve.

Component 3: The Interplay between Cognitive Developments Across Practices

The third component is concerned with questions of the interplay across practices: in what way do cognitive forms elaborated in one practice become appropriated and specialized to accomplish new functions in others?

In the candy selling work, I focused on the interplay between sellers' street mathematics and the mathematics that some of these children were learning at school, an issue that resonates well with current concerns of mathematics educators in the United States (National Council of Teachers of Mathematics, 1989). I analyzed whether learning math at school was appropriated by sellers as they structured and accomplished emergent goals in the street; I also analyzed whether sellers in school and whether sellers made use of their street mathematics to accomplish computational problems in class.

To determine whether children's schooling in math led to differences in how they approached problems that emerged in the candy selling practice, I contrasted the mathematical understandings (as revealed by the tasks noted above) of 12- to 15-year-old sellers who had differing levels of school experience.³ The groups included: Children who had none or little schooling (0-second grade), children who had completed the third or fourth grade, and children who had completed the fifth, sixth, or seventh grade. These findings revealed some notable differences and some notable similarities. With schooling, sellers increasingly were able to read the standard orthography, whereas sellers without schooling performed poorly on the orthography tasks. Further, there was an occasional school child in observations in the street that made use of paper and pencil calculations in mark-up calculations and in strategies to accomplish some of the arithmetic tasks. However, there were no differences linked to schooling in sellers' accurate solutions of the mathematically

³It is common in poor communities in Northeastern Brazil for children to drop out of school at a young age or to never attend school. Thus, unlike the United States, in Recife it was possible to contrast children of the same age who had differing levels of school experience.

more complex currency arithmetic, ratio comparison, and inflation tasks.

To study whether sellers used their street mathematics to help them understand math at school, I used school-type computation problems, administering them in individual interviews to sellers and nonsellers in second and third grade classrooms. The findings revealed that sellers did make use of their practice-linked mathematics in solving school problems: At second grade, sellers achieved accurate solutions to greater numbers of problems than nonsellers; further, sellers strategies appeared to be adaptations of the currency-linked computation procedures that were manifest in sellers arithmetical problem solving in their practice. At third grade, while sellers still performed with greater accuracy than nonsellers, the differences were attenuated.

SUBSEQUENT RESEARCH ON PRACTICES AND CHILDREN'S MATHEMATICS

In subsequent work, I have made efforts to elaborate and systematize the research framework in studies on cultural practices and cognitive development, one on urban children's play of an educational game (Saxe, 1992; Saxe & Bermudez, 1992; Saxe & Guberman, 1993), and in collaborative research in progress, on reform-minded and traditional fifth grade mathematics classrooms (Gearhart, Saxe, & Stipek, in progress). The studies have spawned new and more eclectic techniques as colleagues and I try to represent emergent mathematical environments in classroom settings and the kinds of knowledge that participants (teachers and students) are creating in their practices.

CONCLUDING REMARK

In their efforts to understand, researchers make use of frameworks to guide the identification and reduction of phenomena into interpretable categories. Increasingly, in studies of cognition and development, we find efforts to create frameworks in which culture and cognition are conceived as intrinsically related to one another, and to create and adapt empirical techniques that accordingly reveal cultural dimensions of cognitive development.

My own struggles to mitigate the tension between cultural and developmental analyses of cognition have been protracted. They provide one case study of the productive relation between framework and technique in a body of developmental research. I began with limited

empirical techniques that served essentially no more than confirmatory functions in research on moral development in an Eskimo community. Confronted with the schism between the culturally textured qualities of peoples' everyday lives and the confirmatory methods for studying universal developmental stages, I moved toward the three-component framework. The shift brought with it new framework-linked research goals for documenting cognitive developments specific to cultural practices. To accomplish these research goals, I adapted prior techniques to serve new functions, and these techniques became specialized as my research goals became more differentiated. Thus, in Oksapmin, I created interviews that were geared for eliciting strategies for solving arithmetical problems in the context of a new practice of economic exchange using indigenous numeration. In Brooklyn, I created means of assessing young children's numerical understandings and their links to their everyday number activities. In Brazil, I created observational and interview techniques for documenting the character of mathematical problems that emerged in practices and assessment techniques informed by the observational studies. Now, confronted with new challenges of comparative studies of traditional and reform-minded mathematics classrooms, colleagues and I are viewing classroom practice as cultural practice. In this endeavor, we are again adapting techniques to represent the emergent environments in classrooms and the form-function shifts in teachers and students as they engage with the new challenges of educational reform.

References

- Boas, F. (1911). The mind of primitive man. New York: Macmillan.
- Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. Educational Researcher, 18(1), 32-41.
- Campione, J.C., Brown, A.L., Ferrara, R., & Bryant, N.R. (1984). The zone of proximal development: Implications for individual differences and learning. In B. Rogoff & J. V. Wertsch (Eds.), Children's learning in the zone of proximal development. pp. 45-63. San Francisco: Jossey-Bass.
- Cole, M. (1990). Cultural psychology: A once and future discipline? In J.J. Berman (Ed.), Nebraska Symposium on Motivation, 1989: Cross-cultural Perspectives, 37. Lincoln, NE: University of Nebraska Press.
- Cole, M. (1991). Conclusion. In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), Perspectives on socially shared cognition (pp. 398-417). Washington, D.C.: American Psychological Association.
- Cole, M., & Scribner, S. (1974). Culture and thought: A psychological introduction. New York: Wiley.
- Cole, M., Gay, J., Glick, J. A., & Sharp, D. W. (1971). The cultural context of learning and thinking: An exploration in experimental anthropology. New York: Basic Books.
- Dasen, P. R. (1975). Concrete operational development in three cultures. Journal of cross-cultural psychology, 6, 156-172.
- Fuson, K. (1988). Children's counting and concepts of number. New York: Springer-Verlag.
- Gay, J., & Cole, M. (1965). The new mathematics in an old culture: A study of learning among the Kpelle of Liberia. New York: Holt, Rinehart, & Winston.
- Gearhart, M., Saxe, G.B., Stipek, D. (1991). Portfolios in practice. Unpublished manuscript. UCLA.

- Gelman, R., & Gallistel, R. (1978). The child's understanding of number. Cambridge: Harvard University Press.
- Hutchins, E. (1991). The social organization of distributed cognition. In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), Perspectives on Socially Shared Cognition (pp. 283-307). Washington, D.C.: American Psychological Association.
- Kohlberg, L. (1969). Stage and sequence: The cognitive-developmental approach to socialization. In D. A. Goslin (Ed.), Handbook of socialization theory and research. Chicago: Rand-Mcnally.
- Laboratory of Comparative Human Cognition (1978). Cognition as a residual category in anthropology. Annual Review of Anthropology, 7, 51-69.
- Laboratory of Comparative Human Cognition (1979). What's cultural about cross-cultural cognitive psychology? Annual Review of Psychology, 30, 145-172.
- Langer, J. (1969). Theories of development. New York: Holt, Rinehart & Winston.
- Langer, J. (1986). The origins of logic: One to two years. NY: Academic Press.
- Lave, J. (1977). Tailor-made experiments and evaluating the intellectual consequences of apprenticeship training. Quarterly Newsletter of the Institute for Comparative Human Development, 1(2), 1-3.
- Lave, J. (1990). Cognition in practice. New York: Cambridge University Press.
- Luria, A. R. (1976). Cognitive development: Its cultural and social foundations. Cambridge, MA: Harvard University Press.
- National Council of Teachers of Mathematics (1989). Curriculum and evaluation standards for school mathematics. Reston, VA: NCTM.

- Pea, R. D. (1994). Practices of distributed intelligence and designs for education. In G. Salomon (Ed.), Distributed cognitions: Psychological and educational considerations. (pp. 47-87). NY: Cambridge University Press.
- Pepper, S. (1942). World hypotheses. Berkeley: University of California Press.
- Piaget, J. (1966). Need and significance of cross-cultural studies in genetic psychology. International Journal of Psychology, 1, 3-13.
- Piaget, J. (1970). Piaget's theory. In P. Mussen (Ed.) Carmichael's manual of child psychology. NY: Wiley.
- Posner, J. (1982). The development of mathematical knowledge in two West African societies. Child Development, 53, 200-208.
- Price-Williams, D., Gordon, W., & Ramirez, M. (1967). Manipulation and conservation: A study of children from pottery-making families in Mexico. Memorias del XI Congreso Interamericano de la psicología, Mexico City, 106-121.
- Rogoff, B. (1990). Apprenticeship in thinking: Cognitive development in social context. New York: Oxford University Press.
- Saxe, G. B. (1977). A developmental analysis of notational counting. Child Development, 48, 1512-1520.
- Saxe, G. B. (1979). Developmental relations between notational counting and number conservation. Child Development, 50, 180-187.
- Saxe, G. B. (1981). Body parts as numerals: A developmental analysis of numeration among a village population in Papua New Guinea. Child Development, 52, 306-316.
- Saxe, G. B. (1982). Developing forms of arithmetic operations among the Oksapmin of Papua New Guinea. Developmental Psychology, 18(4), 583-594.
- Saxe, G. B. (1983). Culture, counting, and number conservation. International Journal of Psychology, 18, 313-318.

- Saxe, G. B. (1985). The effects of schooling on arithmetical understandings: Studies with Oksapmin children in Papua New Guinea. Journal of Educational Psychology, 77(5), 503-513.
- Saxe, G. B. (1988). Candy selling and math learning. Educational Researcher, 17(6), 14-21.
- Saxe, G. B. (1988). The mathematics of child street vendors. Child Development, 59, 1415-1425.
- Saxe, G. B. (1991). Culture and cognitive development: Studies in mathematical understanding. Hillsdale, NJ: Erlbaum.
- Saxe, G. B. (1992). Studying children's learning in context: Problems and prospects. Journal of the Learning Sciences. 2(2), 215-234.
- Saxe, G. B., & Bermudez, T. (1992). Emergent Mathematical Environments in Children's Games. Paper presented at the 1992 Meetings of the International Congress of Mathematics Education. Quebec City.
- Saxe, G. B., & Gearhart, M. (1990). The development of topological concepts in unschooled straw weavers. British Journal of Developmental Psychology, 8, 251-258.
- Saxe, G. B., & Guberman, S. R. (1993). Emergent goals in the context of distributed problem solving. Paper presented at the 1993 meeting of the Society for Research in Child Development. New Orleans, LA.
- Saxe, G. B., & Moylan, T. (1982). The development of measurement operations among the Oksapmin of Papua Guinea. Child Development, 53, 1242-1248.
- Saxe, G. B., Gearhart, M., Note, M., & Paduano, P. (in press). Peer interaction and the development of mathematical understandings: A new framework for research and educational practice. H. Daniels (Ed.), Charting the Agenda: Vygotskian Perspectives. London: Routledge.

Saxe, G. B., Guberman, S. R., & Gearhart, M. (1987). Social processes in early number development. *Monographs of the Society for Research in Child Development*. 52(2). [With reviews by B. Rogoff and R. Gelman & C. Massey]

Schweder, R.A. & Sullivan, M. A. (in press). Cultural psychology: Who needs it? In Annual Review of Psychology, 44.

Vygotsky, L. (1986). In A. Kozulin (Ed.), Thought and language. Cambridge, MA: MIT Press.

Vygotsky, L. S. (1978). Mind in society. Cambridge, MA: Harvard University Press.

Werner, H., & Kaplan, B. (1962). Symbol formation. New York: Wiley.

Wertsch, J. (1984). The zone of proximal development: Some conceptual issues. In B. Rogoff, & J. V. Wertsch (Eds.) Children's learning in the "zone of proximal development", San Francisco: Jossey-Bass.

Wertsch, J. (1991). Voices of the mind: A sociocultural approach to mediated action. Cambridge: Harvard University Press.