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Early mathematics teaching and learning in Sudanese families

Azza Moawia Habib

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Early mathematics teaching and learning in Sudanese families

by

Azza Moawia Habib

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE

Department: Human Development and Family Studies
Major: Child Development

Signatures have been redacted for privacy

Iowa State University
Ames, Iowa
1992
To my mother whose ideals like stars I cannot reach, but my path is guided by their light.
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GENERAL INTRODUCTION

Because of the importance of mathematics in society, the development of mathematics has gained worldwide interest from all levels, including parents, teachers, educators, and administrators. Screening tests of mathematics have been developed, such as The Test of Early Mathematics Ability (Ginsburg & Baroody, 1990). Cross-cultural studies of mathematical understanding, especially comparisons between Asian and American children, constitute a large body of current mathematics research.

On the other hand, few studies have been conducted to investigate African children's mathematical understanding. For example, Ginsburg, Posner, and Russell (1981) conducted a study in the Ivory Coast of Africa. Ginsburg and his colleagues (1981) compared illiterate members of the Dioula tribe, in their mathematical understanding, with American children. Sudan, the largest country in Africa, was not included in any of the cross-cultural studies on mathematics. Limited national studies on mathematics, however, have been conducted (e.g., Pollitt, Searl, & El Sheikh, 1987).

The researcher believes that children's early mathematical understanding is largely based on the informal learning the child experiences at home. In that respect the researcher agrees with, for example, Saxe, Guberman, and Gearhart (1987) in their emphasis on the importance of social processes that involve numbers in the development of young children's mathematical understanding. Therefore, the present study was conducted; it is, to the researcher's knowledge, the first study in Sudan to investigate mathematics development in young children before formal mathematics in school.

Explanation of Thesis Format

The alternate thesis format was adopted in the writing of this thesis, which consists of two sections following this general introduction. Section I is a review of literature of the development of mathematical understanding in pre-school children with reference to Sudan. References are
provided following the review. Section II of the thesis consists of a research article. Abstract, introduction, method, results of the study, discussion, conclusions and recommendations, and references are provided. A general summary of the thesis is included followed by a list of references that have been cited in the general introduction and the summary. Finally, appendices are supplemented.
SECTION I. DEVELOPMENT OF MATHEMATICAL THINKING IN
PRE-SCHOOL CHILDREN: LITERATURE REVIEW
LITERATURE REVIEW

Mathematics achievement has been the focus of interest from all groups involved in
education, including parents, educators, and administrators. Studies have been conducted to
investigate many variables related to mathematics achievement and mathematical thinking.
Variables such as sex differences (e.g., Hanna, 1989), and culture (e.g., Song & Ginsburg,
1987; Stevenson, Lee & Stigler, 1986; Stigler, Lee, Lucker & Stevenson, 1982; Ginsburg,
Posner & Russell, 1981) have been studied.

A large body of mathematics studies investigated the development of mathematics
thinking in young children before they start school (e.g., Song & Ginsburg, 1987; Gelman, 1982;
have emphasized the role of social processes and environments that involves numbers and
counting in the enhancement of children's early mathematics development (e.g., Ginsburg &
Russell, 1981; Saxe et al., 1987). The majority of the above studies documented the importance
of activities involving numbers and the important role adults, especially mothers, play in the
development of young children's mathematical understanding.

Informal and Formal Mathematical Thinking

Many theorists (e.g., Thorndike) regarded children as blank slates before starting formal
education (Baroody, 1987). The picture today, however, is quite different; many theorists agree,
for example, that mathematical thinking begins and develops before entering school (e.g.,
Gelman & Gallistel, 1986; Ginsburg, 1986; Baroody, 1987). Mathematical thinking begins early
in children's lives as an informal cognitive activity (Ginsburg, 1989). This informal mathematical
thinking is based largely on counting experiences and serves as a foundation for formal
mathematical thinking that begins with mathematics taught in school (Ginsburg & Baroody,
1990). Before entering school, children develop a beginning understanding of numbers; they
count, construct elementary concepts, and learn to put counting and concepts together to solve
problems (Ginsburg, 1986). These informal mathematical thinking competencies are acquired through various informal ways such as manipulating concrete materials, informal tutoring by adults, siblings and/or peers, imitating adults, and watching educational programs (Ginsburg & Baroody, 1990). Also, children's everyday social activities involving numbers play a great role in developing these mathematical skills (Fusion & Hall, 1983; Saxe et al., 1987). However, Piaget (1952) and Gelman and Gallistel (1986) argue that exposure to a given experience does not guarantee that, in Piagetian terms, it will be assimilated. It is the cognitive structures that guide the organism's tendency to assimilate a given input from the environment (Piaget, 1952; Gelman & Gallistel, 1986). Piaget regarded children's early counting as a result of rote learning that does not reflect the child's mathematical understanding (Piaget, 1952). Moreover, Piaget theorized that not until the concrete operational period of cognitive development, around seven years of age, can the child have any meaningful understanding of numbers (Piaget, 1952). However, Piaget was criticized (e.g., Gelman & Gallistel, 1986; Sophian, 1988) for his characterization of 2-year-old to 7-year-old children in terms of their deficiencies. For example, Sophian (1988) reported that 3- and 4-year-old children have knowledge about one-to-one correspondence, which is the ability to make inferences about two sets of numbers; whereas, Piaget (1952) argued that 3- and 4-year-old children can only perceive the pairings of two sets without the ability to make inferences. Gelman (1982) gave more credit to 3- and 4-year-old children concerning one-to-one correspondence than did Piaget. However, Gelman and Gallistel (1986) argued that pre-schoolers possess basic principles that lead them to learning mathematics. According to their argument, specific tutoring has little role in promoting these principles as children are pre-programmed to abstract these principles from their general exploration of the environment or experiences (Gelman & Gallistel, 1986).

The child by age two or three learns the counting words (e.g., one, two, three) and, as he or she grows older, he or she learns bigger counting numbers and gradually acquires rules
for counting learned counting words such as twenty-one, thirty-nine, and even thirty-ten (Ginsburg & Baroody, 1990). This counting skill is extended to cover calculations. As addition and subtraction of objects are familiar experiences to young children, they learn that when adding one penny to another, the result is two (Baroody, 1987; Ginsburg & Baroody, 1990). Moreover, these basic calculation skills advance to mental calculations as the child learns to add three to one in his or her head without reference to seen objects (Ginsburg & Baroody, 1990). Practice is the cornerstone in elaborating these mental calculations skills (Ginsburg & Baroody, 1990). However, children, and adults for that matter, can engage in informal calculations without being aware of how they do it and without being able to express it in conventional mathematical terminology (Ginsburg & Baroody, 1990).

Many studies support the existence of informal mathematical thinking even in non-schooled populations. For example, Ginsburg et al. (1981) studied in the Ivory Coast of Africa how illiterate members of the Dioula tribe master mathematical skills due to their employment in commerce (Ginsburg et al., 1981). As part of their study, Ginsburg et al. (1981) gave mental addition problems to a sample of 16 unschooled, adult Dioula to solve. The results documented the presence of informal mathematical thinking in the unschooled Dioula.

Formal mathematical thinking, on the other hand, although based on informal mathematical thinking, is learned in formal contexts, that is, the school. School has the goal, according to the Piagetian perspective, of promoting the optimal development of thinking skills appropriate to each level of growth (Thomas, 1985). Ginsburg and Baroody (1990) defined formal mathematical thinking as the extension of informal mathematical thinking which develops by instruction in formal written mathematics with explicit rules, principles, and procedures. In school the child learns to use conventions concerning the reading and writing of numerals like 2 and 5 and on symbols like + and - (Ginsburg & Baroody, 1990). For example, the child knows that 2 and 2 is 4, and 3 times 4 is 12. A third learning occurs from the combination of the above
two. When the child masters them, he or she can then perform written calculations (Ginsburg, 1986). Finally, elementary mathematics involves understanding the concepts and procedures needed to obtain the correct answer for a problem (Ginsburg & Baroody, 1990).

Children's informal mathematical understanding is crucial; informal mathematical concepts and procedures are the foundation of formal knowledge (Ginsburg & Baroody, 1990). Accordingly, any deficits in children's informal mathematical understanding may lead to learning problems with formal mathematics in school. Therefore, parents, especially mothers, need to stimulate their young children's informal mathematical understanding.

Cross-Cultural Studies

In general, cross-cultural studies are beneficial in indicating similarities and differences between different cultures. Similarly, studies of mathematics in different cultures are useful in reflecting the development of children's mathematical understanding in the cultures that are being studied.

As stated previously, many cross-cultural studies of mathematics have been conducted. A large body of these studies has compared the performance of children in Asian countries with those in the United States. For example, studies were conducted to compare informal and formal mathematical thinking such as Song and Ginsburg's study (1987) of the development of informal and formal mathematical thinking in Korean and American children. The sample for the study consisted of a total of 315 Korean and 538 American children, boys and girls, from five age levels: 4-, 5-, 6-, 7-, and 8-year-olds. The children were tested on the Test of Early Mathematical Ability (TEMA), which was constructed by Ginsburg and Baroody in 1983. The results showed that the American children outperformed the Korean children at ages 4 and 5 in informal mathematical thinking. Korean children, however, outperformed the American children at ages 7 and 8 in both informal and formal mathematical thinking.
Stevenson, Stigler, Lee, Lucker, Kitamura, and Hsu (1985) compared the cognitive performance and academic achievement of Japanese, Chinese, and American children. Their study consisted of 240 first- and 240 fifth-grade children in each of the three countries. Ten cognitive tasks and tests of achievement in reading and mathematics were given to children. The researchers found that the high achievement of Chinese and Japanese children compared with American children cannot be attributed to higher intellectual abilities because their results showed no differences in the cognitive functioning of Chinese, Japanese, and American children.

Again, Stigler, Lee, and Stevenson (1987) conducted observations in Chinese, Japanese, and American first- and fifth-grade classrooms to investigate the correlations between classroom structure and management to mathematics achievement. Large cross-cultural differences were found in many variables related to classroom structure and management. Teachers showed consistent differences, in favor of Japanese and Chinese teachers, in the manner in which they asked questions, gave feedback, and the time they devoted to instruction.

Stigler et al. (1982) studied the correlation of curriculum with mathematics performance in elementary school children in Japan, Taiwan, and the United States. The mathematics curricula for elementary schools in the three countries were analyzed by experts. The results indicated that the Japanese curricula contained more concepts and skills and also introduced these concepts and skills earlier than the curricula of Taiwan and the United States. However, the curricula in the United States were somewhat more advanced than in Taiwan. The study also included a construction and administration of mathematics tests to 240 1st-grade and 240 5th-grade children selected from each country. The results documented that Japanese and Chinese children outperformed American children. The researchers concluded that the level of achievement cannot be attributed to curriculum because American curricula were more advanced than in Taiwan; yet children in Taiwan outperformed children in the United States.
Although several international mathematics studies have been conducted (e.g., Hanna's study, 1989, of 20 countries), few studies have been conducted to investigate African mathematics and answer the question "How do Africans count - like us?" (Zaslavsky, 1973, p.6). Ginsburg et al. (1981) compared the Dioula of the Ivory Coast to Americans in their informal and formal mathematics. The American sample consisted of 16 2nd-grade and 16 6th-grade students. The Dioula sample consisted of 16 3rd-grade and 16 6th-grade students. In addition, the study included a sample of unschooled Dioula: 16 adults, 16 9- and 10-year olds, and 16 12- and 13-year olds. Ginsburg et al. (1981) found that Africans' formal mathematical thinking is similar to that of U.S. children. However, informal mathematical thinking is influenced by the experiences offered by a particular environment. In the Dioula case, for example, their employment in commerce enhanced their informal mathematics.

Sudan - the country in Central East Africa with the largest area in all Africa - has not been included in any of the cross-cultural studies on mathematics. Ethnologically, Sudan is composed of several groups. The people of the Northern and Central zones are a mixture of Arabs and Africans. The result of this mixture is that the Northern Sudanese are Negroid in their features but Arabic in their culture (Badri, 1990). The Southern Sudan, however, has remained beyond the reach of Arab influence and is composed of different purely African tribes, each with its own language and customs (Badri, 1990). Tribes sharing characteristics with the Dioula can be found in Southwestern Sudan. Accordingly, Ginsburg et al.'s findings (1981) may be cautiously generalized to this part of Sudan. The Dioula, however, cannot be compared to the Northern part of Sudan; therefore, studies are needed to represent this part of Sudan.

In sum, most of the recent mathematics cross-cultural studies were confined to the Asian countries and the United States. Although few other cross-cultural studies have been conducted (e.g., Ginsburg et al., 1981), the results have not been replicated. Furthermore, researchers who conducted cross-cultural studies thus far did not stress on the social
environment and its role in promoting pre-schoolers' informal mathematical understanding.

Cross-cultural research has had as its primary focus the investigation of formal mathematical understanding, that is, school mathematics.

Factors Influencing Early Mathematical Thinking

Studies of mathematics have outlined major factors that influence the development of formal mathematics. These factors are, for example, intellectual abilities of students (e.g., McGrew & Phel, 1988), and teachers' instruction and classroom structure (e.g., Stigler et al., 1987). On the other hand, the author of this review believes that children's social environments and the social processes in their daily life that involve numbers and counting are the major factors that influence their informal mathematical thinking. Needless to say, intellectual ability is also an important factor in a young child's mathematical understanding.

Intellectual Abilities

It is well established that intellectual ability is a prerequisite for children's mathematics achievement (e.g., McGrew & Phel, 1988). No one, for example, expects a mentally retarded child to reflect a level of mathematical understanding that is comparable to his or her peers.

Badri and Grotberg (1986) conducted a study to investigate the developmental status of Sudanese children in comparison to American norms. The population for their study consisted of 242 children age 5 and a half years and younger, representing both high- and low-income families. The instruments for the study were the Denver Prescreening Developmental Questionnaire, which was adapted for the Sudan (Badri & Grotberg, 1984), and the Goodenough's Draw - A - Man test, which was standardized for the Sudan 25 years ago (Badri & Grotberg, 1986). The findings of the study reflected that the intellectual performance of Sudanese children was below that of American norms. Low-income boys and girls and high-income boys performed less well than high-income girls, who reached American norms.
However, the researchers did not give possible explanations for the superiority of high-income girls. Similar results were reported in a second study (Badri & Grotberg, 1990). The tests of Draw - A - Man and Draw - A - Person were administered to a sample of 120 male children ranging in age from 6 to 9 years. The findings documented that the intellectual level of boys of high socio-economic status (SES) was not considerably higher than that of low-SES boys. Both groups were within the average range of intelligence.

It has been shown that intellectual abilities and mathematics achievement are positively correlated (e.g., McGrew & Phel, 1988). Based on that, and on the studies of Badri and Grotberg (1986), and Badri and Grotberg (1990), one may predict that Sudanese children may perform less well than American children in mathematics. However, the author would argue that the above findings are not conclusive because the reliability and validity of the Draw - A - Man test and Draw - A - Person test for measuring intellectual abilities are questionable. For example, Kellogg (1969) argued that assessment of a child's intelligence by an expert could differ significantly from one drawing to another produced by the same child. In addition, Kellogg (1969) and Cratty (1970) concluded that any assessment of children's intelligence based on their drawings should be carried out after collecting large numbers of drawings from each child, not only one or two drawings. Furthermore, Cratty (1970) stated, concerning the use of Draw - A - Man test for measuring intellectual abilities, "I believe this illustrates the rather tenuous nature of the use of this type of task when evaluating anything but the child's ability to draw the human figure!" (1970, p.159). In addition, the author thinks that Badri and Grotberg (1986) and Badri and Grotberg (1990) used the Draw - A - Man test because it may have been the only instrument for testing intellectual abilities that was standardized and adapted for Sudan.

To conclude, the literature is consistent as far as intellectual abilities and mathematical understanding are concerned. However, research in Sudan does not provide conclusive evidence of the intellectual functioning levels of Sudanese children. Therefore, the author
cannot predict the young Sudanese children's mathematical understanding based on intellectual abilities alone.

**Early Childhood Education**

A large body of evidence, in the United States, indicates that early childhood education has little impact on later academic performance of middle-class children (Zigler, 1987). However, early intervention programs proved to be of extreme benefit to low-income and at-risk children in reducing the rate of placement in special education programs and grade retention, in addition to enhancing elementary school performance (Haskins, 1989). A different point of view can be implied from Stevenson, Lee, Chen, Stigler, Hsu, and Kitamura (1990), who conducted a study in an attempt to understand some of the reasons for the high academic achievement of Chinese and Japanese children in comparison to American children. Their sample consisted of 1440 children from Minneapolis, Taipei, and Sendai, in the United States, Taiwan, and Japan respectively, including 240 1st-graders and 240 5th-graders from each city. Stevenson et al. (1990) found that the length of preschool attendance was not a significant factor in either Minneapolis or Sendai, but it was significant in Taipei. In short, length of pre-school experience did not improve the prediction of academic achievement in Sendai and Minneapolis, where mothers generally had a high school education. However, pre-school experience did improve prediction of academic achievement in Taipei, where the average maternal level of education was lower than in Minneapolis or Sendai (Stevenson et al., 1990). Song and Ginsburg (1987), in contrast, showed that formal mathematical thinking in Korean and American children develops very little between ages 4 and 5 despite attempts of training in some pre-schools. Yet, in the same study the researchers attributed the result that Korean children lag behind U.S. children in the pre-school years in informal mathematics, among other factors, to the facts that "many of the preschools are relatively unstimulating" (1987, p.1294), and that the major objectives of pre-school education in Korea "lie in the learning of appropriate social behavior patterns, not
numbers or letters\textsuperscript{*} (1987, p.1294). To sum up, Stevenson and his colleagues (1990) suggested that early childhood education may play a significant role in enhancing the achievement of children of less-educated mothers.

According to Badri (1990), early childhood education is still struggling to find a place in Sudan's educational system. The Ministry of Education, although accepting the idea of kindergartens since the 1970s, has not required kindergartens in its existing schools. Instead, the Ministry functions as the licensing authority. Accordingly, early childhood education is available to high-income families (Badri, 1990); whereas low-income families have limited choices. This gives a boost to high-income children, while low-income children, who may need early childhood education to function successfully in school, do not get such a boost. Snow (1982) argued that children with lower-SES, among other groups, are in need not only of early childhood education programs, but also special understanding on the part of the schools. In addition, in programs that have shown gains in children's intellectual functioning, Clarke-Stewart and Fein (1983) concluded that the gains were due to program effects, not to parents' effects. Accordingly, the author would indeed consider that early childhood education programs may give the stimulation that lower-SES children need for their overall development.

The literature about early childhood education programs in Sudan, however, lead to questioning the availability of any quality childhood education programs. Therefore, future research needs to examine the impact of early childhood education programs in Sudan that differ in quality on young children's mathematical thinking. Early childhood education may need to play a critical role in working with families to insure that children receive the stimulation they need to construct mathematical understanding.

**Socio-Economic Status of the Family**

Saxe, Guberman, and Gearhart (1987) argued that children's mathematics is influenced by the socio-cultural contexts of their development; thus, the social and
developmental processes interplay in the child's generation of mathematical activities. Saxe and his colleagues argued for the importance of the role that child-adult interaction with number activities plays in the development of the child's mathematical understanding.

In a study of middle- and lower-class mothers, Saxe et al (1987) documented that middle-class mothers were more involved with their children and with a greater range of complexity levels in activities involving numbers than were lower-class mothers with their children. Accordingly, Saxe et al. (1987) found that children of middle-class mothers achieved more advanced performance on tasks involving complex goals than did children of lower-class mothers. Ginsburg and Russell (1981), on the other hand, reported, for the most part, that there were no effects of social class or race on children's mathematical understanding. Moreover, Saxe et al. reported no differences in simple mathematical tasks such as counting words, reading numerals, counting accuracy, and comparisons of number words.

Saxe et al. (1987) argued that their study provided evidence that children's developing competencies are supported in children's everyday social activities involving numbers. In addition, the results reflect that, through instruction, mothers could create contexts in which children would be able to utilize their understanding to achieve more complex goals than they would do alone. In conclusion, Saxe and his colleagues speculated that social experience is critical in any account of cognitive development. In the case of mathematics, children, through adult-guided activities, can generate further understandings that are necessarily linked both to social life and to their constructive efforts.

Saxe et al.'s arguments are in line with the Vygotskian tradition and its emphasis on the zone of proximal development and intellectual scaffolding. The Vygotskians would argue that the zone between the child's unassisted performance and what the child can accomplish with assistance (e.g., scaffolding by an adult) provides the effective learning environment for the child's further development (Bruner, 1985). According to the Vygotskian thinking, "Learning is
interpersonal. It is a dynamic social event that depends upon a minimum of two heads, one better informed or more skilled than the other" (Belmont, 1989, pp. 144-145).

Based on Saxe et al.'s findings (1987), the author predicted that low-SES children in Sudan may lack stimulation from their parents. Grotberg and Badri (1989) reported that high-SES parents answer more questions for their young children and allow more exploratory and manipulative behavior than do low-SES parents. Moreover, low-SES children are less likely to attend early childhood education programs and, therefore, may lack the stimulation that is provided by such programs. Badri and Grotberg (1986) reported that low-income children failed Denver Prescreening Developmental Questionnaire items with greater frequency than did high-income children. These findings are consistent with the results provided by Saxe et al. (1987), that middle-class children performed better in mathematical tasks than did lower-class children. Badri and Grotberg (1986) argued, based on the results of their study, that family social status was a critical indicator of boys' overall development more so than it was for girls' development.

Grotberg and Badri (1986) conducted an experiment as a second phase of their first study. The objectives of the experiment were to change child rearing practices of mothers and to enhance the developmental status of children as a result of early stimulation activities with their mothers. Designed lesson plans were demonstrated for each mother in the treatment group on how to stimulate the development of her child through activities consistent with each child's measured level of development. Compared with post-test performance of the control group on the Denver Prescreening Developmental Questionnaire and on the Draw - A - Man Test, post-tests of the treatment group reflected significant changes from failed items to passed items and from immature to mature drawings appropriate to age. These results were significant across all levels of SES.

Grotberg and Badri's findings (1986) are consistent with Saxe et al.'s argument that the social processes involved in the everyday activities of children play a vital role in their
development. In terms of mathematical development, Grotberg and Badri's conclusions (1986) can also be interpreted in light of Saxe et al.'s conclusion (1981) that mathematical skills could be mastered when children are exposed to environments that are rich in counting experiences. Therefore, parents can enhance their children's mathematical understanding by providing them with mathematical stimulation.

**Child Rearing Patterns**

Based on the above, it is projected that parenting patterns and the rearing practices parents adopt may play a vital role in the development of young children's mathematical understanding. For example, Song and Ginsburg (1987) attributed the low performance of Korean pre-school children in informal mathematics, among other factors, to family patterns and rearing practices. For instance, in the Korean culture it is regarded as immoral for children to count money.

Schaeffer (1987) conducted a longitudinal research to study maternal characteristics during a child's infancy (i.e., maternal child rearing practices, educational beliefs, values, and behavior) that may predict the child's academic competence at school entrance. Schaeffer started the study with a sample of 321 American mothers and their infants, 237 of whom participated in the interviews that were conducted during the children's kindergarten year. Observations were conducted during interviews and during child care situations (e.g., bathing, dressing, and playing). Children's academic competence was assessed from teacher ratings and from school records of grade retention or promotion at the end of kindergarten. Both the observation and interview data documented that maternal democratic beliefs and self-directing values were positively correlated with children's later academic competence and motivation. Authoritarian beliefs and conforming values, on the other hand, were found to correlate negatively with children's achievement.
In Sudan, Badri (1978) conducted a study to investigate child rearing practices in Sudanese families. He examined different aspects of Sudanese rearing practices (e.g., maternal warmth). Badri (1978) interviewed 150 mothers of 5-year-old children. Later, Grotberg and Badri (1989) reported that the rearing practices reported by Badri (1978) reflect the continuing patterns and practices Sudanese parents and families still use to rear their young children. According to Grotberg and Badri (1989), the following seem to describe quite accurately these continuing patterns and practices. In general, parents do not encourage curiosity, exploratory, and manipulative behavior of their young children. However, high-income parents answer more questions from their children than do low-income parents and also permit more exploratory behavior.

Sudanese parents discipline their children strictly and with physical punishment, but low-income parents discipline their children more strictly than do high-income parents. Obedience is the trait most valued in children by parents; children are taught to be polite and submissive to adults. Parents do not tolerate anger outbursts against themselves from a child and punish by hitting or spanking the child. High-income parents praise their children more than do low-income parents, but both use tangible rewards for good behavior. Parents do not like their children to annoy them or to "follow them around." They tell them to go someplace else and be quiet. The only exception to this was for low-income mothers, who enjoyed having their daughters "follow them around." There is a great deal of interaction between parents and children; parents give attention to a child who seeks it. However, children are urged not to "bother" other adults with questions and comments. Children have ample opportunities to interact with other children, especially in the extended family. All parents have high expectations for their young children for educational and professional achievement, regardless of the gender of the child. Parents tend to use the same child rearing practices for boys and girls. The major exception to this was with low-income mothers who like having their daughters "follow them around."
There are many contradictions and conflicting results in the literature related to Sudan. For example, Badri and Grotberg (1986) reported that high-income girls' intellectual abilities are higher than those of low- and high-income boys and low-income girls. Badri and Grotberg argued that the child rearing practices in Sudan as well as the limited opportunities for early stimulation of young children, may account for this difference and, for that matter, for all differences observed. Accordingly, one would expect that high-income girls were reared differently. Yet, subsequent results provided by Grotberg and Badri (1989) indicate no differences; the only difference reported was concerning low-income girls, who spent more time with their mothers. One possible explanation one could offer is that using the Draw - A - Man test, as mentioned elsewhere, is not a reliable or valid instrument for measuring intelligence.

The author maintains that the social environment and social processes in the everyday life of children enhance their mathematical abilities. The author agrees with many researchers (e.g., Fuson & Hall, 1983; Saxe et al., 1987) and disagrees with Gelman and Gallistel (1986) and their theory that inborn structure in the brain leads to the acquisition of mathematics without the input of the environment. Accordingly, child rearing practices may have a vital role in promoting children's mathematical thinking, especially informal mathematical thinking before entering school. However, one cannot deny that the child's learning depends both on his or her present understanding and on interaction with his or her environment, including parents.

Although the available literature about Sudan is somewhat contradictory concerning some findings, the net result indicates that both high- and low-income parents seem to be more authoritarian than American parents. Levine (1970) suggested that early training in obedience adversely affects intellectual development, especially in the ability to solve problems. Accordingly, one would speculate that the rearing practices of Sudanese parents would adversely affect their children's mathematical thinking.
**Sex Differences**

Recent research seems to diminish sex differences between boys and girls in mathematics achievement, except in high school mathematics (e.g., Feingold, 1988). This was documented by Hanna (1989), who examined sex differences in mathematics achievement of girls and boys in grade 8 from a cross-cultural perspective using the data of the Second International Mathematics Study. Hanna (1989) concluded that differences among countries were greater than sex differences. The same findings were reported among four-, five-, six-, seven-, and eight-year-old Korean and American children (Song & Ginsburg, 1987), and among first- and fifth-grade Chinese, Japanese, and American children (Stevenson et al., 1990).

In Sudan, Pollitt et al. (1987) found that the introduction of the new program of mathematics, with its emphasis on both conceptual and procedural knowledge, enabled girls to perform better in mathematics than before. The results of the evaluation test, which was given after a period of experimentation with the new program, indicated a substantial improvement among girls' achievement in mathematics. Pollitt et al. (1987) attributed this finding to the fact that girls feel too shy to ask questions in the classroom and to display their lack of understanding to their fellow students. They are, however, capable of sustained personal effort and perseverance (Pollitt et al., 1987). In the traditional program students were encouraged to learn by rote (Pollitt et al., 1987). In contrast, the modern program, with its emphasis on understanding both concepts and procedures, gave a basis from which it was possible for girls to learn by themselves in addition to what they could understand in the classroom (Pollitt et al., 1987).

However, the notion that girls in general perform less well in math than do boys seems to contradict Badri and Grotberg's finding (1986) that high-income girls were the most intelligent among all other groups. The different methods that were used in both studies, however, may
account for the conflicting results. In Badri and Grotberg's study (1986), the instrument was the Draw-A-Man test, while Pollitt et al.'s notion was based on classroom ratings.
CONCLUSION

The literature presented in this review about Sudan does not reflect the processes involved in early mathematics learning and teaching in Sudanese families. Given the efforts, however, of Badri (1978), Badri and Grotberg (1986), Grotberg and Badri (1986), Grotberg and Badri (1989), and Badri and Grotberg (1990) involving Sudanese child rearing practices and the developmental levels of young Sudanese children, one may predict that the Sudanese familial practices do not enhance the development of young children's mathematical understanding. Based on Saxe et al.'s conclusion (1987) concerning the importance of social processes involving numbers in the development of early mathematical skills, for example, one would expect the authoritarian way of Sudanese parents to affect adversely the development of children's mathematical understanding.

However, the literature is full of contradictory results. In addition, early mathematics development in young Sudanese children is an untouched field. Therefore, empirical research is called for to address the issue of social processes in Sudanese families, if any, that enhance or hinder the development of mathematical understanding in young children. For instance, are numbers and counting familiar experiences in the everyday activities of the Sudanese young child? What is the role of Sudanese mothers in enhancing the development of their young children's mathematical understanding? What is involved in early mathematics teaching and learning in Sudanese families? Future research in Sudan needs to answer these questions.
REFERENCES


SECTION II. EARLY MATHEMATICS TEACHING AND LEARNING IN SUDANESE FAMILIES
ABSTRACT

The present study investigated the roles of Sudanese mothers and early childhood education experiences in the development of young children's mathematical understanding. The sample of the study consisted of 80 mother-child dyads. The Test of Early Mathematics Ability-Second Edition (TEMA-2) was used to assess children's mathematical understanding. Interviews were conducted to investigate mothers' perception of the daily mathematical activities of their children at home. Mothers with more education reported that they provided more stimulation of their children's mathematical development than did mothers with less education. Children of mothers who provided more mathematical stimulation performed better on the test than did children of mothers who provided less mathematical stimulation. Results of the study did not support the prediction that children with early childhood education experiences would reflect a more mathematical understanding than would children without early childhood education experiences. Conclusions, implications, and recommended future studies are included.
INTRODUCTION

Many theorists agree that mathematical thinking begins and develops before entering school (e.g., Gelman & Gallistel, 1986; Ginsburg, 1986; Baroody, 1987). This informal mathematical thinking serves as a foundation for formal mathematical thinking that begins with mathematics that is taught in school (Ginsburg, 1986). Before entering school, children develop a beginning understanding of numbers; they count, construct elementary concepts, and learn to put counting and concepts together to solve problems (Ginsburg, 1986). These informal mathematical thinking competences are acquired through various informal ways such as manipulating concrete materials, informal tutoring by adults, siblings and/or peers, imitating adults, and watching educational programs (Ginsburg & Baroody, 1990). Also, children's everyday social activities involving numbers play a great role in developing these mathematical skills (Saxe, Guberman & Gearhart, 1987).

However, Piaget (1952) and Gelman and Gallistel (1986) argue that exposure to a given experience does not guarantee that, in Piagetian terms, it will be assimilated. It is the cognitive structures that guide the organism's tendency to assimilate a given input from the environment (Piaget, 1952; Gelman & Gallistel, 1986). Piaget regarded children's early counting as a result of rote learning that does not reflect the child's mathematics understanding (Piaget, 1952). Moreover, Piaget theorized that not until the concrete operational period of cognitive development, around seven years of age, can the child have any meaningful understanding of number (Piaget, 1952). However, Piaget was criticized (e.g., Gelman & Gallistel, 1986; Sophian, 1988) for his characterization of 2-year-old to 7-year-old children in terms of their deficiencies. For example, Sophian (1988) reported that 3- and 4-year-old children have knowledge about one-to-one correspondence, which is the ability to make inferences about two sets of numbers; whereas Piaget (1952) argued that 3- and 4-year-old children can only perceive the pairings of two sets without the ability to make inferences. Gelman (1982) gave more credit to 3- and 4-year-old children concerning one-to-one correspondence than did Piaget. However, Gelman and
Gallistel (1986) argued that pre-schoolers possess basic principles that lead them to learning mathematics. According to their argument, specific tutoring has little role in promoting these principles as children are pre-programmed to abstract these principles from their general exploration of the environment or experiences (Gelman & Gallistel, 1986).

The child by age two or three learns the counting words (e.g., one, two, three) and, as he or she grows older, he or she learns bigger counting numbers and gradually acquires rules for counting learned counting words such as twenty-one, thirty-nine, and even thirty-ten (Ginsburg & Baroody, 1990). This counting skill is extended to cover calculations. As addition and subtraction of objects are familiar experiences to young children, they learn that when adding one penny to another, the result is two (Baroody, 1987; Ginsburg & Baroody, 1990). Moreover, these basic calculation skills advance to mental calculations as the child learns to add three to one in his or her head without reference to seen objects (Ginsburg & Baroody, 1990). Practice is the cornerstone in elaborating these mental calculations skills (Ginsburg & Baroody, 1990). However, children, and adults for that matter, can engage in informal calculations without being aware of how they do it and without being able to express it in conventional mathematical terminology (Ginsburg & Baroody, 1990).

Many studies support the existence of informal mathematical thinking even in non-schooled populations. For example, Ginsburg, Posner, and Russell (1981) found, in the Ivory Coast of Africa, that illiterate members of the Dioula tribe master mathematical skills due to their employment in commerce. As part of their study, Ginsburg et al. gave mental addition problems to a sample of 16 unschooled, adult Dioula to solve. The results documented the presence of informal mathematical thinking.

Formal symbolic mathematical thinking, on the other hand, although based on informal mathematical thinking, is learned in formal contexts, that is, the school. School has the goal of, according to the Piagetian perspective, promoting the optimal development of thinking skills
appropriate to each level of growth (Thomas, 1985). Ginsburg and Baroody (1990) defined
formal mathematical thinking as the extension of informal mathematical thinking, which develops
by instruction in formal written mathematics with explicit rules, principles, and procedures. In
school the child learns to use conventions concerning the reading and writing of numerals like 2
and 5 and on symbols like + and - (Ginsburg & Baroody, 1990). For example, the child knows
that 2 and 2 is 4, and 3 times 4 is 12. A third learning occurs from the combination of the above
two. When the child masters them, he or she can then perform written calculations (Ginsburg,
1986). Finally, elementary mathematics involves understanding the concepts and procedures
needed to obtain the correct answer for a problem (Ginsburg & Baroody, 1990).

**Socio-Economic Status of the Family**

Saxe, Guberman, and Gearhart (1987) argued that children's mathematics is influenced by
the socio-cultural contexts of their development; thus, the social and developmental processes
interplay in the child's generation of mathematical activities. Saxe et al. argued for the importance of
the role of child-adult interaction with number activities in the development of the child's mathematics
understanding. In a study of middle- and lower-class mothers, Saxe et al (1987) documented that
middle-class mothers were more involved with their children and with a greater range of complexity
levels than were lower-class mothers with their children in activities involving numbers. Accordingly,
Saxe et al. (1987) found that children of middle-class mothers achieved more advanced
performance on tasks involving complex goals than did children of lower-class mothers. Saxe et al.
argued that their study provided evidence that children's developing competences are supported in
children's everyday social activities involving numbers. In addition, they argued that, through
instruction, mothers could create contexts in which children would be able to utilize their
understanding to achieve more complex goals than they would do alone. Saxe et al.'s arguments
are in line with the Vygotskian tradition in its emphasis on the zone of proximal development and
intellectual scaffolding. The Vygotskians would argue that the zone between the child's unassisted
performance and what the child can accomplish with assistance (e.g., scaffolding by an adult) provides the effective learning environment for the child's further development (Bruner, 1985).

With respect to Sudan, Badri and Grotberg (1986) reported that low-income children failed Denver Prescreening Developmental Questionnaire items with greater frequency than did high-income children. In addition, Grotberg and Badri (1989) reported that high-SES parents answer more questions for their young children and allow more exploratory and manipulative behavior than do low-SES parents. These findings are consistent with the results provided by Saxe et al. (1987) that middle-class children performed better in mathematical tasks than did lower-class children. Badri and Grotberg (1986) argued, based on the results of their study, that family social status was a more critical indicator of boys' overall development than it was for girls' development.

Grotberg and Badri (1986) conducted an experiment as a second phase of their first study. The objectives of the experiment were to change child rearing practices of mothers and to enhance the developmental status of children as a result of early stimulation activities with their mothers. Designed lesson plans were demonstrated for each mother in the treatment group on how to stimulate the development of her child through activities consistent with each child's measured level of development. Compared with post-test performance of the control group on the Denver Prescreening Developmental Questionnaire and the Draw - A - Man Test, post-tests of the treatment group reflected significant changes from failed items to passed items and from immature to mature drawings appropriate to age. These results were significant across all levels of SES. Again, Grotberg and Badri's findings (1986) are also consistent with Saxe et al.'s argument that the social processes involved in the everyday activities of children play a vital role in their development. In terms of mathematics development, Grotberg and Badri's conclusions (1986) can be interpreted in light of Saxe et al.'s conclusion (1981) that mathematical skills could be mastered when children are exposed to environments that are rich
in counting experiences. Therefore, parents can enhance their children's mathematical understanding by providing them with mathematical stimulation.

**Early Childhood Education**

A large body of evidence, in the United States, indicates that early childhood education has little impact on later academic performance of middle-class children (Zigler, 1987). However, early intervention programs proved to be of extreme benefit to low-income and at-risk children in reducing the rate of placement in special education programs and grade retention, in addition to enhancing elementary school performance (Haskins, 1989). Song and Ginsburg (1987) showed that formal mathematical thinking in Korean and American children develops very little between ages 4 and 5 despite attempts of training in some pre-schools. Yet, in the same study the researchers attributed the results that Korean children lag behind U.S. children in the pre-school years in informal mathematics, among other factors, to the facts that "many of the preschools are relatively unstimulating" (1987, p.1294), and the major objectives of pre-school education in Korea "lie in the learning of appropriate social behavior patterns, not numbers or letters" (1987, p.1294). Stevenson, Lee, Chen, Stigler, Hsu, and Kitamura (1990), in contrast, conducted a study in an attempt to understand some of the reasons for the high academic achievement of Chinese and Japanese children in comparison to American children. Length of preschool experience did not improve the prediction of academic achievement in Sendai and Minneapolis, where mothers generally had at least a high school education. However, pre-school experience did improve prediction of academic achievement in Taipei, where the average maternal level of education was lower than in Minneapolis or Sendai (Stevenson et al., 1990).

**Child Rearing Patterns**

Previous research has suggested that Sudanese parents do not encourage curiosity, exploratory and manipulative behavior among their young children; however high-income parents answer more questions from their children than do low-income parents and also permit more
exploratory behavior (Badri, 1978; Grotberg & Badri, 1989). In interviews, Sudanese parents reported that they did not like their children to annoy them or "follow them around" (Grotberg & Badri, 1989). According to Grotberg and Badri (1989), Sudanese parents tell their children to go someplace else and be quiet. However, there is a great deal of interaction between parents and children; parents give attention to a child who seeks it (Grotberg & Badri, 1989).

The researcher maintains that the social environment and social processes in the everyday life of children enhance mathematical abilities. The researcher agrees with many researchers (e.g., Fuson & Hall, 1983; Saxe et al., 1987), and disagrees with Gelman and Gallistel (1986) and their theory that inborn structure in the brain leads to the acquisition of mathematics without the input of the environment. Accordingly, child rearing practices may have a vital role in promoting children's mathematical thinking, especially informal mathematical thinking before entering school. However, one cannot deny that the child's learning depends both on his or her present understanding and on interaction with his or her environment, including parents.

The Present Study

Based on the above literature, the first objective of the present study was to investigate the social processes that are involved in the learning and teaching of early mathematics in Sudanese families. The researcher wanted to investigate the roles of Sudanese mothers in the development of young children's mathematical understanding. The second objective of the study was to investigate the impact of early childhood education on children's mathematical understanding. The researcher predicted the following: 1) Mothers with more education will provide more stimulation of their children's mathematics development than will mothers with less education, 2) children of mothers who provide more mathematical stimulation will earn higher scores in the Test of Early Mathematical Ability-2 (TEMA-2) than will children of mothers who provide less stimulation, and 3) children attending early childhood programs will do better in TEMA-2 than will children who are not attending such programs.
METHOD

Subjects

Subjects in the present study were 80 mothers and their children, who ranged in age from 48 to 69 months of age (M = 56; SD = 6.02). The subjects were from intact homes. Equal numbers of boys and girls and equal numbers of children with and without early childhood education experiences were included. Maternal education ranged from primary schooling (e.g., four years of formal education) to post-graduate.

The subjects were recruited from the three towns that constitute the capital of Sudan: Khartoum, Khartoum North, and Omdurman. Three different neighborhoods from each town were selected for the study. Hai Al-Zehour, Al-Amarat, and Al-Sahafa were selected from Khartoum. Helat Hamad, Al-Safia, and Shambat were selected from Khartoum North. Al-Moulazmeen, Ombada, and Bait Al-Mal were selected from Omdurman. Those neighborhoods represent different socio-economic classes. The subjects were recruited through door-to-door contact. This method of recruitment was adopted for the study for two reasons. First, the informal way of the Sudanese lifestyle made door-to-door recruitment feasible. Second, Sudan lacks public records that are easily available or adequately compiled; therefore, door-to-door recruitment was the only way to recruit subjects for the study.

Recruitment of mother-child dyads was stratified by sex of the child, early childhood education experience of the child, and education of the mother. There were 8 cells with 10 mother-child dyads in each. Around 100 mother-child dyads were contacted; only 80 were selected to fill the cells. Once a cell was filled, recruitment went on to the next cells. Secondary education or less, and post-secondary education were the two levels of maternal education used during recruitment. For the purpose of statistical analyses, however, four levels of maternal education were used: Level 1, intermediate school or below; Level 2, secondary school; Level 3, partial college or specialized training; and Level 4, college degree or graduate training.
Approval for conducting the study was obtained from the Human Subjects Committee at Iowa State University (see Appendix A). Consent for the participation of children and mothers in the study was obtained verbally from mothers prior to any assessment or interview.

**Instruments**

The Test of Early Mathematics Ability-Second Edition (TEMA-2) was used for the study (see Appendix B). Ginsburg and Baroody introduced the first and second editions of TEMA in 1983 and 1990, respectively. The items in TEMA-2 were derived from items originally employed in previous research (e.g., Ginsburg & Russell, 1981). The TEMA-2 consists of 65 questions that measure the understanding of informal mathematics (n = 35) and formal mathematics (n = 30). To assess the child's understanding of informal mathematics, items measuring concepts of relative magnitude, counting, and calculation are included. Four kinds of items are included in TEMA-2 to assess the child's competence in formal mathematics: knowledge of convention, number facts, calculation, and base-ten concepts.

TEMA-2 was translated into Arabic for the Sudanese children by the researcher, whose first language is Arabic. In order to make some of the items understandable to children, the researcher had to modify some items in minor ways without changing the basic objective of each item. For example, item 14 of TEMA-2 states "JOEY HAS ONE PENNY ... ;" the researcher switched "JOEY" with a common Sudanese name. Item 34 states "NOW I WANT YOU TO COUNT BACKWARDS, LIKE WHEN A ROCKET BLASTS OFF ... ." Feedback from local experts on Sudanese culture indicated that children were not expected to be familiar with the phrase "LIKE WHEN A ROCKET BLASTS OFF," therefore, the researcher eliminated this phrase.

In order to assess the adequacy of translation and acceptability for the Sudanese children, the Arabic version of TEMA-2 was evaluated by local experts at Ahfad University for Women, and pilot testing was conducted to six children. Internal consistency of the adapted TEMA-2 was verified
using Cronbach's alpha ($r = .93$). Raw scores of TEMA-2 were used for statistical analyses in the study; children's scores ranged from 3 to 34 ($M = 17.39, SD = 7.74$).

To investigate the mother's perception of the daily mathematical activities of her child at home and her role in promoting the child's mathematical understanding, a Maternal Math Stimulation Interview (MMSI) was developed by the researcher (see Appendix C). Part 1 of the MMSI opened with demographic questions about the family from which social status was computed using the Hollingshead four-factor index of social status (Hollingshead, 1975). Hollingshead based social status on four factors: occupation, education, marital status, and sex of the parent. Occupation was graded on a 9-point scale and education was graded on a 7-point scale. The 12-point education scale that was used during data collection for the present study was converted to that of Hollingshead (see appendix D). The researcher and a fellow Sudanese researcher classified the different occupations of the Sudanese mothers and fathers in the sample according to the Hollingshead's 9-point scale of occupation.

According to Hollingshead, the social status of an individual can be calculated by adding the result from multiplying the scale value for occupation by a weight of five to the result from multiplying the scale value for education by a weight of three. If the father and mother were both gainfully employed, the social status of the family would be the average of the social status of both father and mother. However, in the present study the researcher used the father's social status to reflect the social status of the family. In Sudan, the social status of a family is assessed by the social status of the father regardless of the educational level or occupational status of the mother. For example, Badri (1978) stated that the level of education of the father is a viable index for classifying urban populations in Sudan into middle- and lower-socio-economic classes.

Part 2 of the MMSI consisted of a series of 12 questions to assess maternal math stimulation; questions were derived from interview questions used by Saxe et al. (1987). The researcher, who is a citizen of Sudan, modified the questions to suit the Sudanese culture. Piloting
was conducted before data collection. A scale was constructed for scoring data from Part 2 of the MMSI (see Appendix C). Scores were summed across the items of Part 2 to produce a total score reflecting maternal stimulation of young children's mathematical development. Possible scores range from 7 to 49; actual scores ranged from 7 to 43 ($M = 22.43$, $SD = .97$). Percentage agreement on scoring the MMSI was checked. Initially, inter-rater agreement on the items ranged from 80% to 100%. After resolving disagreements with discussion, final inter-rater agreement reached 100%. Internal consistency of the scale was verified using Cronbach's alpha ($\alpha = .72$). Dropping the item regarding the use of Sudanese mothers of invented games from the scale would have increased the internal consistency of the scale ($\alpha = .77$). Nevertheless, the researcher maintained this item for face validity reasons; the positive response to it by the mothers was very high, reflecting the cultural value of using invented games in stimulating children.

**Procedure**

All the interviews for mother-child dyads were conducted by the researcher. The child assessment and mother interview were both completed in one home visit, during which the researcher assessed the child's understanding of mathematics first and interviewed the mother second. The child assessment was conducted in a separate room without the attendance of other family members. Mothers were asked, however, to remain in the room for the first few minutes while the researcher became acquainted with the child. If the child showed signs of discomfort, the mother was then asked to remain for the whole time the assessment was conducted. However, the mother was strictly encouraged not to intervene in the assessment process. Six of the mother-child dyads selected for the study were replaced because children were either unable or unwilling to concentrate despite repeated attempts on the part of the researcher.

The researcher assessed children's understanding of mathematics individually following the instructions for administering the assessment and the instructions for each item as described in the TEMA-2 manual (see Appendix B). The average time for the child assessment was 25 minutes. In
interviewing mothers, the researcher relied heavily on probe questions to avoid social desirability responses from the mothers. The researcher narrowed down the mother's response by asking more related questions. The following is an example of this process:

Researcher: How frequently does your child play with this game?
Mother: Often.
Researcher: How often? Around once or twice a week.
Mother: More than that - almost everyday.
Researcher: Around four or five times a week.
Mother: Yes.

The researcher used the above pattern to match mother's response to the choices of each item. Both the mother and the researcher would agree on the most representative choice of the mother's response. The average time for mother interview was 20 minutes.
RESULTS

Maternal Education and Early Childhood Education Experience

The first objective of the present study was to investigate the roles of Sudanese mothers in the development of young children’s mathematical understanding. The researcher predicted that mothers with more education would provide more stimulation of their children’s mathematical understanding than would mothers with less education. The second objective of the present study was to investigate the impact of early childhood education on children’s mathematics development. The researcher predicted that children attending early childhood programs will gain higher scores in TEMA-2 than will children who are not attending such programs.

To test for the above two predictions, a 4 (maternal education) x 2 (early childhood education) multivariate analysis of variance (MANOVA) was used with the MMSI and TEMA-2 scores as dependent variables. Significant effects of maternal education on MMSI and TEMA-2 scores were found [F(3, 72) = 5.85; p < .001 and F(3, 72) = 3.55; p < .02, respectively]. Contrary to the researcher's prediction, no significant effects of early childhood education were found on children's TEMA-2 scores (p < .24). Table 1 reflects the means and standard deviations of TEMA-2 scores as a function of early childhood education experiences and maternal education.

Insert Table 1 about here

Scheffe's multiple-range tests for post-hoc analyses revealed certain significant differences in MMSI scores. Mothers who completed secondary school (Level 2) provided more stimulation of their children's mathematics than did Level 1 mothers, who had completed intermediate school or less, [t(72) = 2.15, p < .03]. Also, mothers with college degrees or above (Level 4) provided more stimulation than did mothers who had completed intermediate school or less (Level 1), and mothers with partial college education and specialized training (Level 3) [t(72) = 3.94, p < .0001 and t(72) = 3.94, p < .0001]
3.39, \( p < .001 \), respectively]. Furthermore, Scheffe's comparison analyses for the effects of the four levels of maternal education on children's scores on TEMA-2 revealed other significant differences. Children of mothers with college education and above (Level 4) scored higher than children of mothers who had completed intermediate school or less (Level 1) \([t(72) = 2.87, p < .005]\). Again, children of Level 4 mothers, who had completed college or had graduate training did better in TEMA-2 than did children of Level 3 mothers, who were enrolled in college, had completed partial college, or had specialized training, \([t(72) = 2.74, p < .008]\). Table 2 shows these post-hoc analyses. The results document, for the most part, that mothers with more education provided more stimulation of their children's mathematical understanding than did mothers with less education.

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Insert Table 2 about here

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Table 3 reflects the means and standard deviations of MMSI and TEMA-2 scores for the four levels of maternal education. The results show that mothers in Level 3 provided less stimulation, and their children demonstrated lower levels of mathematical understanding, than did mothers with less and mothers with more education. Indeed, the scores of these mothers and their children approximated that of mothers with only a primary education. However, the results of the study document the researcher's prediction that maternal education is positively correlated with children's mathematics achievement \((r = .25, p < .01)\).

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Insert Table 3 about here

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In the next series of analyses the researcher tried to identify factors that might be related to the lower than expected performance of mothers in the third level of education in stimulating their children's mathematics. One possible explanation for the lower levels of stimulation provided by the
mothers enrolled in college in the present sample is that they paid more attention to their studies and, therefore, provided less stimulation to their children. However, when mothers enrolled in college were eliminated from the third level maternal education, the means and standard deviations of the remaining mothers and children were still significantly lower than mothers in Level 2 and mothers in Level 4 in both the MMSI and TEMA-2 scores. When enrolled mothers were removed from the analyses, no significant mean differences were detected in MMSI and TEMA-2 scores \( t(17) = .30, p = .77; \) and \( t(17) = .11, p = .92, \) respectively. Table 4 reflects these means and standard deviations.

Another possible explanation was that the family's social status might explain the observed results. The means and standard deviations of family status for the four levels of maternal education are shown in Table 5. The results did not show a significantly lower family social status of mothers in Level 3 compared to Level 2 mothers \( t(38) = 1.46, p = .15 \). However, the results reflected a significantly lower family status of Level 3 mothers compared to Level 4 mothers \( t(38) = 6.69, p < .0001 \).

Maternal Stimulation

The third objective of the study was to investigate the impact of maternal mathematical stimulation on children's mathematics achievement. Pearson product correlations showed that scores on the MMSI were positively related to TEMA-2 scores \( r = .65, p < .001 \), as well as to maternal education \( r = .34, p < .01 \). As predicted, children of mothers who provide more
mathematical stimulation earned higher scores on the TEMA-2 than did children of mothers who provided less mathematical stimulation.

**Maternal Employment**

Although there was a trend towards a positive correlation between children's scores on the TEMA-2 and employment \( (p = .08) \), maternal employment and maternal education were highly correlated \( (r = .53, \ p < .01) \). Using a 2 x 2 Chi-Square documented the significant relationship between employment and maternal education \[ \chi^2 (1, N = 80) = 24.36; \ p < .0001 \]. At three of the four levels of maternal education, 67% of the mothers were not employed outside the home; however, at the highest level of maternal education, 67% of the mothers were so employed. Also, a Pearson correlation coefficient reflected a positive correlation between maternal education and maternal employment \( (r = .53; \ p < .01) \). Therefore, it is not possible to separate the impact of maternal education from employment on maternal stimulation or on children's mathematical understanding.

**Family Social Status**

Family social status was positively correlated with maternal stimulation \( (r = .46, \ p < .01) \), and with children's scores on TEMA-2 \( (r = .25, \ p < .01) \). Multiple regression was used to measure the total amount of variance accounted for by the mother's stimulation on children's scores on TEMA-2 after removing the variance accounted for by family social status. The results of the regression analysis and standardized betas demonstrated a strongly positive correlation between mother's stimulation and children's scores on TEMA-2 after removing the variance accounted for by family social status \( (r = .63, \ p < .001) \). The standardized beta weights for family status and mother's stimulation were -.06, and .68, respectively.

**Sex and Age of Child**

To test for the effects of sex and age of child on mother stimulation and TEMA-2 scores, a 2 (age of child) x 2 (sex of child) analysis of variance (ANOVA) was used with the MMSI and TEMA-2
scores as dependent variables. The results reflected significant effects of age of child on MMSI and TEMA-2 scores [\( F (1,76) = 6.64; p < .01 \) and \( F (1,76) = 90.79; p < .001 \), respectively]. Five-year-old children received more stimulation from their mothers and achieved higher scores in TEMA-2 than did 4-year-old children. However, no significant effects of sex were found on MMSI and TEMA-2 scores (\( p = .51 \) and \( p = .28 \), respectively).

**Comparison of TEMA-2 Scores of American and Sudanese Children**

Comparisons were made of Sudanese children to American children in their performance in TEMA-2. The medians of 4- and 5-year-old children in the American standardization sample to the median of Sudanese children were compared. Due to the large differences in sample sizes, the researcher could only obtain rough estimate; the standardization sample consisted of 896 children from a total of 27 American states, whereas the sample of the study consisted of 80 Sudanese children. The median scores of children ranging from 4 years to 4 years and 5 months were 10 for both the American standardized sample and the Sudanese sample. The median scores for children ranging from 4 years and 6 months to 4 years and 11 months were 17 and 18 for the standardized sample and the sample of the study, respectively. The median scores for children ranging in age from 5 years to 5 years and 5 months were 24 and 23, respectively, for the American and Sudanese samples. Finally, the median scores for children ranging from 5 years and 6 months to 5 years and 11 months were 27 and 28 for the American and Sudanese samples, respectively.
DISCUSSION

Maternal Education

The first objective of the study was to examine the role Sudanese mothers play in the development of their young children's mathematical understanding. The results documented, for the most part, the prediction that mothers with more education would provide more stimulation of their children's mathematics development than would mothers with less education. However, the findings present an unexpected picture of mothers in the third level of education, those with some post-secondary education. These mothers did not report providing as much stimulation to their children as did the mothers who had completed secondary education but not pursued post-secondary training. Level 3 mothers provided less stimulation to their children's mathematics than did mothers with less and those with more education. Indeed, the scores of these mothers and their children approximated that of mothers with only a primary- or intermediate-level education.

In an effort to explain the discrepancies in the results, the researcher suggests that one possible explanation may be that mothers enrolled in college paid more attention to their studies and, therefore, provided less stimulation to their children. The statistical analyses conducted after eliminating college mothers, who composed 25% of mothers with some post-secondary education, from the sample, did not give support to the prediction that enrollment in college is the reason why mothers did not provide enough stimulation to their children. The results reflected that the performance of mothers with some post-secondary education (e.g., partial college), without those mothers who were enrolled in college, was not significantly higher than when college-enrolled mothers were included. Also, children of mothers enrolled in college demonstrated nonsignificantly lower mathematics achievement levels than did children of mothers with post-secondary training but not enrolled in college. Accordingly, the researcher suspects that enrollment in college, among other factors, may contribute to the lower levels of mathematics stimulation from mothers. Another possible explanation that can be offered for the observed results is that mothers in the third level of
education were from families of lower social status than the rest of mothers in the sample. Saxe et al. (1987) reported that middle-class mothers were more involved in mathematical activities and were more stimulating to their children than were lower-class mothers. The results of the present study support Saxe et al.'s findings: family social status was positively correlated with maternal stimulation ($r = .46, p < .01$) and children's achievement in mathematics ($r = .25, p < .01$).

Therefore, the researcher assumed that mothers of lower family social status would not give as much stimulation to their children as would mothers of higher family social status. The analyses documented that mothers in the third level of education were not from families with significantly lower family social status than were mothers with only secondary education. Yet, the latter mothers provided more stimulation of their children's mathematical understanding than did the mothers with some post-secondary training. However, the analyses indicated that mothers with college degrees or beyond were from families of significantly higher social status than were mothers with only some post-secondary education.

In the present study it was not possible to separate the impact of maternal education from employment on maternal stimulation or on children's mathematical understanding. The results reflected a high positive correlation between maternal education and maternal employment. However, it would be fair to say that maternal employment was not responsible for the results concerning the third level of maternal education. Most mothers in the highest level of education in the sample were employed; however, they provided the highest levels of stimulation, among all mothers, to their children who, in turn, reflected high levels of mathematical understanding.

In sum, none of the explanations above seems to throw the light on the reasons behind the lower levels of stimulation provided by mothers with some post-secondary education but without standard college degrees. One is still puzzled as to why such mothers failed to provide stimulation to their young children despite their advanced educational levels. Motivational or cohort factors may have contributed to the results. Future research will need to examine the impact of post-secondary
training on maternal stimulation of children's mathematics development, as well as on their children's mathematical understanding.

**Early Childhood Education Experience**

The second objective of the study was to examine the impact of early childhood education on the development of children's mathematical understanding. The researcher found, contrary to her prediction, that the children's enrollment in early childhood education programs was not correlated with their levels of mathematical understanding. Children without early childhood education experiences demonstrated no deficits in their mathematical understanding, compared to those with early childhood education experiences. Results of the present study are in line with earlier findings in the United States for the impact of early childhood education: early childhood education has little impact on children's later academic performance (Zigler, 1987; & Haskins, 1989). The results, however, contradict Stevenson et al.'s findings (1990) that pre-school experience improved prediction of children's academic achievement in Taipei, Taiwan, where the average level of maternal education was low. However, in this study early childhood education was considered as an all-or-none trait without focusing on the quality or quantity of early childhood programs.

On the other hand, the findings may be attributed, according to Badri (1990), to the fact that early childhood education is still struggling to find a place in Sudan's educational system. The Ministry of Education, although accepting the idea of pre-schools since the 1970s, has not required pre-schools in its existing schools (Badri, 1990). Instead, the ministry functions as the licensing authority leaving all major decisions to the directors of pre-schools who may not be aware of the elements of good programs. Early childhood education in Sudan is not classified into pre-school, day-care, and kindergarten as the case in the United States, for example. Instead, the word "Kindergarten," according to the Sudanese educational dictionary, refers to any type of early childhood program, before first grade, whether it is a pre-school, a day-care, or a kindergarten. Furthermore, early childhood education programs are, and by large, financed basically by parents'
fees. As evidence of the marginal status early childhood education occupies in the Sudan's educational system, there is only one institution in Sudan that is addressing early childhood education issues (i.e., Ahfad University for Women). In addition, at present there are only three Sudanese child development specialists with post-graduate degrees in early childhood education. Based on this background, it would not be logical to suspect the availability of any quality childhood education programs in Sudan. Future research, however, needs to examine the impact of early childhood education programs in Sudan that differ in quality on children's mathematical understanding.

**Maternal Stimulation**

The third, and the major, objective of the study was to determine the impact of maternal stimulation on children's mathematical understanding. The results supported the prediction that children of mothers who provided more mathematical stimulation reflected higher levels of mathematical understanding than did children of mothers who did not provide as much stimulation. The mothers interviewed reported that they used invented mathematics games that involve songs, counting, and motor activities, mainly fingers and hands. Stimulating the child through invented games was common among the majority of Sudanese mothers at all levels of maternal education. In addition to that, highly educated mothers used store-bought games and number books, and used them more frequently than did mothers with less education.

Controlling for family status, maternal stimulation still accounted for 40% of the variance in children's mathematics performance. In contrast, maternal education accounted for only 6% of the variance. The researcher, as a child development specialist, considers this result very promising as it suggests that there is room for intervention. Implications for parent education could be based on the results of the study. Again, the fact that mother's stimulation accounted for children's mathematical understanding more so than did family social status strengthens the researcher's argument that, through intervention and parent education, children's mathematical understanding could be
enhanced. The finding is consistent with Ginsburg and Russell's results (1981) that social class did not affect children's mathematical understanding. The results are, also, in line with both the Vygotskian tradition and Saxe et al.'s conclusions (1987) that the social processes and children's everyday activities involving numbers can indeed enhance their mathematical understanding.

**Sex and Age of Child**

The results of the study documented that there were no sex differences in mothers' stimulation of their children's mathematical understanding. This result is consistent with Badri and Grotberg's findings (1986) that all parents from the different socio-economic backgrounds have high expectations for their young children for educational and professional achievement, regardless of the gender of the child. Also, parents tend to use the same child rearing practices for boys and girls (Grotberg & Badri, 1989). In addition, the results reflected no sex differences in terms of children's mathematics performance. These results are consistent with the American literature (e.g., Feingold, 1988). The results of the study, however, are contrary to Badri and Grotberg's reports (1986) that high-income girls were more intelligent than low-income boys and girls, and high-income boys. One explanation that can be offered for the discrepancies in the results with those of Badri and Grotberg (1986) is the fact that Badri and Grotberg used the Draw - A - Man test for measuring intelligence. Kellogg (1969) argued that assessment of a child's intelligence by an expert could differ significantly from one drawing to another produced by the same child. Kellogg (1969) and Cratty (1970) concluded that any assessment of children's intelligence based on their drawings should be carried out after collecting large numbers of drawings from each child, not only one or two drawings. Furthermore, Cratty (1970) stated, concerning the use of the Draw - A - Man test for measuring intellectual abilities, "I believe this illustrates the rather tenuous nature of the use of this type of task when evaluating anything but the child's ability to draw the human figure!" (1970, p.159).

On the other hand, the results of the study reflected significant differences as far as the age of the child is concerned. Mothers stimulated 5-year-old children in the sample more than they
stimulated 4-year-old children. One possible explanation is that Sudanese mothers may consider 4-year-olds too young to worry about counting and mathematics. Indeed, several mothers reflected during the interview that their children were young, and that was the reason behind their not providing stimulation to the children. Five-year-olds, on the other hand, received more stimulation from their mothers and demonstrated more understanding of mathematics than did 4-year-olds.

**Comparison of TEMA-2 Scores of American and Sudanese Children**

Initial comparison showed that the performance of the Sudanese children in the present study was comparable to that of the American children in the standardization sample of the TEMA-2 (Ginsburg & Baroody, 1990). This result supports the validity of TEMA-2 for the Sudanese culture. In addition, it fails to support Badri and Grotberg's conclusion (1986) that Sudanese children did not reach American norms in their intellectual abilities. Furthermore, this result reflects that Sudanese mothers may be comparable to American mothers in their stimulation of their children's mathematical understanding. However, the above is not conclusive; therefore, empirical evidence should be generated through future research.
CONCLUSIONS AND IMPLICATIONS

The results of this study have documented that maternal stimulation is the cornerstone in enhancing early mathematical thinking in children. Even the negative results obtained concerning mothers with post-secondary education, but less than college degrees, seem to point out to the importance of maternal stimulation. These mothers failed to stimulate their children to the extent that these children reflected lower levels of mathematical understanding.

Parent education is the perfect answer to how one can convey to parents, especially mothers, the importance of early childhood stimulation for children’s mathematics achievement and, for that matter, their overall cognitive development. The researcher thinks, moreover, the main target group should be mothers with low educational backgrounds. However, mothers need to know that formal education for young children at the school nor at home is not called for. Parents should not think that in order to enhance their children’s mathematical understanding, they must have them start writing numbers using pencils and papers. On the contrary, the informal social processes that involves numbers and counting is what is called for. A mother, for example, who asks her child to help her prepare dinner and says “Let’s count how many plates we need,” is a perfect example of these informal social activities.

Future research needs to address the question of why mothers with post-secondary education in the present sample were not comparable to mothers with only secondary education, nor with mothers with college degrees and graduate training. Future research also needs to provide the Sudan’s literature with empirical evidence of the quality of early childhood education programs in Sudan. Comparisons with quality programs in the United States might be of help in this area.
REFERENCES


Table 1

Means and Standard Deviations of TEMA-2 Scores for the Four Levels of Maternal Education by Childhood Education Status

<table>
<thead>
<tr>
<th>Maternal Education</th>
<th>No Childhood Education</th>
<th>Childhood Education</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Means (SD)</td>
<td>Means (SD)</td>
</tr>
<tr>
<td>Level 1</td>
<td>13.91 (7.88)</td>
<td>15.50 (8.35)</td>
</tr>
<tr>
<td></td>
<td>n = 11</td>
<td>n = 8</td>
</tr>
<tr>
<td>Level 2</td>
<td>20.11 (6.11)</td>
<td>16.92 (6.96)</td>
</tr>
<tr>
<td></td>
<td>n = 9</td>
<td>n = 12</td>
</tr>
<tr>
<td>Level 3</td>
<td>12.00 (5.62)</td>
<td>18.11 (6.95)</td>
</tr>
<tr>
<td></td>
<td>n = 10</td>
<td>n = 9</td>
</tr>
<tr>
<td>Level 4</td>
<td>19.60 (7.50)</td>
<td>22.82 (8.45)</td>
</tr>
<tr>
<td></td>
<td>n = 10</td>
<td>n = 11</td>
</tr>
</tbody>
</table>
Table 2

T-Values of the Post-Hoc Comparisons between Means of the Four Levels of Maternal Education in MMSI and TEMA-2 Scores

<table>
<thead>
<tr>
<th>Maternal Education</th>
<th>MMSI Scores</th>
<th>TEMA-2 Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 Vs. Level 2</td>
<td>-2.15*</td>
<td>NS</td>
</tr>
<tr>
<td>Level 1 Vs. Level 3</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Level 1 Vs. Level 4</td>
<td>-3.94****</td>
<td>-2.87***</td>
</tr>
<tr>
<td>Level 2 Vs. Level 3</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Level 2 Vs. Level 4</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Level 3 Vs Level 4</td>
<td>-3.39****</td>
<td>-2.74**</td>
</tr>
</tbody>
</table>

Note: Degrees of freedom = 76
NS = not significant at .05
* p < .05
** p < .01
*** p < .005
**** p < .001
Table 3

Means and Standard Deviations of MMSI and TEMA-2 Scores for the Four Levels of Maternal Education

<table>
<thead>
<tr>
<th>Maternal Education</th>
<th>n</th>
<th>MMSI Scores</th>
<th>TEMA-2 Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Means (SD)</td>
<td>Means (SD)</td>
</tr>
<tr>
<td>Level 1</td>
<td>19</td>
<td>20.26 (8.77)</td>
<td>14.58 (7.89)</td>
</tr>
<tr>
<td>Level 2</td>
<td>21</td>
<td>26.24 (7.64)</td>
<td>18.29 (6.65)</td>
</tr>
<tr>
<td>Level 3</td>
<td>19</td>
<td>21.79 (8.47)</td>
<td>14.89 (6.86)</td>
</tr>
<tr>
<td>Level 4</td>
<td>21</td>
<td>31.24 (10.08)</td>
<td>21.29 (7.98)</td>
</tr>
</tbody>
</table>
Table 4
Means and Standard Deviations of MMSI and TEMA-2 Scores of Level 3 of Maternal Education Before and After Removing College Mothers from Analyses

<table>
<thead>
<tr>
<th></th>
<th>With College Mothers (n = 19)</th>
<th>Without College Mothers (n = 14)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MMSI Scores</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Means</td>
<td>21.79</td>
<td>22.14</td>
</tr>
<tr>
<td>SD</td>
<td>8.47</td>
<td>8.25</td>
</tr>
<tr>
<td><strong>TEMA-2 Scores</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Means</td>
<td>14.89</td>
<td>15.00</td>
</tr>
<tr>
<td>SD</td>
<td>6.86</td>
<td>6.63</td>
</tr>
</tbody>
</table>
Table 5

Means and Standard Deviations of Family Social Status for the Four Levels of Maternal Education

<table>
<thead>
<tr>
<th>Maternal Education</th>
<th>Means (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>33.95 (9.58)</td>
</tr>
<tr>
<td>Level 2</td>
<td>55.76 (5.58)</td>
</tr>
<tr>
<td>Level 3</td>
<td>52.68 (5.41)</td>
</tr>
<tr>
<td>Level 4</td>
<td>62.14 (3.40)</td>
</tr>
</tbody>
</table>
GENERAL SUMMARY

Based on the literature provided in Section I, the researcher maintains that the social environment and social processes in the every day life of children enhance their mathematical understanding. Many researchers are in support with this view (e.g., Fuson & Hall, 1983; Saxe, Guberman, & Gearhart, 1987). The Sudanese literature, however, provided by Badri (1978), Badri and Grotberg (1986), Grotberg and Badri (1986), Grotberg and Badri (1989), and Badri and Grotberg (1990) involving Sudanese child rearing practices and the developmental levels of young Sudanese children, one may predict that the Sudanese familial practices do not enhance the development of young children's mathematical understanding.

Given the above background, the researcher conducted the study described in Section II of the thesis with the objectives of investigating the social processes involved in the learning and teaching of early mathematics in Sudanese families, and the impact of early childhood education on children's mathematical understanding. The researcher predicted that 1) mothers with more education would provide more stimulation of their children's mathematics development than would mothers with less education, 2) children of mothers who provided more mathematical stimulation would demonstrate higher levels of mathematical thinking than would children of mothers who provided less stimulation, and 3) children who attended early childhood education programs would demonstrate higher levels of mathematical thinking than would children who did not attend such programs.

The results of the study documented, for the most part, that more educated mothers provided more stimulation of their children's mathematical understanding than did less educated mothers. However, mothers with post-secondary education but less than college degree reported that they did not provide as much stimulation as did other mothers. The results of the study failed to support the prediction that enrollment in early childhood programs would enhance children's mathematical understanding. The results documented that maternal stimulation is of great
importance to children's mathematical understanding. As predicted, children of mothers who provided more stimulation demonstrated higher levels of mathematical understanding than did children of mothers who provided less stimulation.

The results of the study warrant the researcher's conclusion that maternal stimulation is the cornerstone in the development of early mathematical understanding of young children. Future research, however, needs to address the negative results concerning mothers with some post-secondary education and their failure to provide their young children with the stimulation needed to construct early mathematical understanding. Future research also needs to investigate the quality of early childhood education programs in Sudan.
REFERENCES


ACKNOWLEDGEMENTS

I am deeply indebted and thankful to my major professor, Dr. Susan Hegland, for her advice, guidance, unending patience, and tolerance throughout my master's program. I am really grateful for her support of and interest in my study, and my future academic career.

My gratitude is extended to Dr. Albert King, Dr. Mack Shelley, and Dr. Joan Herwig for serving in my graduate committee. I would like to thank Dr. Albert King for providing excellent suggestions for improving my research, for believing in me, and for giving me fatherly advice. I wish to express my appreciation to Dr. Mack Shelley for his advice, stimulating discussions, and suggestions. My sincere thanks go to Dr. Joan Herwig for her constructive guidance and support of graduate program since the first day I came to Iowa State University. I am also grateful to Dr. Dhalia Stockdale who attended my final orals as a substitute professor for Dr. Albert King.

I would like to express my gratitude to Dr. Donna Cowan who was instrumental in making my graduate study at Iowa State University possible. My thanks are also due to Dr. Edith Grotberg and Dr. Gasim Badri for providing me with the relevant literature. I would also like to acknowledge Sidiga who offered her help and support.

I am indebted to Ahfad University, my number one motivator, without which neither this thesis, nor this degree would have been possible. I hope to make a contribution to Ahfad throughout my professional career.

As it is always true, this work could not have been accomplished without the participation of subjects. I offer the Sudanese mothers and children who participated in the study my special appreciation and gratitude.

And most importantly, I would like to express my deepest love to my parents. Without their love and encouragement throughout all the years of my education and my life, this work would not have existed. You were, are, and will always be great. As for Waleed, Amal, and little Ahmed, I find no appropriate words to express my feelings than "I love you guys."
I may not have made it this far without the support and encouragement of my fellow Sudanese students in Ames and their families. Each one’s home was my home away from home. I am really grateful, my friends.

Kamal was always there when I needed an encouraging word or when I just needed someone to put things back into perspective. Thank you, Kamal, for being a great friend. Also, I would like to express my love and gratitude to Amani who was always there to offer her support and a shoulder when I needed it most. God bless you, Amani.

I would like to thank my many friends in Ames and my special friends in Virginia. Although the miles may be numerous between us in the future, the enjoyable memories will remain near. And finally, I cannot forget to acknowledge my friends back in Sudan who were always in my thoughts, as, I hope, I was in theirs. Thank you guys for being my friends and keeping up with me.
APPENDIX A: HUMAN SUBJECTS COMMITTEE FORM
65
Information for Review of Research Involving Human Subjects
Iowa State University
(Please type and use the attached instructions for completing this form)

1. Title of Project: Early mathematics teaching and learning in Sudanese families.

2. I agree to provide the proper surveillance of this project to ensure that the rights and welfare of the human subjects are protected. I will report any adverse reactions to the committee. Additions to or changes in research procedures after the project has been approved will be submitted to the committee for review. I agree to request renewal of approval for any project continuing more than one year.

   Azza Habib 12-10-1990
   Typed Name of Principal Investigator  Date  Signature of Principal Investigator

   H.D.F.S.  300 Child Development Building
   Department  Campus Address  Campus Telephone

3. Sub-investigators  Date  Relationship to Principal Investigator

   12-10-1990  Major Professor

4. Principal Investigator(s) (check all that apply)
   □ Faculty  □ Staff  □ Graduate Student  □ Undergraduate Student

5. Project (check all that apply)
   □ Research  □ Thesis or dissertation  □ Class project  □ Independent Study (490, 590, Honors project)

6. Number of subjects (complete all that apply)
   □ 89 Adults, non-students  □ # ISU student  □ 89# minors under 14  □ other (explain)
   □ # minors 14 - 17

7. Brief description of proposed research involving human subjects: (See Instructions, Item 7. Use an additional page if needed.)

   Please see attached sheet

(Please do not send research, thesis, or dissertation proposals.)

8. Informed Consent:
   □ Signed informed consent will be obtained. (Attach a copy of your form.)
   □ Modified informed consent will be obtained. (See instructions, item 8.)
   □ Not applicable to this project.
9. **Confidentiality of Data:** Describe below the methods to be used to ensure the confidentiality of data obtained. (See instructions, item 9.)

   The identities of the subjects will not be revealed in any publication, computer data storage, document, recording photograph, or in any other way which relates to this study. Only group analyses of the data will be reported.

10. **What risks or discomfort will be part of the study?** Will subjects in the research be placed at risk or incur discomfort? Describe any risks to the subjects and precautions that will be taken to minimize them. (The concept of risk goes beyond physical risk and includes risks to subjects' dignity and self-respect as well as psychological or emotional risk. See instructions, item 10.)

   No risks

11. **CHECK ALL** of the following that apply to your research:

   - A. Medical clearance necessary before subjects can participate
   - B. Samples (Blood, tissue, etc.) from subjects
   - C. Administration of substances (foods, drugs, etc.) to subjects
   - D. Physical exercise or conditioning for subjects
   - E. Deception of subjects
   - F. Subjects under 14 years of age and/or Subjects 14 - 17 years of age
   - G. Subjects in institutions (nursing homes, prisons, etc.)
   - H. Research must be approved by another institution or agency (Attach letters of approval)

If you checked any of the items in 11, please complete the following in the space below (include any attachments):

**Items A - D** Describe the procedures and note the safety precautions being taken.

**Item E** Describe how subjects will be deceived; justify the deception; indicate the debriefing procedure, including the timing and information to be presented to subjects.

**Item F** For subjects under the age of 14, indicate how informed consent from parents or legally authorized representatives as well as from subjects will be obtained.

**Items G & H** Specify the agency or institution that must approve the project. If subjects in any outside agency or institution are involved, approval must be obtained prior to beginning the research, and the letter of approval should be filed.

   The data will be collected through home visits. The researcher can obtain consent during the visit.
Checklist for Attachments and Time Schedule

The following are attached (please check):

12. □ Letter or written statement to subjects indicating clearly:
   a) purpose of the research
   b) the use of any identifier codes (names, #')s, how they will be used, and when they will be
      removed (see item 17)
   c) an estimate of time needed for participation in the research and the place
   d) if applicable, location of the research activity
   e) how you will ensure confidentiality
   f) in a longitudinal study, note when and how you will contact subjects later
   g) participation is voluntary; nonparticipation will not affect evaluations of the subject

13. □ Consent form (if applicable)

14. □ Letter of approval for research from cooperating organizations or institutions (if applicable)

15. □ Data-gathering instruments

16. Anticipated dates for contact with subjects:
   First Contact                           Last Contact
   12/17/1990                             05/20/1991
   Month / Day / Year                      Month / Day / Year

17. If applicable: anticipated date that identifiers will be removed from completed survey instruments and/or audio or visual tapes will be erased:
   12/24/1991
   Month / Day / Year

18. Signature of Chairperson Date Department or Administrative Unit
   ____________  12/11/90  HD-FS

19. Decision of the University Human Subjects Review Committee:
   □ Project Approved  □ Project Not Approved  □ No Action Required

   Patricia M. Keith  10/8/91
   Name of Committee Chairperson Date Signature of Committee Chairperson

Maternal math interview is in final form. Azza Habib, Principal Investigator, did the interviewing in Sudan in Dec., 1990. Azza will send over a copy of the test for the file.

   - Per Azza Habib
   10/8/91
APPENDIX B: TEST OF EARLY MATHEMATICS ABILITY-SECOND EDITION
**General Administration Guidelines**

1- The TEMA-2 is only administered to individuals. It is not designed as a group measure and should not be used as one.

2- The TEMA-2 is not a timed test; therefore no precise time limits are imposed on the children being tested. They should, within reason, be given as long a time as necessary to complete a question. The interviewers should rely on their own judgment.

3- To shorten testing time as much as possible, entry points and basals and ceilings should be used. Testing always begins with the item that corresponds to the child's age. When working with 3-, 4-, 5-, 6-, 7-, and 8-year-old children, the interviewer should begin assessment with item 1, 7, 15, 22, 32, and 43, respectively. Examiners begin assessment at entry level and test until five consecutive items are missed (the ceiling) or until the last item is administered. Once a ceiling has been established, go back and establish a basal if the student has not already answered five consecutive items correctly. That is, if he or she has not correctly answered five items in succession during the establishment of a ceiling, return to the entry point and test downward until five items in a row are answered correctly or until the first item is administered. All items below the basals are scored as correct.

4- Have readily available all materials necessary before administering the assessment.

5- The Assessment should be administered in a quiet, comfortable, nondistracting environment. Very young children are often best assessed in quiet areas in a familiar setting. This is especially true if the interviewer is not well known to the child. If such a place is not available, the interviewer should try to set up an area for testing as similar as possible to the child's regular environment.

6- Keep the child at ease, but focused on the assessment.

7- Praise and encourage children with comments like, "YOU ARE DOING WELL." At no time, however, comment on the accuracy of individual responses.
8- Interviewers should feel free to improvise on the directions to some degree. The most important consideration should be that the child clearly understands the instructions for each item before responding. The interviewer, however, must be sure not to change the essence of the item if directions are modified.

9- The interviewer should stop assessment immediately if children show signs of tiring or losing interest; assessment should be continued at another time. For the youngest children tested, the interviewer should be sensitive to fatigue, distraction, or lack of attention.
Specific Instructions for Administering the Items

We remind the examiner that the children receive one point for every item answered correctly. The points are summed, and this value is called the raw score. The directions for giving and scoring the items follow.

1. INTUITIVE NUMBERING (Informal)

Materials: Card 1-1 with a picture of two cats in a row, Card 1-2 with one cat, and Card 1-3 with three cats in a row.

Procedure: For Part A, show Card 1-1 and ask a child, "HOW MANY CATS DO YOU SEE?" For Part B, show Card 1-2 and repeat the question. For Part C, show Card 1-3 and repeat the question.

Scoring: To pass, a child must identify A as "two," B as "one," and C as some number other than one or two. A child who correctly identifies all three sets passes the item.

2. FINGER DISPLAYS: 1, 2, MANY (Informal)

Procedure: For Part A, ask a child, "SHOW ME TWO FINGERS." For Part B, say, "SHOW ME ONE FINGER." For Part C, say, "SHOW ME FIVE FINGERS."

Scoring: A child must correctly display two fingers and one finger for Parts A and B, respectively. He or she must show three or more fingers for Part C. To pass, a child must display the correct number for all three parts.

3. COUNTING BY ONES: 1 TO 5 (Informal)

Procedure: Hold up five fingers and say, "WOULD YOU COUNT THESE FINGERS?" If a child is silent, say, "COUNT THEM FOR ME. ONE [pause] YOU GO NOW."

Scoring: To pass, the child must count from one to five in the correct order.

4. PERCEPTION OF MORE (Informal)

Materials: Cards 4-1 (10 versus 2 dots), 4-2 (7 versus 3 dots), 4-3 (2 versus 8 dots), 4-4 (1 versus 6 dots), 4-5 (9 versus 4 dots).
**Procedure:** For practice, show the child Card 4-1 and say: "LET'S TRY THE MORE GAME. ON THIS CARD THERE ARE DOTS ON THIS SIDE AND DOTS ON THIS SIDE. LOOK CAREFULLY AND POINT TO THE SIDE THAT HAS MORE DOTS." If the child is correct, say, "THAT'S RIGHT. THAT SIDE HAS MORE." If the child is wrong, say, "NO, THIS SIDE HAS MORE. SEE, IT HAS A LOT OF DOTS. [Make an exaggerated circular gesture over the side with 10 dots.] THIS SIDE DOES NOT HAVE MORE. IT HAS ONLY A FEW." Make a small circling gesture over the side with two dots. Then give the rest of the items in order. Present each quickly, for about 5 seconds. Each time, say, "POINT TO THE SIDE THAT HAS MORE DOTS." If the child tries to count the dots, say, "CAN YOU TELL ME WHICH SIDE HAS MORE DOTS JUST BY LOOKING?" Stop testing once a child misses any but the practice question.

**Scoring:** To pass the item, a child must respond correctly to the last four questions (2, 3, 4, and 5).

5. **ENUMERATION: 1 TO 5 (Informal)**

**Materials:** Card 5-1 (two stars), 5-2 (four stars in a line), 5-3 (five stars in a line).

**Procedure:** Note that this procedure is used for both Items 5 and 6. Say, "LET'S PLAY THE HIDE-THE-STARS GAME. I'LL SHOW A CARD WITH SOME STARS ON IT." Show the practice card (Card 5-1). "YOU COUNT THE STARS." If the child does not respond, prompt with, "COUNT THESE STARS." After this, turn the card away and say, "HOW MANY STARS DID YOU COUNT?" [This is important for item 6.] Repeat the procedure with Cards 5-2 and 5-3.

**Scoring:** To pass, the child must count correctly or otherwise provide the correct total for both Cards (5-2 and 5-3).

6. **CARDINALITY RULE (Informal)**

**Scoring:** The scoring for this item is based on the response to the question, "HOW MANY STARS DID YOU COUNT?" on Cards 5-2 and 5-3. To pass, a child must identify the last number counted in order to indicate the total number of stars for Cards 5-2 and 5-3. That is, the
child must indicate that he or she counted "four" for Card 5-2 and "five" for Card 5-3. If a child responds to Card 5-2 only by counting, for example, "There are one, two, three, four stars," but does not indicate how many stars there are altogether, score this item as failed.

7. NUMBER CONSTANCY (Informal)

*Materials:* Five pennies.

*Procedure:* For Part A, put out three pennies in a row and say, "WATCH AS I COUNT THESE PENNIES. (Count the pennies) ONE, TWO, THREE." Ask, "HOW MANY PENNIES ARE THERE?" After a child responds "Three," say, "WATCH, NOW I'M GOING TO MAKE A SHAPE WITH THE PENNIES." After arranging the pennies in a triangle ask, "HOW MANY PENNIES ARE THERE? CAN YOU TELL ME WITHOUT COUNTING?" Do not let the child recount.

Cover the set, if necessary. For Part B, repeat the procedure with five pennies. After the child agrees there are five pennies, say, "WATCH, NOW I'M GOING TO MAKE A CIRCLE WITH THE PENNIES." For Part C, repeat the procedure with four pennies but mix the row of pennies together in a bunch.

*Scoring:* To pass, a child must indicate that after the transformation in appearance, both sets still have the same number of pennies.

8. PRODUCE SETS UP TO 5 (Informal)

*Materials:* 10 pennies.

*Procedure:* Place 10 pennies on the desk and say, "GIVE ME THREE PENNIES. GOOD. NOW GIVE ME FIVE PENNIES."

*Scoring:* To pass, a child must correctly count out three and then five pennies.

9. FINGER DISPLAYS TO 5 (Informal)

*Procedure:* Say, "LET'S GIVE OUR FINGERS SOME EXERCISE. SHOW ME TWO FINGERS." If the student is correct, say, "GOOD, YOU HELD UP TWO FINGERS VERY QUICKLY." If the student is not correct, say, "NO, HOLD UP TWO FINGERS LIKE THIS." Then say:
A. "HOLD UP THREE FINGERS"
B. "HOLD UP FIVE FINGERS"
C. "HOLD UP FOUR FINGERS"

If a student uses his or her fingers to "sign" the number 6, use the special prompt, "IS THERE ANOTHER WAY YOU CAN SHOW ME THAT NUMBER? PUT OUT ____ FINGERS." Stop testing after the student has missed two problems.

Scoring: To pass, a child must correctly display three, five and four fingers, respectively.

10. COUNTING BY ONES: 1 TO 10 (Informal)

Materials: 10 small blocks, coins, and so forth.

Procedure: Show the child the objects. Say, "LET'S PLAY THE COUNTING GAME. COUNT TOGETHER WITH ME AS I POINT TO EACH BLOCK." Point in turn to the first three blocks as you count along with the child, "ONE, TWO, THREE." Then say, "NOW YOU COUNT BY YOURSELF." Continue to point to each block, but expect the child to say the counting numbers by himself or herself. If the child does not count, say, "WHEN WE COUNT WE SAY, 'ONE, TWO, THREE, AND THEN COMES . . . .'

Scoring: To pass, the child must count all the numbers from 3 to 10 in the correct order.

11. COUNT AFTER: 1 TO 9 (Informal)

Procedure: For A hold out two fingers and say, "COUNT MY FINGERS WITH ME; TWO, THREE, FOUR AND THEN COMES . . . ." (pause and hold out the fifth finger).

A. 2, 3, 4, AND THEN COMES . . .
B. 7, 8, 9, AND THEN COMES . . . (Hold out tenth finger)
C. 3, 4, 5, AND THEN COMES . . . (Hold out sixth finger)
D. 5, 6, 7, AND THEN COMES . . . (Hold out eighth finger)

Scoring: To pass, a child must correctly identify the fourth number in the sequence for all four items.
12. READING SINGLE-DIGIT NUMERALS (Formal)

_Materials:_ Card 12-1 (with numeral 2), Card 12-2 (with numeral 5), and Card 12-3 (with numeral 6).

_Procedure:_ Show the child Card 12-1 and say, "WHAT NUMBER IS THIS?" If the child does not respond, prompt with, "TELL ME WHAT NUMBER THIS IS." Continue with same instructions for Cards 12-2 and 12-3.

_Scoring:_ To pass a child must correctly read all three numerals.

13. WRITING SINGLE-DIGIT NUMERALS (Formal)

_Materials:_ Worksheet.

_Procedure:_ Say, "I'M GOING TO TELL YOU SOME NUMBERS AND I'D LIKE YOU TO WRITE THEM DOWN ON THE WORKSHEET HERE. (Point to space 13.) THE FIRST NUMBER IS SEVEN." Pause for the child to write. Then say, "THE NEXT NUMBER IS THREE." After the child has written the number say, "THE LAST NUMBER IS NINE."

_Scoring:_ To pass, the child must write all three numerals correctly. Reversed numerals - for example, for 7 - are considered correct. Penmanship is not a consideration; sloppy numerals are acceptable.

14. CONCRETELY MODELING ADDITION WORD PROBLEMS (Informal)

_Materials:_ 10 pennies, chips, or other small countable objects.

_Procedure:_ Say, "I'M GOING TO TELL YOU SOME STORIES ABOUT JOEY AND HIS MONEY. IF YOU WANT, YOU CAN USE YOUR FINGERS OR THESE PENNIES TO HELP YOU FIND THE ANSWER." If a child does not use fingers or pennies and responds with an incorrect answer, give the following prompt: "USE YOUR FINGERS OR THESE PENNIES TO FIGURE OUT HOW MUCH FIVE PENNIES AND TWO MORE ARE." After giving each of the problems below, put any pennies used back into a single pile. Each time do not tell the child whether the answer is right or wrong. Stop testing after the child misses two questions.
A. "JOEY HAS ONE PENNY, AND HE GETS TWO MORE. HOW MANY DOES HE HAVE ALTOGETHER? IF YOU WANT, YOU CAN USE YOUR FINGERS OR THESE PENNIES TO HELP YOU FIND THE ANSWER."

B. "JOEY HAS FOUR PENNIES, AND HE GETS THREE MORE. HOW MANY DOES HE HAVE ALTOGETHER? IF YOU WANT, YOU CAN USE YOUR FINGERS OR THESE PENNIES TO HELP YOU FIND THE ANSWER."

C. "JOEY HAS THREE PENNIES, AND HE GETS TWO MORE. HOW MANY DOES HE HAVE ALTOGETHER? IF YOU WANT, YOU CAN USE YOUR FINGERS OR THESE PENNIES TO HELP YOU FIND THE ANSWER."

Scoring: To pass, a child must correctly answer at least two of the three problems.

15. WRITTEN REPRESENTATION (Formal)


Procedure: Say, "HERE IS A PICTURE OF SOME DOGS. (Show child Card 15-1.) USE THIS PAPER AND PENCIL TO SHOW ME HOW MANY DOGS THERE ARE." If the child draws pictures of dogs, ask, "CAN YOU SHOW ME ANOTHER WAY WITHOUT PICTURES?" If the child responds to Problem 15-1 by drawing tallies, lines, marks, circles, or a numeral, repeat the procedure with Cards 15-2, 15-3, and 15-4.

Card 15-2: "HOW MANY CATS ARE THERE?"

Card 15-3: "HOW MANY LIONS ARE THERE?"

Card 15-4: "HOW MANY TIGERS ARE THERE?"

Scoring: To pass, a child must draw the correct number of tallies, lines, marks, circles, numerals (but not pictures) for at least three of the four problems.

16. CONCEPTION OF MORE (Informal)

Procedure: Say, "SUPPOSE I HAVE TEN PENNIES AND YOU HAVE ONLY ONE. WHO HAS
MORE? I DO, DON'T I? NOW I WANT YOU TO TELL ME WHICH IS MORE, SIX OR FIVE?
NINE OR TEN? SEVEN OR SIX? FOUR OR FIVE?*

Scoring: To pass, the child must get four out of four problems correct.

17. COUNTING OUT LOUD: 21 (Informal)

Procedure: Say, "I'D LIKE YOU TO COUNT OUT LOUD FOR ME. I'LL TELL YOU WHEN TO STOP." If the child is silent, say, "COUNT OUT LOUD LIKE THIS WITH ME: ONE, TWO, THREE . . . YOU KEEP GOING NOW BY YOURSELF AND COUNT UP AS HIGH AS YOU CAN." If the child counts correctly, stop him or her at 42 (since this is relevant for Item 28). If the child stops his or her correct counting before 42, ask what number comes next and then urge the child to continue. Consider the item completed when the child makes his or her first error or if the child stops and maintains that he or she can count no higher.

Scoring: To pass, the child must count to at least 21 without error. (If the child counts to 41 without error, give him or her a pass on Item 28, also.)

18. COUNT AFTER ME: 1 (Informal)

Procedure: Say, "NOW WE ARE GOING TO DO COUNTING AFTER ME. I'LL SAY SOME NUMBERS AND YOU SAY THE NUMBER THAT COMES NEXT. IF I SAY, 'ONE, TWO,' YOU SAY THE NUMBER THAT COMES NEXT." If the child is silent, say, "GO AHEAD, YOU SAY..." Either "three" or "three, four" is considered correct. If the child is still silent, say, "THREE." For all children, then say, "YOU ALWAYS SAY THE NUMBER THAT COMES NEXT."
A. "TWENTY-THREE, TWENTY-FOUR . . . ."
B. "THIRTY-TWO, THIRTY-THREE . . . ."

Scoring: To pass, the child must get both items correct by saying "Twenty-five" or "Twenty-five, twenty-six" to A and "Thirty-four" or "Thirty-four, thirty-five" to B.

19. ADDING OBJECTS (Informal)

Materials: Card 19, 10 pennies, chips, or other small countable objects.
Procedure: Say, "JOEY HAS TWO PENNIES." On Card 19, place two pennies or chips in the box to your right. "HE GETS ONE MORE PENNY. Place one penny or chip in the box to your left. "HOW MANY DOES HE HAVE ALTOGETHER? IF YOU WANT, YOU CAN USE YOUR FINGERS TO HELP YOU FIND THE ANSWER." If the child's answer is correct, say, "GOOD, THAT'S RIGHT," and go on. If the child's answer is wrong, say, "NO, HE HAS THREE PENNIES. HE STARTED WITH TWO AND THEN GOT ONE MORE, SO HE HAS THREE ALTOGETHER."

Next give the following three problems, putting out the indicated number of pennies or other small, countable objects. After each problem, remove all the pennies and start over again. Each time do not tell the child whether he or she is right or wrong.

A. "JOEY HAS SIX PENNIES AND HE GETS TWO MORE. HOW MANY DOES HE HAVE ALTOGETHER?"

B. "JOEY HAS FOUR PENNIES AND HE GETS THREE MORE. HOW MANY DOES HE HAVE ALTOGETHER?"

C. "JOEY HAS FIVE PENNIES AND HE GETS THREE MORE. HOW MANY DOES HE HAVE ALTOGETHER?"

Scoring: To pass, the child must answer correctly two of the three problems.

20. ENUMERATION: SMALL (Informal)

Material Needed: Cards 20-1 and 20-2.

Procedure: Say, "COUNT THESE DOTS WITH YOUR FINGER AND TELL ME HOW MANY THERE ARE. DO IT CAREFULLY." If the child does not point with a finger, say, "MAKE SURE YOU TOUCH EACH DOT AS YOU COUNT." Give the child Card 20-1 and after he or she completes it, Card 20-2.

Scoring: To pass, the child must indicate that card 20-1 has 9 and card 20-2 has 10 dots.

Further, the child must obtain the correct answer by counting each dot once, and only once.
by accident, the child gets a right answer by counting some dots twice and skipping others, he or she does not receive a pass.

21. COUNT BACK FROM 10 (Informal)

Procedure: Say, "NOW I WANT YOU TO COUNT BACKWARDS, LIKE WHEN A ROCKET BLASTS OFF. FOR INSTANCE, 'THREE, TWO, ONE, BLAST-OFF.' NOW YOU COUNT BACKWARDS, STARTING FROM TEN."

Scoring: To pass, the child must say, "Ten, nine, eight, seven, six, five, four, three, two, one."

22. MENTAL ADDITION: PENNIES (Informal)

Material Needed: 10 pennies, chips or other small countable objects.

Procedure: Put two pennies in your left hand and one penny in your right hand. Say, "WATCH THIS. I HAVE TWO PENNIES IN THIS HAND, SEE?" Now close your hand so that the child cannot see the collection. "NOW I PUT THE PENNIES TOGETHER. HOW MUCH ARE TWO AND ONE ALTOGETHER?" If the child is correct, say, "THAT'S RIGHT. I HAVE THREE ALTOGETHER. I STARTED WITH TWO HERE AND ONE HERE, SO THERE ARE THREE IN MY HANDS ALTOGETHER." If the child is wrong, say, "NO, I HAVE THREE ALTOGETHER. I STARTED WITH TWO HERE AND ONE HERE, SO THERE ARE THREE IN MY HANDS ALTOGETHER." Put the pennies back in the pile and say, "LET'S DO SOME MORE." In the following problems, use the same procedures described above.

A. "I HAVE THREE IN THIS HAND AND TWO IN THIS HAND. NOW I PUT THEM TOGETHER. HOW MUCH ARE THREE AND TWO ALTOGETHER?"

B. "I HAVE FOUR IN THIS HAND AND THREE IN THIS HAND. NOW I PUT THEM TOGETHER. HOW MUCH ARE FOUR AND THREE ALTOGETHER?"

C. "I HAVE FIVE IN THIS HAND AND TWO IN THIS HAND. NOW I PUT THEM TOGETHER. HOW MUCH ARE FIVE AND TWO ALTOGETHER?"

Scoring: To pass, the child must achieve a correct answer on two of the three problems.
23. MENTAL NUMBER LINE: I (Informal)

**Material Needed:** Card 23.

**Procedure:** Show Card 23 and, pointing to the practice box, say, "NOW LET'S DO THIS. HERE IS A SIX. WHICH IS CLOSER TO SIX, FIVE OR NINE?" If the child seems confused say, "IS FIVE CLOSER TO SIX OR IS NINE CLOSER TO SIX?" If the child is correct say, "THAT'S RIGHT, FIVE IS CLOSER. IT'S ONLY ONE AWAY FROM SIX; NINE IS THREE AWAY FROM SIX." If the child is wrong, say, "NO, FIVE IS CLOSER: IT'S ONLY ONE AWAY FROM SIX; NINE IS THREE AWAY FROM SIX." After this practice trial, show the test items in order as follows:

A. Say, "HERE IS A SEVEN. WHICH IS CLOSER, ONE OR NINE?"
B. Say, "HERE IS A THREE. WHICH IS CLOSER, NINE OR FIVE?"
C. Say, "HERE IS AN EIGHT. WHICH IS CLOSER, TEN OR TWO?"
D. Say, "HERE IS A FIVE. WHICH IS CLOSER, ONE OR SEVEN?"
E. Say, "HERE IS A THREE. WHICH IS CLOSER, ONE OR SIX?"

**Scoring:** To pass, the child must be correct on four of five problems. The correct answers are

(A) nine; (B) five; (C) ten; (D) seven; (E) one.

24. PRODUCE 19 (Informal)

**Material Needed:** 25 pennies, chips, or other small countable objects.

**Procedure:** Say, "HERE ARE A WHOLE BUNCH OF PENNIES. GIVE ME EXACTLY NINETEEN. COUNT OUT JUST NINETEEN."

**Scoring:** To pass, the child must put out exactly 19 pennies. The easiest way to keep track of the total is to count the remainder. Thus, if the child begins with 25, just note whether six are left.

25. READING NUMERALS: TEENS (Formal)

**Material Needed:** Card 25.

**Procedure:** Show the child Card 25 and, pointing to 10, say, "WHAT NUMBER IS THIS?" or, if
necessary, "READ THIS NUMBER FOR ME." Then repeat with the 13 and 16. If the child simply reads the individual digits ("one, oh" or "one, three"), say, "HOW ELSE CAN WE SAY THIS NUMBER?"

**Scoring:** To pass, the child must read all three numbers properly. That is, "ten," "thirteen," "sixteen."

26. WRITING TWO-DIGIT NUMERALS (Formal)

**Material Needed:** Worksheet.

**Procedure:** Say, "I'M GOING TO TELL YOU SOME NUMBERS AND I'D LIKE YOU TO WRITE THEM DOWN ON THE WORKSHEET HERE." Point to space 26 "THE FIRST NUMBER IS TWENTY-THREE." Pause for the child to write. Then say, "THE SECOND IS NINETY-SEVEN."

**Scoring:** To pass, the child must write both numbers correctly. Reversed numerals - for example, 97- are considered correct. Reversed order of numerals - for example, 32 for 23 - is not correct. Penmanship is not a consideration; sloppy numerals are acceptable.

27. COUNTING OUT LOUD: 41 (Informal)

**Procedure:** Say, "I'D LIKE YOU TO COUNT OUT LOUD FOR ME. I'LL TELL YOU WHEN TO STOP." If the child is silent, say, "COUNT OUT LOUD LIKE THIS WITH ME: ONE, TWO, THREE . . . YOU KEEP GOING NOW BY YOURSELF AND COUNT UP AS HIGH AS YOU CAN." If the child counts correctly, stop him or her at 42. If the child stops his or her correct counting before 42, ask what number comes next and then urge the child to continue. Consider the item completed when the child makes his or her first error or if the child stops and maintains that he or she can count no higher.

**Scoring:** To pass, the child must count to at least 41 without error. If the child correctly counts to at least 21, give him or her a pass on item 18 also, even in the unlikely event that he or she failed it earlier.
28. COUNT BY TENS (Informal)

Procedure: Say, "COUNT BY TENS FOR ME." If the child makes no response, prompt by saying, "COUNT BY TENS LIKE THIS, TEN, TWENTY, THIRTY . . . YOU KEEP GOING."

Scoring: To pass, the child must say, "Ten, twenty, thirty, forty, fifty, sixty, seventy, eighty, ninety." Or, if he or she was prompted, "Forty, fifty, sixty, seventy, eighty, ninety." Score the child wrong if he or she obviously says or whispers the intervening numbers (e.g., whispers "eleven, twelve, thirteen . . . nineteen" or "twenty-one, twenty-two . . . twenty-nine.")

29. READING NUMERALS: TWO DIGITS (Formal)

Material Needed: Card 29.

Procedure: Show the child Card 29 and, pointing to 28, say, "WHAT NUMBER IS THIS?" or, if necessary, "READ THIS NUMBER FOR ME." Then repeat with the 47 and then 90. If the child simply reads the individual digits ("two, eight" or "nine, oh"), say, "HOW ELSE CAN WE SAY THIS NUMBER?"

Scoring: To pass, the child must read all three numbers properly. That is, "twenty-eight," "forty-seven," "ninety."

30. COUNT AFTER ME: II (Informal)

Procedure: Say, "NOW WE ARE GOING TO DO COUNT AFTER ME. I'LL SAY SOME NUMBERS AND YOU SAY THE NUMBER THAT COMES NEXT. LIKE IF I SAY, 'ONE, TWO,' YOU SAY THE NUMBER THAT COMES NEXT." If the child is silent, say, "GO AHEAD, YOU SAY . . . ." Either "three" or "three, four" is considered correct. If the child is still silent, say, "THREE." For all children, then say, "YOU ALWAYS SAY THE NUMBER THAT COMES NEXT."

A. "TWENTY-EIGHT, TWENTY-NINE . . . ."

B. "FORTY-EIGHT, FORTY-NINE . . . ."

Scoring: To pass, the child must get both items correct by saying "thirty" or "thirty, thirty-one" to A and "fifty" or "fifty, fifty-one" to B.
31. MENTAL NUMBER LINE II (Informal)

**Material Needed:** Card 31.

**Procedure:** Show Card 31 and, pointing to the practice box, say, "NOW, LET'S DO THIS. HERE IS A SIX. WHICH IS CLOSER TO SIX, FIVE OR NINE?" If the child seems confused, say, "IS FIVE CLOSER TO SIX OR IS NINE CLOSER TO SIX?" If the child is correct, say, "THAT'S RIGHT, FIVE IS CLOSER. IT'S ONLY ONE AWAY FROM SIX; NINE IS THREE AWAY FROM SIX." If the child is wrong, say, "NO, FIVE IS CLOSER. IT'S ONLY ONE AWAY FROM SIX; NINE IS THREE AWAY FROM SIX." After this practice trial, show the test items in order like this:

A. Say, "HERE IS A THIRTY-TWO. WHICH IS CLOSER, TWENTY-FOUR OR SIXTY-TWO?"
B. Say, "HERE IS AN EIGHTY-FOUR. WHICH IS CLOSER, FIFTY-ONE OR NINETY-SIX?"
C. Say, "HERE IS A FORTY-EIGHT. WHICH IS CLOSER, TWENTY-THREE OR FIFTY-FOUR?"
D. Say, "HERE IS A SIXTY-FIVE. WHICH IS CLOSER, FORTY-NINE OR NINETY-NINE?"
E. Say, "HERE IS A SEVENTY-ONE. WHICH IS CLOSER, FORTY-NINE OR EIGHTY-FOUR?"

**Scoring:** To pass, the child must be correct on four of five problems. The correct answers are (A) twenty-four, (B) ninety-six, (C) fifty-four, (D) forty-nine, (E) eighty-four.

32. ENUMERATION: LARGE (Informal)

**Material Needed:** Cards 32-1 and 32-2.

**Procedure:** Say, "COUNT THESE DOTS WITH YOUR FINGER, AND TELL ME HOW MANY THERE ARE. DO IT CAREFULLY." If the child does not point with the finger, say, "MAKE SURE YOU TOUCH EACH DOT AS YOU COUNT." Show the child Card 32-1 and after he or she completes it, Card 32-2.

**Scoring:** To pass, the child must indicate that Card 32-1 has 14 dots and that Card 32-2 has 16 dots. Further, the child must obtain the correct answer by counting each dot once and only once.
If by accident, the child gets a right answer by counting some dots twice and skipping others, he or she does not receive a pass.

33. COUNT AFTER ME: III (Informal)

Procedure: Say, "NOW WE ARE GOING TO DO COUNT AFTER ME. I'LL SAY SOME NUMBERS AND YOU SAY THE NUMBER THAT COMES NEXT. LIKE IF I SAY ONE, TWO, YOU SAY THE NUMBER THAT COMES NEXT." If the child is silent, say, "GO AHEAD, YOU SAY . . . ." Either "three" or "three, four" is considered correct. If the child is still silent, say, "THREE." For all children, then say, "YOU ALWAYS SAY THE NUMBER THAT COMES NEXT."

A. "SIXTY-EIGHT, SIXTY-NINE . . . ."

B. "EIGHTY-EIGHT, EIGHTY-NINE . . . ."

Scoring: To pass, the child must get both items correct by saying "seventy" or "seventy, seventy-one" for A and "ninety" or "ninety, ninety-one" for B.

34. COUNT BACK FROM 20 (Informal)

Procedure: Say, "NOW I WANT YOU TO COUNT BACKWARDS, LIKE WHEN A ROCKET BLASTS OFF. FOR INSTANCE, 'THREE, TWO, ONE, BLAST-OFF.' NOW YOU COUNT BACKWARDS, STARTING FROM TWENTY."

Scoring: To pass, the child must say, "Twenty, nineteen, eighteen, seventeen, sixteen, fifteen, fourteen, thirteen, twelve, eleven, ten, nine, eight, seven, six, five, four, three, two, one." Self-correction acceptable.

35. SUBTRACTION FACTS: N - N (Formal)

Material Needed: Card 35.

Procedure: Say, "NOW I'M GOING TO SHOW YOU SOME TAKE-AWAY PROBLEMS. TELL ME QUICKLY WHAT YOU THINK THE ANSWER IS. HERE IS A PRACTICE PROBLEM."

Show the child Card 35, part A, 2-1 and say, "HOW MUCH IS TWO TAKE AWAY ONE? JUST TELL ME WHAT POPS INTO YOUR HEAD WHEN I SAY, 'HOW MUCH IS TWO TAKE AWAY
ONE? * After the child answers, point to Card 35, part B, and say, "NOW DO THIS. HOW MUCH IS TWO TAKE AWAY TWO?" Then point to Card 35, part C, and say, "HOW MUCH IS SIX TAKE AWAY SIX?"

Scoring: To pass, the child must produce a correct answer on both problems. Further, the child must get the answer quickly, within 3 seconds, and without counting. Since the aim of this item is to determine whether the child remembers the answer, he or she does not pass if he or she obviously calculates, even if a correct answer is obtained quickly.

36. COUNT BY TENS OVER 100 (Informal)

Procedure: Say, "COUNT BY TENS FOR ME STARTING WITH ONE HUNDRED." If the child makes no response, prompt by saying, "COUNT BY TENS LIKE THIS, ONE HUNDRED, ONE HUNDRED TEN, ONE HUNDRED TWENTY . . . YOU KEEP GOING."

Scoring: To pass the child must say, "One hundred, one hundred ten, one hundred twenty, one hundred thirty, one hundred forty, one hundred fifty, one hundred sixty," or, if he or she was prompted, "one hundred thirty, one hundred forty, one hundred fifty, one hundred sixty." Score the child wrong if he or she obviously whispers the intervening numbers (e.g., whispers "one hundred one, one hundred two, one hundred three . . . one hundred nine" or "one hundred eleven, one hundred twelve, one hundred thirteen . . . one hundred nineteen.")

37. ADDITION FACTS: SMALL (Formal)

Material Needed: Card 37.

Procedure: Say, "NOW I'M GOING TO SHOW YOU SOME ADDING PROBLEMS. TELL ME QUICKLY WHAT YOU THINK THE ANSWER IS. HERE IS A PRACTICE PROBLEM." Show the child Card 37, part A, 2 + 2 and say, "HOW MUCH IS TWO AND TWO ALTOGETHER? JUST TELL ME WHAT POPS INTO YOUR HEAD WHEN I SAY, 'HOW MUCH IS TWO AND TWO ALTOGETHER?'" * After the child answers, point to Card 37, part B and say, "NOW DO THIS. HOW MUCH IS THREE AND FOUR ALTOGETHER?" Then point to Card 37, part C and
say, "HOW MUCH IS SIX AND THREE ALTOGETHER?"

**Scoring:** To pass, the child must achieve a correct answer on both problems. Further, the child must get the answer quickly, within about 3 seconds, and without counting. Since the aim of this item is to determine whether the child remembers the answer, he or she does not pass if he or she obviously calculates, even if a correct answer is obtained quickly.

38. **READING NUMERALS: THREE DIGITS (Formal)**

*Material Needed:* Card 38.

*Procedure:* Show the child Card 3B* and, pointing to 105, say, "WHAT NUMBER IS THIS?" or, if necessary, "READ THIS NUMBER FOR ME." Then repeat with the 162 and then the 280. If the child simply reads the individual digits ("one, oh, five" or "one, six, two"), say, "HOW ELSE CAN WE SAY THIS NUMBER?"

*Scoring:* To pass, the child must read all three numbers properly. These answers are correct: "one hundred five," "one hundred sixty-two," "two hundred eighty." Also correct are: "one hundred and five," "one hundred and sixty-two," and "two hundred and eighty."

39. **WRITING THREE-DIGIT NUMERALS (Formal)**

*Material Needed:* Worksheet.

*Procedure:* Say, "I'M GOING TO TELL YOU SOME NUMBERS AND I'D LIKE YOU TO WRITE THEM DOWN ON THE WORKSHEET HERE." Point to Space 39 and say, "THE FIRST NUMBER IS ONE HUNDRED TWO." Pause for the child to write. Then say, "THE SECOND IS TWO HUNDRED NINETY."

*Scoring:* To pass, the child must write both numbers correctly. Reversed numerals - for example 2 0 for 290 - are considered incorrect. Penmanship is not a consideration, so that sloppy numerals are acceptable so long as no reversals take place.

40. **ADDITION FACTS: SUMS OF 10 (Formal)**

*Material Needed:* Card 40.
Procedure: Say, "NOW I'M GOING TO SHOW YOU SOME ADDING PROBLEMS. TELL ME QUICKLY WHAT YOU THINK THE ANSWER IS. HERE IS A PRACTICE PROBLEM." Show the child Card 40, part A, 2 + 2. "HOW MUCH IS TWO AND TWO ALTOGETHER? JUST TELL ME WHAT POPS INTO YOUR HEAD WHEN I SAY, 'HOW MUCH IS TWO AND TWO ALTOGETHER?'" After the child answers, point to Card 40, part B, and say, "NOW DO THIS. HOW MUCH IS SIX AND FOUR ALTOGETHER?" Then point to Card 40, part C, and say, "HOW MUCH IS SEVEN AND THREE ALTOGETHER?"

Scoring: To pass, the child must achieve a correct answer on both problems. Further, the child must get the answer quickly, within about 3 seconds, and without counting. Since the aim of this item is to determine whether the child remembers the answer, he or she does not pass if he or she obviously calculates, even if a correct answer is obtained quickly.

41. TENS IN ONE HUNDRED (Formal)

Material Needed: Card 41.

Procedure: Show the child Card 41 and say, "IN THE PICTURE HERE IS A HUNDRED-DOLLAR BILL. THE HUNDRED DOLLAR BILL IS WORTH HOW MANY TEN-DOLLAR BILLS?" If the child does not seem to understand, say, "IF YOU TRADED IN THE HUNDRED-DOLLAR BILL AT A BANK, HOW MANY TEN-DOLLAR BILLS WOULD YOU GET?"

Scoring: To pass, the child must say "ten" without calculating the result (e.g., counting by tens).

42. COUNT AFTER ME: IV (Informal)

Procedure: Say, "NOW WE ARE GOING TO DO COUNT AFTER ME. I'LL SAY SOME NUMBERS AND YOU SAY THE NUMBER THAT COMES NEXT. LIKE IF I SAY, 'ONE, TWO,' YOU SAY THE NUMBER THAT COMES NEXT." If the child is silent, say, "GO AHEAD, YOU SAY . . . ." Either "three" or "three, four" is considered correct. If the child is still silent, say, "THREE." For all children, then say, "YOU ALWAYS SAY THE NUMBER THAT COMES NEXT."

A. "ONE HUNDRED FORTY-FOUR, ONE HUNDRED FORTY-FIVE . . ."
B. "ONE HUNDRED SEVENTY-EIGHT, ONE HUNDRED SEVENTY-NINE . . ."  

_Scoring:_ To pass, the child must get both items correct by saying "One hundred forty-six" or "one hundred forty-six, one hundred forty-seven" to A and "one hundred eighty" or "one hundred eighty, one hundred eighty-one" to B.

43. WRITTEN ADDITION ACCURACY: NO CARRYING (Formal)  

_Material Needed:_ Worksheet.  

_Procedure:_ Show the child Box 43 on the worksheet. Say, "DO THESE ADDING PROBLEMS HERE."  

_Scoring:_ To pass, the child must get correct answers to both problems (23 + 15 = 38 and 64 + 32 = 96). The method used by the child is not considered in scoring these problems. Thus, the child may use the standard method, may add mentally, or may add from left to right, as long as the answer is correct.

44. SUBTRACTION FACTS: M - N = N (Formal)  

_Material Needed:_ Card 44.  

_Procedure:_ Say, "NOW I'M GOING TO SHOW YOU SOME TAKE-AWAY PROBLEMS. TELL ME QUICKLY WHAT YOU THINK THE ANSWER IS. HERE IS A PRACTICE PROBLEM." Show the child card 44, part A, 2-1. "HOW MUCH IS TWO TAKE AWAY ONE?" After the child answers, point to Card 44, part B, and say, "NOW DO THIS. HOW MUCH IS EIGHT TAKE AWAY FOUR?" Then point to Card 44, part C, and say, "HOW MUCH IS TWELVE TAKE AWAY SIX?"  

_Scoring:_ To pass, the child must achieve a correct answer on both problems. Further, the child must get the answer quickly, within about 3 seconds, and without counting. Since the aim of this item is to determine whether the child remembers the answer, he or she does not pass if he or she obviously calculates, even if a correct answer is obtained quickly.
45. **ADDITION FACTS: LARGE DOUBLES (Formal)**

*Material Needed:* Card 45.

*Procedure:* Say, "NOW I'M GOING TO SHOW YOU SOME ADDING PROBLEMS. TELL ME QUICKLY WHAT YOU THINK THE ANSWER IS. HERE IS A PRACTICE PROBLEM." Show the child Card 45, part A, $2 + 2$, and say, "HOW MUCH IS TWO AND TWO ALTOGETHER? JUST TELL ME WHAT POPS INTO YOUR HEAD WHEN I SAY, 'HOW MUCH IS TWO AND TWO ALTOGETHER?'" After the child answers, point to Card 45, part B, and say, "NOW DO THIS. HOW MUCH IS EIGHT AND EIGHT ALTOGETHER?" Then point to Card 45, part C, and say, "HOW MUCH IS SEVEN AND SEVEN ALTOGETHER?"

*Scoring:* To pass, the child must achieve a correct answer on both problems. Further, the child must get the answer quickly, within about 3 seconds, and without counting. Since the aim of this item is to determine whether the child remembers the answer, he or she does not pass if he or she obviously calculates, even if a correct answer is obtained quickly.

46. **HUNDREDS IN ONE THOUSAND (Formal)**

*Material Needed:* Card 46.

*Procedure:* Show the child Card 46 and say, "IN THE PICTURE HERE IS A THOUSAND-DOLLAR BILL. THE THOUSAND-DOLLAR BILL IS WORTH HOW MANY HUNDRED-DOLLAR BILLS?" If the child does not seem to understand, say, "IF YOU TRADED IN THE THOUSAND DOLLAR BILL AT A BANK, HOW MANY HUNDRED-DOLLAR BILLS WOULD YOU GET?"

*Scoring:* To pass, the child must say "ten" without calculating the result (e.g., without counting by hundreds).

47. **MULTIPLICATION FACTS: N x 1 (Formal)**

*Material Needed:* Card 47.

*Procedure:* Say, "NOW I'M GOING TO SHOW YOU SOME TIMES PROBLEMS. TELL ME QUICKLY WHAT YOU THINK THE ANSWER IS. HERE IS A PRACTICE PROBLEM." Show
the child Card 47, part A, 2 x 1, and say, "HOW MUCH IS TWO TIMES ONE? JUST TELL ME
WHAT POPPS INTO YOUR HEAD WHEN I SAY, 'HOW MUCH IS TWO TIMES ONE?'" After
the child answers, point to Card 47, part B and say, "NOW DO THIS. HOW MUCH IS THREE
TIMES ONE?" Then, point to Card 47 part C and say, "HOW MUCH IS SIX TIMES ONE?"

Scoring: To pass, the child must achieve a correct answer on both problems. Further, the child
must get the answer quickly, within about 3 seconds, and without counting. Since the aim of this
item is to determine whether the child remembers the answer, he or she does not pass if he or
she obviously calculates, even if a correct answer is obtained quickly.

48. SUBTRACTION ALIGNMENT (Formal)


Procedure: Show the child Card 48, part A. Say, "FRAN WAS TOLD TO WRITE DOWN THE
TAKEAWAY PROBLEM EIGHTY-SIX MINUS FOUR. DID SHE LINE IT UP RIGHT OR
WRONG?" Next use the same instruction for

B. NINETY-EIGHT MINUS SEVEN

C. SEVENTY MINUS FIVE

D. THREE HUNDRED FIFTY-SIX MINUS TWENTY-FOUR

E. FOUR HUNDRED SIXTY-EIGHT MINUS THIRTY-TWO

Scoring: To pass, the child must obtain correct answers on all problems. The correct answers
are (A) right; (B) wrong; (C) right; (D) right; (E) wrong.

49. SUBTRACTION FACTS: 10 - N (Formal)

Material Needed: Card 49.

Procedure: Say, "NOW I'M GOING TO SHOW YOU SOME TAKE-AWAY PROBLEMS. TELL
ME QUICKLY WHAT YOU THINK THE ANSWER IS. HERE IS A PRACTICE PROBLEM."
Show the child Card 49, part A, 2-1, and say, "HOW MUCH IS TWO TAKE AWAY ONE? JUST
TELL ME WHAT POPS INTO YOUR HEAD WHEN I SAY "HOW MUCH IS TWO TAKE AWAY
ONE?" After the child answers, point to Card 49, part B, and say, "NOW DO THIS. HOW MUCH IS TEN TAKE AWAY THREE?" Then point to Card 49, part C and say, "HOW MUCH IS TEN TAKE AWAY SIX?"

Scoring: To pass, the child must achieve a correct answer on both problems. Further, the child must get the answer quickly, within about 3 seconds, and without counting. Since the aim of this item is to determine whether the child remembers the answer, he or she does not pass if he or she obviously calculates, even if a correct answer is obtained quickly.

50. ADDING MULTIPLES OF TEN (Formal)

Procedure: Say, "HERE ARE SOME QUESTIONS ABOUT ADDING MONEY. WE'LL PRETEND THAT YOU HAVE SOME MONEY AND I GIVE YOU SOME MORE." The first problem is A. "IF YOU START WITH NINE DOLLARS AND I GIVE YOU ONE TEN-DOLLAR BILL, WHAT DO YOU END UP WITH?" The remaining problems are:

B. "IF YOU START WITH SIX DOLLARS AND I GIVE YOU TWO TEN-DOLLAR BILLS, WHAT DO YOU END UP WITH?"

C. "IF YOU START WITH FOUR DOLLARS AND I GIVE YOU THREE TEN-DOLLAR BILLS, WHAT DO YOU END UP WITH?"

D. "IF YOU START WITH TWO DOLLARS AND I GIVE YOU TEN TEN-DOLLAR BILLS, WHAT DO YOU END UP WITH?"

E. "IF YOU START WITH THIRTY-SEVEN DOLLARS AND I GIVE YOU ONE TEN-DOLLAR BILL, WHAT DO YOU END UP WITH?"

Scoring: To pass, the child must receive correct answers on 4 of 5 problems. The correct answers are (A) $19; (B) $26; (C) $34; (D) $102; (E) $47.

51. MENTAL NUMBER LINE III (Informal)

Material Needed: Card 51.

Procedure: Show Card 51 and, pointing to the practice box, say "NOW LET'S DO THIS. HERE
IS A SIX. WHICH IS CLOSER TO SIX, FIVE OR NINE? If the child seems confused, say, "IS FIVE CLOSER TO SIX OR IS NINE CLOSER TO SIX?" If the child is correct, say, "THAT'S RIGHT, FIVE IS CLOSER: IT'S ONLY ONE AWAY FROM SIX, NINE IS THREE AWAY FROM SIX." If the child is wrong, say, "NO, FIVE IS CLOSER: IT'S ONLY ONE AWAY FROM SIX: NINE IS THREE AWAY FROM SIX." After this practice trial, show the test items in order:

A. Say, "HERE IS TWO HUNDRED. WHICH IS CLOSER, NINETY-NINE OR FOUR HUNDRED?"

B. Say, "HERE IS FIVE THOUSAND. WHICH IS CLOSER, ONE THOUSAND OR EIGHT THOUSAND?"

C. Say, "HERE IS SEVEN HUNDRED. WHICH IS CLOSER, THREE HUNDRED OR NINE HUNDRED?"

D. Say, "HERE IS FIVE THOUSAND. WHICH IS CLOSER, TWO THOUSAND OR NINE THOUSAND?"

E. Say, "HERE IS THREE THOUSAND FIVE HUNDRED. WHICH IS CLOSER, TWO THOUSAND OR SEVEN THOUSAND?"

Scoring: To pass, the child must be correct on four out of five problems. The correct answers are (A) ninety-nine; (B) eight thousand; (C) nine hundred; (D) two thousand; (E) two thousand.

52. ADDITION ALIGNMENT (Formal)

Material Needed: Card 52.

Procedure: Show the child Card 52, part A and say, "ANDY WAS TOLD TO WRITE DOWN THE ADDING PROBLEM THIRTY-FOUR PLUS FIVE. DID HE LINE IT UP RIGHT OR WRONG?"

Next, use the same instructions for:

B. FIFTY-THREE PLUS FOUR

C. ONE HUNDRED FIFTY-SIX PLUS FORTY-THREE

D. TWO HUNDRED THIRTY-FOUR PLUS SIXTY-ONE
E. THREE HUNDRED FORTY-TWO PLUS FIFTY-ONE

**Scoring:** To pass, the child must obtain correct answers on all problems. The correct answers are (A) wrong; (B) right; (C) right; (D) wrong; (E) wrong.

53. READING NUMERALS: FOUR DIGITS (Formal)

**Material Needed:** Card 53.

**Procedure:** Show the child Card 53 and, pointing to 1,002, say, "WHAT NUMBER IS THIS?" or, if necessary, "READ THIS NUMBER FOR ME." Then repeat with the 4,073 and then the 2,301. If the child simply reads the individual digits ("one, oh, oh, two" or "two, three, oh, one"), say, "HOW ELSE CAN WE SAY THIS NUMBER?"

**Scoring:** To pass, the child must read all three numbers properly. The following are correct: "one thousand two," "four thousand seventy-three," "two thousand three hundred one." Also correct are: "one thousand and two," "four thousand and seventy-three," and "two thousand three hundred and one."

54. ADDITION FACTS: LARGE (Formal)

**Material Needed:** Card 54

**Procedure:** Say, "NOW I'M GOING TO SHOW YOU SOME ADDING PROBLEMS. TELL ME QUICKLY WHAT YOU THINK THE ANSWER IS. HERE IS A PRACTICE PROBLEM." Show the child Card 54, part A, 2 + 2, and say, "HOW MUCH IS TWO AND TWO ALTOGETHER? JUST TELL ME WHAT POPS INTO YOUR HEAD WHEN I SAY, 'HOW MUCH IS TWO AND TWO ALTOGETHER?'" After the child answers, point to Card 54, part B, and say, "NOW DO THIS. HOW MUCH IS EIGHT AND FIVE ALTOGETHER?" Then point to Card 54, part C, and say, "HOW MUCH IS NINE AND SEVEN ALTOGETHER?"

**Scoring:** To pass, the child must achieve a correct answer on both problems. Further, the child must get the answer quickly, within about 3 seconds, and without counting. Since the aim of this item is to determine whether the child remembers the answer, he or she does not pass if he or
she obviously calculates, even if a correct answer is obtained quickly.

55. WRITTEN ADDITION ACCURACY: CARRYING (Formal)

*Material Needed:* Worksheet.

*Procedure:* Show the child Box 55 on the worksheet. Say, "DO THESE ADDING PROBLEMS HERE."

*Scoring:* To pass, the child must get correct answers to both problems (\(35 + 28 = 63\) and \(57 + 46 = 103\)). The method used by the child is not considered in scoring these problems. Thus, the child may use the standard method, or may add mentally, or may add from left to right, so long as the answer is correct.

56. WRITTEN ADDITION PROCEDURE: CARRYING (Formal)

*Material Needed:* Worksheet.

*Procedure:* Show the child Box 56 on the worksheet. Say, "DO THESE ADDING PROBLEMS HERE. SHOW ALL YOUR WORK ON THE WORKSHEET AND TELL ME WHAT YOU ARE DOING. EXPLAIN EVERYTHING YOU DO TO SOLVE THE PROBLEM."

*Scoring:* To pass, the child must solve at least one problem using the standard algorithm. That is, the child must perform standard column addition, from right to left, with "carrying," as usually taught in school. For example, in \(168 + 156\), the child must first add \(8 + 6\), put down \(4\) and carry the \(1\); add \(6\) and \(5\) to get \(11\) and then add the \(1\); put down \(2\) and carry the \(1\), and so on. If the child uses a different method taught in your school, consider the answer correct.

57. SUBTRACTING MULTIPLES OF TEN (Formal)

*Procedure:* Say, "HERE ARE SOME QUESTIONS ABOUT SUBTRACTING MONEY. WE'LL PRETEND THAT YOU HAVE SOME MONEY AND I TAKE SOME AWAY." The first problem is:

A. "IF YOU START WITH EIGHTEEN DOLLARS AND I TAKE AWAY ONE TEN-DOLLAR BILL, WHAT DO YOU END UP WITH?"

B. "IF YOU START WITH THIRTY-FIVE DOLLARS AND I TAKE AWAY TWO TEN-DOLLAR
BILLS, WHAT DO YOU END UP WITH?"
C. "IF YOU START WITH FORTY-TWO DOLLARS AND I TAKE AWAY ONE TEN-DOLLAR BILL, WHAT DO YOU END UP WITH?"
D. "IF YOU START WITH SIXTY-SEVEN DOLLARS AND I TAKE AWAY SIX TEN-DOLLAR BILLS, WHAT DO YOU END UP WITH?"
E. "IF YOU START WITH ONE HUNDRED THIRTEEN DOLLARS AND I TAKE AWAY ONE TEN-DOLLAR BILL, WHAT DO YOU END UP WITH?"

Scoring: To pass, the child must receive correct answers on four out of five problems. The correct answers are (A) $8; (B) $15; (C) $32; (D) $7; (E) $103.

58. MENTAL SUBTRACTION I (Informal)

Procedure: Say, "NOW I'M GOING TO GIVE YOU SOME SUBTRACTING PROBLEMS TO DO IN YOUR HEAD, SOME TAKE-AWAY PROBLEMS LIKE, 'HOW MUCH IS EIGHT APPLES TAKE AWAY FOUR APPLES?' TRY TO GET THE RIGHT ANSWER EACH TIME. YOU CAN FIGURE IT OUT ANY WAY YOU WANT TO.
A. HOW MUCH ARE SEVENTEEN APPLES TAKE AWAY EIGHT APPLES?
B. HOW MUCH ARE EIGHTEEN APPLES TAKE AWAY SIX APPLES?
C. HOW MUCH ARE SIXTEEN APPLES TAKE AWAY FIVE APPLES?"

Scoring: To pass, the child must get all three problems correct.

59. SMALLEST AND LARGEST DIGITS (Formal)

Material Needed: Card 59 and Worksheet.

Procedure: Show the child Card 59 and say, "HERE ARE SOME WRITTEN NUMBERS. THREE IS A ONE-DIGIT NUMBER BECAUSE WHEN WE WRITE IT, WE NEED ONLY ONE NUMBER. TWENTY-FOUR IS A TWO-DIGIT NUMBER BECAUSE WHEN WE WRITE IT WE NEED TWO NUMBERS. FIVE HUNDRED SEVENTY-EIGHT IS A THREE-DIGIT NUMBER BECAUSE WHEN WE WRITE IT WE NEED THREE NUMBERS." Take away the card and show
the child Box 59 on the worksheet. Say, "WRITE THE ANSWERS TO MY QUESTIONS IN THESE SPACES.

A. WHAT IS THE SMALLEST ONE-DIGIT NUMBER?
B. WHAT IS THE LARGEST ONE-DIGIT NUMBER?
C. WHAT IS THE LARGEST TWO-DIGIT NUMBER?
D. WHAT IS THE SMALLEST TWO-DIGIT NUMBER?
E. WHAT IS THE SMALLEST THREE-DIGIT NUMBER?
F. WHAT IS THE LARGEST THREE-DIGIT NUMBER?"

Scoring: For A, either 1 or 0 is considered acceptable. The remaining correct answers are (B) 9; (C) 99; (D) 10; (E) 100; (F) 999. To pass, the child must get correct answers to all the problems.

60. MENTAL ADDITION (Informal)

Procedure: Say, "NOW I'M GOING TO GIVE YOU SOME ADDING PROBLEMS TO DO IN YOUR HEAD, LIKE, 'HOW MUCH ARE FIVE APPLES AND FIVE APPLES?' TRY TO GET THE RIGHT ANSWER EACH TIME. YOU CAN FIGURE IT OUT ANY WAY YOU WANT TO.

A. HOW MUCH ARE TWENTY APPLES AND FIFTEEN APPLES?
B. HOW MUCH ARE FOURTEEN APPLES AND THIRTEEN APPLES?
C. HOW MUCH ARE SIXTEEN APPLES AND TWELVE APPLES?"

Scoring: To pass, the child must get all three problems correct.

61. COUNT BY FOUR (Informal)

Procedure: Say, "COUNT BY FOURS FOR ME." If the child makes no response, prompt by saying, "COUNT BY FOURS LIKE THIS: FOUR, EIGHT, TWELVE . . . YOU KEEP GOING."

Scoring: To pass, the child must say, "Eight, twelve, sixteen, twenty, twenty-four." Or, if he or she was prompted, "sixteen, twenty, twenty-four." Score the child wrong if he or she obviously say or whispers the intervening numbers (e.g., whispers, "five, six, seven" or "nine, ten, eleven").
62. WRITTEN SUBTRACTION ACCURACY: BORROWING (Formal)

Material Needed: Worksheet.

Procedure: Show the child Box 62 in the worksheet. Say, "DO THESE TAKE-AWAY PROBLEMS HERE."

Scoring: To pass, the child must get correct answers to both problems (45 - 17 = 28 and 60 - 24 = 36). The method used by the child is not considered in scoring this problem. Thus the child may use the standard method, or subtract mentally, or count backward, so long as the answer is correct.

63. MULTIPLICATION FACTS: N x 2 (Formal)

Material Needed: Card 63.

Procedure: Say, "NOW I'M GOING TO SHOW YOU SOME TIMES PROBLEMS. TELL ME QUICKLY WHAT YOU THINK THE ANSWER IS. HERE IS A PRACTICE PROBLEM." Show the child Card 63, part A, 2 x 1. "HOW MUCH IS TWO TIMES ONE? JUST TELL ME WHAT POPS INTO YOUR HEAD WHEN I SAY 'HOW MUCH IS TWO TIMES ONE'". After the child answers, point to Card 63, part B, and say, "HOW MUCH IS THREE TIMES TWO?" Then point to Card 63, part C, and say, "HOW MUCH IS EIGHT TIMES TWO?"

Scoring: To pass, the child must achieve a correct answer on both problems. Further, the child must get the answer quickly, within about 3 seconds, and without counting. Since the aim of this item is to determine whether the child remembers the answer, he or she does not pass if he or she obviously calculates, even if a correct answer is obtained quickly.

64. WRITTEN SUBTRACTION PROCEDURE: BORROWING (Formal)

Material Needed: Worksheet.

Procedure: Show the child Box 64 on the worksheet. Say, "DO THESE TAKE-AWAY PROBLEMS HERE. SHOW ALL YOUR WORK ON THE WORKSHEET AND TELL ME WHAT YOU ARE DOING. EXPLAIN EACH THING YOU DO TO SOLVE THE PROBLEM."
Scoring: To pass, the child must solve at least one problem using the standard algorithm. That is, the child must perform standard column subtraction, from right to left, with "borrowing," as usually taught in school. For example for the problem 406 - 79, the child must see that 9 cannot be subtracted from 6 and that 1 cannot be borrowed from 0; then the child must borrow 1 from 4, making the 0 into 10; then the child can borrow 1 from 10, making it a 9 and the 6 a 16, and so on. If the child uses a different method taught in your school, consider the answer correct.

65. MENTAL SUBTRACTION II (Informal)

Procedure: Say, "NOW I'M GOING TO GIVE YOU SOME SUBTRACTING PROBLEMS TO DO IN YOUR HEAD. THESE ARE TAKE-AWAY PROBLEMS LIKE, 'HOW MUCH IS EIGHT APPLES TAKE AWAY FOUR APPLES?' TRY TO GET THE RIGHT ANSWER EACH TIME. YOU CAN FIGURE IT OUT ANY WAY YOU WANT.

A. HOW MUCH ARE NINETEEN APPLES, TAKE AWAY FOURTEEN APPLES?
B. HOW MUCH ARE SEVENTEEN APPLES, TAKE AWAY ELEVEN APPLES?
C. HOW MUCH ARE TWENTY-ONE APPLES, TAKE AWAY FOURTEEN APPLES?"

Scoring: To pass, the child must get all three problems correct.
Picture Book
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**PRACTICE A**

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Card 31
6 + 3

3 + 4

2 + 2
130

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12 - 6 \\
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A

B

C

2 + 2

8 + 8

7 + 7
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\[ \begin{align*}
A: & \quad 34 + 5 \\
B: & \quad 53 + 4 \\
C: & \quad 156 + 43 \\
D: & \quad 234 + 61 \\
E: & \quad 342 + 51
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1,002 4,073 2,301
2 + 2

8 + 5

9 + 7

A

B

C
## Worksheet

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APPENDIX C: MATERNAL MATH STIMULATION INTERVIEW
[The interviewer starts by thanking the mother for participating in the study]. Thank you for your participation in our study. This interview is not going to take much of your time.

**Part 1**

[The interviewer asks demographic questions about the socio-economic status of the family as follows]. Would you please tell me the educational level of your husband and yourself. Are you and your husband employed?

**Mother’s Education** [The interviewer checks the highest level completed]

- ___ some years in primary school
- ___ completed primary school
- ___ some years in intermediate school
- ___ completed intermediate school
- ___ some years in secondary school
- ___ completed secondary school
- ___ partial college
- ___ enrolled in college
- ___ specialized training (Diploma)
- ___ college degree
- ___ post-graduate training

**Father’s Education** [The interviewer checks the highest level completed]

- ___ some years in primary school
- ___ completed primary school
- ___ some years in intermediate school
- ___ completed intermediate school
- ___ some years in secondary school
- ___ completed secondary school
___ partial college
___ enrolled in college
___ specialized training (Diploma)
___ college degree
___ post-graduate training

**Parental Employment**

Mother ________________________________________________________

Father ________________________________________________________

[The interviewer then asks about the child]. Now would you please tell me how old is your child? Is he/she enrolled in a preschool program? [The interviewer should ask and probe why the child is enrolled or why the child is not enrolled].

**Age and Sex of Child**

Years____  Months____  Days____  Male____  Female____

**Early Childhood Education Enrollment**  [The interviewer checks whatever applicable]

___ No  
1- can play at home  
2- child not ready  
3- mother not employed  
4- can not afford it  

___ Yes  
1- to play  
2- prepare for school  
3- due to employment
Part 2

[In this part of the interview the interviewer asks the mother about games, books, puzzles, toys, invented games, and activities that the child do at home that may help teach numbers, counting, addition, and subtraction].

Store-Bought Games

First, I'd like to know if your child has some store-bought games and puzzles or not. [If the answer is yes, the interviewer continues as follows] Could you describe any game for me? How do you and your child use the game? In particular, what do you do and what does your child do? [The interviewer should continue probing until she gets a clear description of the character of the interaction with every game].

Use of Store-bought Games [The interviewer checks one of the following]

____ 1- no math games [the interviewer, then, skips to number books]
____ 2- math games that child uses by self
____ 3- mother help child
____ 4- mother and child play

[Then the interviewer continues as follows]. Some of these games may be specifically intended to teach about numbers, while some others may just involve numbers or counting but are not meant to teach; we can consider them as fun games. [The interviewer categorizes the games into two categories: teaching games and fun games; then proceeds as follows]. Of these games that are intended to teach about numbers, about how often does your child play with any of these at home? And, how much does your child play with these fun games? [If the child, however, has only teaching games or fun games, the interviewer asks about the games the child has].

Teaching Games

____ No
Fun Games

_____ Yes  Frequency:  ______ 1- once a month  
______ 2- twice a month  
______ 3- once a week  
______ 4- twice a week  
______ 5- four or five times a week  
______ 6- everyday

_____ No

Number Books

_____ No  

_____ Yes  Frequency:  ______ 1- once a month  
______ 2- twice a month  
______ 3- once a week  
______ 4- twice a week  
______ 5- four or five times a week  
______ 6- everyday

[The interviewer then asks the mother about number books]. Now I would like to ask you about books. Does your child have any number books? [If the answer is yes, the interviewer then continues as follows]. How often does your child look at any of these books?
[The interviewer now asks about invented games]. Do you and your child do any day-to-day activities or invented games that involve numbers or counting? [If the answer is yes, for each activity the interviewer elicits description]. How often does your child do any of these activities or games?

**Invented Games**

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<tr>
<td>Yes</td>
<td>Frequency:</td>
</tr>
<tr>
<td></td>
<td>1- once a month</td>
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<td>2- twice a month</td>
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<td>3- once a week</td>
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<td>4- twice a week</td>
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<td>5- four or five times a week</td>
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<td>6- everyday</td>
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[The interviewer then asks the mother about the child's counting as follows]. Does your child use numbers or counts spontaneously without your encouragement. [If the answer is yes, the interviewer continues as follows] Would you describe these? How often does your child seem to count spontaneously?

**Child Counting**

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<tr>
<td>Yes</td>
<td>Frequency:</td>
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<tr>
<td></td>
<td>1- once a month</td>
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<td>2- twice a month</td>
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<td>6- everyday</td>
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[Finally, the interviewer probes about the involvement of the mother counting activities].

How would you characterize your interest and involvement in doing number or counting activities with your child in the last few months? [According to the mother's response and from the interview as a whole, the interviewer rates the interest of mother in counting activities on a 5-point scale].

Mother's Interest in Counting Activities with Child

_____ 1- not interested at all
_____ 2- somewhat interested
_____ 3- interested
_____ 4- very interested
_____ 5- extremely interested
APPENDIX D: EDUCATION SCALES
<table>
<thead>
<tr>
<th><strong>Data Collection Scale</strong></th>
<th><strong>Hollingshead's Scale</strong></th>
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<tbody>
<tr>
<td>Some years in primary</td>
<td>Less than 7th grade</td>
</tr>
<tr>
<td>Completed primary school</td>
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</tr>
<tr>
<td>Some years in intermediate school</td>
<td>Junior high school (9th grade)</td>
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<tr>
<td>Completed intermediate school</td>
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<tr>
<td>Some years in secondary school</td>
<td>Partial high school (10th or 11th grade)</td>
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<td>Completed secondary school</td>
<td>High school graduate</td>
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<tr>
<td>Partial college</td>
<td>Partial college (at least one year)</td>
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<tr>
<td>Enrolled in college</td>
<td>Specialized training</td>
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<td>Specialized training</td>
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</tr>
<tr>
<td>College degree</td>
<td>Standard college or university graduation</td>
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<tr>
<td>Post-graduate training</td>
<td>Professional training (graduate degree)</td>
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</table>