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LOYOLA UNIVERSITY OF CHICAGO

MATHEMATICS ACHIEVEMENT AMONG CHINESE-AMERICAN AND CAUCASIAN-AMERICAN FIFTH AND SIXTH GRADE GIRLS

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BY
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MATHEMATICS ACHIEVEMENT AMONG CHINESE-AMERICAN AND CAUCASIAN-AMERICAN FIFTH AND SIXTH GRADE GIRLS

The inferior mathematics performance (1) of United States schoolchildren relative to that of children from China, Korea, and Japan and (2) of girls relative to boys in the United States concerns professionals in many sectors. In the United States, girls of Asian descent outperform other girls.in math. This study was undertaken to examine sociocultural factors in the development of mathematics achievement among two groups of American girls differing in ethnicity. A sample of 30 second-generation Chinese-American and 30 Caucasian-American fifth and sixth grade girls was recruited from intact families where at least one parent had a graduate degree. Subjects completed the Spatial Relations Test from the Primary Mental Abilities Test, the Children's Personality Questionnaire, a personal information and attitudes questionnaire, and an interview. The researcher also collected scores from fifth grade standardized achievement tests and spring, 1990 semester grades. Mothers and fathers of the girls completed questionnaires and were interviewed in their homes. In addition, mother-father-daughter triads were observed interacting with two mathematics computer programs. Chinese-American girls scored significantly higher on mathematics and spatial relations measures, had higher expectations for math participation, and emerged with personality characteristics (tendermindedness, undemonstrativeness, soberness, and self-assurance) that were more closely linked to mathematics achievement in this study than did Caucasian-American girls. Chinese-American parents regulated their daughters' activities more, used a more directive teaching style, used praise less frequently, pretaught math to their daughters more frequently, and had higher aspirations for their daughters' education. Chinese-American mothers expressed more positive math attitudes, demonstrated higher perceived math competence, and evidenced stronger mathematics preparation than Caucasian-American mothers. Consistent moderate to strong correlations were found between daughter variables and mother variables in the math domain, but not in the domains of language arts or science. No significant links were found for corresponding father measures and daughters' attitudes or achievement. Girls appear to be modeling their mothers' attitudes toward math. Gender stereotyping of mathematics achievement appears to be stronger among Caucasian-Americans. The mathematics superiority of Chinese-American girls can be attributed to a complex interplay of cultural, school, parenting, and personality factors.

VITA

The author, Carol Speake Huntsinger, was born in Rock Rapids, Iowa, on April 22, 1941. She entered the University of Minnesota in September, 1959, where she majored in nursery school-kindergarten-primary education, receiving a B.S. with high distinction in June, 1962.

She taught three-year-olds at the Institute of Child Welfare Laboratory Nursery School at the University of Minnesota and kindergarten in the St. Paul and Roseville, Minnesota school systems. After an eight-year parental leave, she reentered the early childhood profession as director and teacher at the Libertyville Cooperative Nursery School, Libertyville, Illinois in 1972. In addition, she began teaching early childhood education courses at the College of Lake County, Grayslake, Illinois, in 1976. She received a M.Ed. degree in early childhood education from National-Louis University in 1979.

In 1986, she resigned from Libertyville Cooperative Nursery School to pursue further education. After studying music and psychology during 1986, she entered the Erikson Institute doctoral program in child development at Loyola University of Chicago in September, 1987. From 1986-1988, she taught music to preschoolers at Northeastern Illinois University. She taught early childhood education courses at Triton College in River Grove, Illinois in 1989. She continued to teach early childhood education and psychology at the College of Lake County part-time until August, 1990, when she accepted a full-time faculty position in psychology and human services.

With Paul E. Jose of Loyola University of Chicago, she co-authored a paper, "A Test of Gardner's Modularity Theory: A Comparison of Memory for Digits and Tones," published in the Spring, 1991 issue of Psychomusicology.

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I would like to dedicate this dissertation to the memory of my father, Jay B. Speake, who was a wonderful math teacher, and to my mother, Verna B. Speake, who was a wonderful English teacher.

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CHAPTER 1

Introduction

The learning and teaching of mathematics is an area of concern to United States educators. Two strands of recent research on math achievement among schoolchildren have focused on cross-national comparisons and gender differences. Asian children have demonstrated superior math performance in most cross-national studies (Hess, Chang, & McDevitt, 1987; Miura & Okamoto, 1989; Moore & Stanley, 1986; Song & Ginsburg, 1987; Stanley, Huang, & Zu, 1986; Stevenson, 1991; Stevenson, Lee, & Stigler, 1986; Stevenson, Lee, Chen, Lummis, Stigler, Fan, & Ge, 1990; Stigler, Lee, Lucker, & Stevenson, 1982). In the California Assessment Programs of 1980 and 1982, Asian-Americans scored higher than all other groups on standardized tests of mathematics (Miura & Okamoto, 1989). In the Johns Hopkins Study of Mathematically Precocious Youth (Moore & Stanley, 1986), 68 of the 295 United States youths, who scored higher than 700 on the math portion of the SAT before their thirteenth birthday, are Asian-Americans. Fifty-six of the 68 Asian-Americans came from China, Taiwan, or Korea. The proportion of Asian youths in this select group (22%) far exceeds the percentage of Asians in the United States population (2.1%). Half of the "700M" girls are Asian. The Asian girls' SAT Math scores were higher than those of the Asian boys in the “700M” sample.

Research focusing on gender differences in the mathematics achievement of elementary school children have generally reported few or no differences (Armstrong, 1985; Benbow, 1988; Benbow & Stanley, 1980, 1983; Miura & Okamoto, 1989; Stevenson et al., 1986). The meta-analysis undertaken by Hyde, Fennema, and Lamon (1990) found that girls were slightly superior to boys in the elementary and middle school years. Around the age of 12 or 13, the performance of boys begins to increase relative to that of girls (Hyde, Fennema, & Lamon, 1990; Maccoby & Jacklin, 1974; Marshall & Smith, 1987; Visser, 1987). Girls excel in computational abilities in elementary school; boys equal girls in computation and understanding of concepts and surpass girls in problem solving in high school (Hyde, Fennema, & Lamon, 1990). Males retain that superiority through the adult years (Hyde, Fennema, & Lamon, 1990). In 1985, male performance greatly exceeded female performance on the SAT-Math test (Hyde, Fennema, & Lamon, 1990).

Among intellectually talented students, gender differences in mathematics reasoning ability are large and increase with degree of precocity. The greatest gender differences exist among the most talented United States youth (Benbow & Stanley, 1980, 1983; Chipman & Thomas, 1985; Hyde, Fennema, & Lamon, 1990; Moore & Stanley, 1986; Raymond & Benbow, 1989). Asians in the United States appear to be an exception to the rule. In the Johns Hopkins Study of Mathematically Precocious Youth, Asian girls' SAT-Math scores are higher than Asian boys' scores.

In any cross-cultural comparison, it is essential to consider the cultural contexts in which the variables of interest are embedded. In the Vygotskyian theoretical framework, one cannot separate individuals from the social and cultural settings within which they function (Rogoff, 1990; Saxe, 1991; Wertsch, 1985). Children's understandings and the cognitive achievement and social practices of the cultural group are intricately woven together (Saxe, 1991). Because the individual and the social environment are so closely intertwined, a researcher must keep both in focus when looking at questions across cultures.

The cultural traditions, derived from religious systems, political systems, economic systems, medical systems, and educational systems, are transmitted through generations, creating values and beliefs that are assumed by members of the cultural group. All these interrelated systems contribute to an individual's thinking. Rogoff (1990) states, "Cultural practices are influential in setting the problems that need solving, providing technologies and tools for their solution, and channeling problem-solving efforts in ways that are valued by local standards" (p. 43). There is an interdependence, then, between cognition and culture; they are constructed together (Cole, 1985). It is important to examine the interplay between the sociohistorical contexts and the cognitive domain of mathematics in the Chinese-American and the Caucasian-American samples in this study. How do the contexts of education among the two ethnic groups differ?

Education has a long tradition of being highly valued in the Chinese society. It has been the most important means of personal advancement for over a thousand years (Chen & Uttal, 1988; Hess et al., 1987). During that time, national examinations were the only criterion for the selection of civil servants. Even now, in China, the examinations represent the only route for rural people to move to urban areas and for people to emigrate to the United States. A high score on the National College Entrance Exams is required for admittance to college in China; only 4-5% of college-age youth are admitted to college. (Chen & Uttal, 1988; Wang & Creedon, 1989). Competition is a major source of achievement motivation for Chinese people. Wang and Creedon (1989) found that Chinese youth named career success as their most important personal goal.

Another belief commonly held by Chinese people is the belief in human malleability and self-improvement (Chen & Uttal, 1988; Farmer, Hambly, Kopf, Marshall, & Taylor, 1986; Wan, 1980). They believe that societal improvement begins with self-improvement. Chen and Uttal (1988) state, "The Confucian doctrine was cultivate yourself, regulate your family, govern well your state, then order well the kingdom" (p. 354). Education and diligent study are seen as important paths to self-improvement. Although the Chinese acknowledge that there are differences in the rates at which people learn, all people are regarded as capable of the highest achievement if they put forth enough effort. Tan (1989) writes of a father's belief in "his *nengkan*--his ability to do anything he put his mind to. It was this belief in their *nengkan* that...had given them the confidence to believe that their luck would never run out." (p. 121). Confucian doctrine speaks to "the role of mental concentration. . .the primacy of effort the need for persistence. . .and the efficacy of effort" (Hess et al., 1987, p. 180). Modern day Chinese parents and educators use legends containing vivid examples of the value of effort with their children: "Che Yin made light for his studies by carrying fireflies; and Sun Kang studied by the light of the moon reflected off the snow" (Hess et al., 1987, p. 180). Mothers also search out and alert their offspring to stories of remarkable accomplishments by children as a way of inspiring motivation (Tan, 1989).

The collective view of achievement held by the Chinese is another cultural belief influencing education (Chen & Uttal, 1988; Chin, 1988; Wan, 1980). For the Chinese, responsibilities are social and are construed in terms of relationships with other people (Chin, 1988; Farmer et al., 1986). There is a strong identification with the group and a sense of mutual obligation among its members (Spence, 1985). The concept of achievement motivation is socially-oriented. A Chinese child's achievement is viewed as a result of family or community efforts, rather than of the child's independent efforts. There is no clear division between the private and public self (Chin, 1988). The boundaries around the sense of self are more permeable and diffuse compared to American children and adults. The ideas of collective support and competition may seem incompatible to Americans. Evidence for the coexistence of the two values in the Chinese culture comes from the author's observations of Suzuki parents who encourage their own children to do their best, but who are genuinely pleased with outstanding performances on the part of other people's children.

Another Confucian value held by Asian families is that of filial piety--great respect for parents and grandparents (Chin, 1988; Park, 1983; Tweddell & Kimball, 1985; Wan, 1980). The concept is not just a fulfillment of duty to one's parents, but it includes honor and reverence for them as well. A man perceives his purpose in terms of his role as a son. Children, young and old, are expected to be obedient. Tan (1989) illustrates, "You can't ever tell a Chinese mother to shut up" (p. 173).

The United States was founded on the principles of freedom and individual rights. Self-reliance and independence have been central values associated with America since the first European settlers landed about four hundred years ago. The tradition of hard work was synonymous with the early Pilgrims and Puritans. Protestantism carried with it the traditional work ethic: work hard, make something of yourself, and become materially prosperous (Spence, 1985). From early times, children were encouraged to become self-reliant and independent--to act as autonomous individuals.

The value of effort in achievement was transmitted from parents to children in many ways. Young girls learned to embroider poems and sayings reflecting the work ethic. Typical of such poems was one delicately crossstitched by the author's great-great-grandmother, Mary Anne Hopkins in 1824 at the age of nine years (V. B. Speake, personal communication, May 22, 1991).

> Industry taught in early days not only gives the teacher praise;
> But gives us pleasure when we view the work that we are taught to do.
> Our parents with exulting joy, survey it as no childish toy;
> But as a prelude that each day, a greater genius shall display.
> Go on, my dears, strive to excel; Improve in work and reading well.

In the last forty years, the traditional value of achievement and hard work has declined in the United States. The heros of American culture are not people with whom we associate sustained effort and education (Hess et al., 1987). The country is less oriented toward scholarly achievement. Worker productivity has gone down, and students in the nation's schools are achieving more poorly. Work is now viewed as something that should be inherently satisfying, rather than simply as a means of earning money or prestige (Spence, 1985). School is looked upon as an experience that should be fun.

The 1970s saw the emergence of unbridled individualism, emphasizing the autonomous self (Spence, 1985). The sense of self in the United States has clear boundaries. At the highest levels of both Kohlberg's and Maslow's scales, the self rises above acceptance of and conformity to societal standards. The economic system, built on the idea of private enterprise, rewards conspicuous consumption. (In the 1990s, however, more environmentally responsible attitudes toward consumption appear to be emerging.) Spence concludes, "The self has been torn loose from a wider set of values that bind the person to the family and community....Working hard and striving to perform well and to succeed often have socially deleterious effects if they are not embedded in commitments to the larger community--family, country, and humankind as a whole" (p. 1292).

There are similarities in the traditional values of both cultures under study; each looks favorably on hard work and achievement. One of the most obvious differences is the individual orientation toward achievement in the United States as compared with the collective orientation in the Chinese culture. Within this framework of cultural beliefs, we will examine the specific contextual factors involved in the superior mathematics achievement of Chinese-American as compared with Caucasian-American girls. Three general hypotheses will be investigated:

1. There will be significant differences between Chinese-American and Caucasian-American fifth and sixth grade girls with respect to overall math achievement, spatial relations performance, personality factor measures, and attitudes.

2. Parents of Chinese-American girls and parents of Caucasian-American girls will provide significantly different home learning environments.

3. Parental attitudes and socialization practices will be correlated with math achievement in their daughters across both groups.

CHAPTER 2

Review of the Literature

The implicit question in investigations of cross-cultural and gender differences in mathematics performance is one of nature (biological predisposition) versus nurture (environmental factors). In the United States, laypeople often assume biological explanations for differences in performance. There are very few studies that clearly deal with possible genetic factors in explaining math performance differences, however. Because genetics interacts with environmental factors from conception, it is virtually impossible to investigate the relative contributions of biological and environmental determinants to differences in mathematics performance. Most researchers have focused on socio-cultural factors in examining differences in math achievement.

Sociocultural Explanations

Cultural Values and Practices. Environmental explanations of cross-cultural differences in mathematics achievement are usually preferred. Song and Ginsburg (1987) and Stevenson et al. (1985) conclude that the superior mathematics performance of Asian children does not result from initial genetic intellectual advantage, for general cognitive differences were not found in their samples. Stevenson, Lee, and Stigler (1986) found that family, school, and cultural support for mathematics achievement were important factors. Chinese children spent much more time on homework, and family members spent more time helping them with homework. Asian children were much more likely than American children to have a desk for studying and to report positive attitudes toward homework. Chinese teachers valued homework to a much greater degree. Young children were found to become quickly aware that education is highly prized in China and Japan.

The Chinese culture, based on Confucianism, has high regard for educational achievement and effort (Chin, 1988; Chiu, 1987; Hess, Chang, & McDevitt, 1987; Sue & Zane, 1985; Wan, 1980). Scholarship and effort are seen as major routes to social and economic advancement. In fact, Chin (1988) points out that success at each educational level, as measured by examinations, determines the course of children's lives in China. Chinese parents believe it is the parental duty to instill in their children positive attitudes toward school. The strong emphasis on achievement is not perceived as a source of stress by Chinese children in China (Chen & Uttal, 1988) because it is the norm in that cultural context.

Parents' expectations for academic success and their attributions of their children's academic achievement to effort are two important factors differentiating Asian parents from American parents (Chalip & Stigler, 1986; Chen & Uttal, 1988; Hess et al., 1987; Holloway & Hess, 1985; Stevenson et al., 1986; Stigler et al., 1982). While Asian parents attribute poor performance to lack of effort on the part of their child, American parents are as likely to pinpoint lack of ability or poor school training as the cause of poor performance. Asian parents believe that achievement precedes ability--that talent can be developed--whereas the predominant American belief is that ability underlies achievement--that talent is a God-given entity. Asian children are more likely to have an internal locus of control--the belief that they are in control of their performance (Hess et al., 1987). In the attribution literature, attributions to effort have not been shown to be as ego-enhancing as attributions to ability (Parsons, Adler, & Kaczala, 1982). Because Chinese children's self-esteem is more closely tied to the status and prestige of the family (Storfer, 1990) and

American children's self-esteem is usually viewed as an individual matter, it would seem that attribution to individual ability is probably not an important factor in the development of self-esteem for the Chinese child.

Hess et al. (1987) and Foorman, Yoshida, Swank, & Garson (1989) have discussed childrearing practices, specifically mentioning "persistence training"--an intense commitment to excellence in the pursuit of a worthwhile skill--in Japanese families. That same commitment has been noted in Chinese-American families (Huntsinger, 1989b). The Chinese culture stresses obedience to parents and respect for authority (Chin, 1988; Chiu, 1987; Hess et. al, 1987; Steward & Steward, 1973). Parent conceptions of the "good" child differ across cultures (Hess et al., 1987; Park, 1983). Asian parents value a child who is obedient, mild, gentle, and self-controlled. American parents value an assertive, socially competent, courteous child. Papousek and Papousek (1991) report that Chinese parents tend to be very indulgent of their children under four years, but insist on obedience after that. They tend to discourage exploration and activity in infants. Chinese mothers in China and the United States are more protective of their children than Caucasian-American mothers; they regulate more closely the choice of their children's toys, activities, and friends (Chin, 1988; Chiu, 1987; Huntsinger, 1989a). It is common for Chinese children in China and the United States to have homework assignments every day during the summer vacation (Chin, 1988; Huntsinger, 1989a). Sexual expression and behavior of the children in traditional Japanese (and Chinese) families is traditionally rigidly controlled (Hirayama & Hirayama, 1986). Lin and Fu (1989) have found that, although the Chinese value family interdependence and minimize the development of individuality in the family, they do encourage independence in other domains, such as school work. They conclude that cultures that develop a deep sense of respect for family values and high academic aspirations can safely encourage independence in their children.

Teaching techniques utilized by mothers and teachers vary between Asian and American cultures. In China and Japan (Gardner, 1989; Hess et al., 1987; Stevenson et al., 1986; Storfer, 1990) mothers usually emphasize the procedural (bottom-up processing) approach--they demonstrate the procedure to their children. Asian mothers expect that their child will infer the correct principle from repeated practice. American mothers, in contrast, rely on the conceptual (top-down processing) approach and expect the child to master the concept before mastering the task. Gardner (1989) contrasts the Chinese belief that skills should be taught early and that creativity emerges from well-learned skills with the Western belief that early childhood is a time for exploration and creativity, and that the elementary school is early enough to teach skills. Caudill and Weinstein's (1969) comparative study of maternal-infant behavior in America and Japan revealed that Japanese mothers do substantially more rocking and holding of their infants while American mothers are much more likely to chat with their infants. The Japanese infants are in the quiet alert state more of the time and receive more visual-spatial stimulation, whereas American infants receive more verbal stimulation. Japanese and Chinese cultural values and child-rearing practices have been described by Storfer (1990) as being very similar. American parents and teachers rely heavily on verbal explanations. It may be that the Asians develop right hemispheric brain function and spatial/structural reasoning more fully through this practice, whereas Americans rely more heavily on language and the left hemisphere.

Cognitive and Language Explanations of Cultural Differences. Several recent researchers have focused on cognitive style, cognitive representation, and language characteristics in exploring cross-national differences in mathematics achievement. Smith and Caplan (1988) used the Matching Familiar Figures Test (MFFT) to measure the reflectivity-impulsivity dimension of cognitive style in Chinese-American children. Previous studies had noted that the performance of Japanese and Chinese-American children was distinctive in that they became far more accurate on the MFFT with only small increases in latency, in contrast to American and Israeli children who became more accurate with larger increases in latency from age 5 to age 10. Japanese and Chinese children began responding more slowly and carefully (indicating greater reflectivity), whereas Israeli and American chidren began at a faster pace and made more errors (indicating greater impulsivity). Japanese and Chinese-American children showed a constant accuracy at increasing speed after age 8 and 9 respectively; American and Israeli children showed a similar increase in speed with constant accuracy at ages 11 and 12. Smith and Caplan (1988) found Japanese children to be more efficient in processing and to exhibit a developmental precocity two years ahead of children in the United States. "Japanese children may learn to set lower, but adequate criteron levels for certainty in tasks or may develop superior judgment about when to stop processing and respond," state Smith and Caplan (1988, pp. 51-52).

Foorman et al. (1989) examined the effects of interactive computer training in visual and verbal reasoning on figural matrix performance of Japanese and American schoolchildren. Verbal training consisted of verbally labeling elements and transformations, and visual training involved visually animating and executing transformations. Visually trained Japanese children responded faster than visually trained American children for every kind of single transformation. No difference was found in the second, fifth, and eighth graders' accuracies, but a difference in response latency emerged. The improvement in accuracy from the second to the fifth grade was accompanied by an increase in response latency for the American children, but not for the Japanese children. When the American children decreased their errors, they also responded more slowly, possibly demonstrating overreflectivity or compulsivity. As the matrices increased in complexity, the processing tempo gap widened. Foorman et al. concurred with Smith and

Caplan that this phenomenon was due to differences in information processing style rather than competence, for there were no national-group differences in performance on measures of general cognitive functioning, perceptual reasoning, or spatial relations.

Stigler, Lee, and Stevenson (1986) found large mean differences in forward digit span performance between Chinese and American adults. The average digit span for Chinese adults was 9 to 10 digits; the average digit span for Americans was 7 digits. Chen and Stevenson (1988) found striking Chinese superiority in digit span performance among Chinese and American 4-, 5-, and 6-year-olds. This clear superiority has been attributed to the differences between the lengths of time required to pronounce digit names in Chinese and English (Chen & Stevenson, 1988; Stigler, Lee, & Stevenson, 1986). The pronunciation duration of digits in Chinese is shorter than that of digits in English. If that robust difference exists among Chinese-American and Caucasian-American speakers of English, however, a clear Chinese-American superiority in short-term memory capacity might be indicated.

Miura and Okamoto (1989) and Miura, Kim, Chang, and Okamoto (1988) have hypothesized that differences between Caucasian-American and Japanese-American students may be due to fundamental variations in the cognitive representation of number, resulting from differences in numerical language characteristics. They noted that the superior performance of Asian students in abstract counting (Miller & Stigler, 1987), in understanding base 10 concepts (Song & Ginsburg, 1987), and mathematics achievement (Stevenson et al., 1986) is already apparent by first grade. In Japanese, Korean, and Chinese languages, spoken numerals correspond exactly to their written form. Eleven is expressed as "ten-one;" twelve is "ten-two;" and twenty is "two ten(s)." English language speakers must memorize the spoken numerals rather than relying on an orderly system.

An examination of the cognitive representation of number found that Japanese-American first graders were more likely to represent numbers using canonical Base 10 construction (tens and ones). Caucasian-American first graders were more likely to use a collection of units. When asked to represent the number 43 for example, Japanese-American children would select 4 ten blocks and 3 unit blocks, whereas Caucasian-American children selected 43 unit blocks. Japanese-American children displayed greater mental facility with number quantities, and even without formal training in numbers 10 and greater, as a group, they showed good understanding of place value.

While sociocultural explanations have been invoked almost exclusively in investigations of cross-cultural differences in math achievement, the research on gender differences takes into account the possibility of biological factors, as well. Biological factors may play a more important role in early adolescence than in middle childhood or later adolescence.

Biological Factors in Gender Differences

For the last decade, Camille Benbow and her colleagues have worked at systematically eliminating environmental hypotheses, thus supporting a biological position on gender differences in mathematics performance. Benbow and associates (Benbow & Stanley, 1980; Benbow & Stanley, 1983; Raymond & Benbow, 1986; Raymond & Benbow, 1989) differentiate between mathematics aptitude (as measured by the SAT-M) and mathematics achievement. In their investigations of the large gender difference favoring males on the SAT-M among intellectually talented junior high school students, they concluded that parental socialization patterns cannot account significantly for the gender gap in mathematical reasoning ability at that age. Benbow and Stanley (1980) stated, "We favor the hypothesis that sex differences in achievement in and attitude toward mathematics result from superior male mathematical ability, which may in turn be related to greater male ability in spatial tasks" (p. 1264). Results of the 1980 research were reported in an article in Newsweek (Williams & King, 1980) entitled "Do Males Have a Math Gene?" More recently Raymond and Benbow (1986, 1989) hypothesized that parental socialization patterns may influence gender differences in math and science achievement after junior high, but they believe socialization does not have a significant effect on mathematics aptitude prior to high school. This indicates a softening of the original position favoring genetics advanced in 1980.

Most studies involving genetic factors have addressed gender differences in spatial ability, rather than other aspects of mathematics performance. Maccoby and Jacklin (1974) identified spatial ability as one of four well-established gender differences. It has been characterized as important for mathematical performance. Spatial ability, as defined by Peterson (1976), is "the ability to visually manipulate images without the aid of verbal mediation. Tests that measure spatial ability require a mental rotation, reflection, inversion, or other transformation of an object or figure" (p. 524). Gender differences in spatial abilities favoring males after puberty have been noted by a number of researchers (Benbow & Stanley, 1980; Maccoby & Jacklin, 1974; Sanders & Soares, 1986). It has been suggested that girls reason less well in the mathematical realm because of a deficit in spatial ability. In particular, Peterson (1976) has suggested that spatial ability is related to biological factors, specifically the sex hormones. She found that the physical characteristics of less masculine boys and less feminine girls (later maturing adolescents) were positively related to spatial ability, but the mechanism and the specific hormones involved remained unidentified. She suggested that environmental factors are always important, even though there might be a biological relationship between physical and cognitive characteristics, because cultures tend to reinforce biological predispositions.

Waber (1976, 1977) found that males and females who performed better on measures of spatial ability than on verbal measures showed more hemispheric lateralization. The group who was more lateralized and better at spatial tasks tended to be later maturers, so she inferred a relationship between the pattern of cognitive functioning, the degree of brain lateralization, and the timing of puberty. She suggested that the physiological correlates of maturation influence the development of the organization of higher cortical functions and are one of the determinants of sex differences in cognition--especially for spatial visualization. She concluded that biological functions should be taken into consideration in any investigation of behavioral sex differences.

Newcombe and Bandura (1983), in a study of 85 11-year-old girls, concluded that spatial ability was positively related to (1) later maturation and (2) masculine personality traits and wanting to be a boy. Because the maturation rate and masculinity variables were shown to be independently associated with spatial ability, the authors suggested that both factors could be determinants of gender differences in spatial ability.

Diamond, Carey, and Back (1983) found that early maturing girls perform more poorly on the Embedded Figures Test and that girls in the midst of pubertal change (age 12) encoded faces less efficiently than 10- or 14-year-old girls. The authors felt that lower spatial performance could be a direct result of hormonal effects on cortical functioning, or it could be an indirect result--a reorganization of the encoding process in terms of social stereotypes that become more salient at that stage of maturation. The aforementioned four studies found no association between maturation and verbal production ability. This was interpreted as evidence for a genetic component in the development of spatial ability.

A study of women in late adolescence by Rierdan and Koff (1984) failed to confirm a relationship between maturation (the age at menarche) and spatial ability (performance on the Group Embedded Figures Test). The researchers suggested that the relationship demonstrated with younger adolescents by Waber, (1976, 1977), Newcombe and Bandura (1983), and Diamond et al. (1983) may not persist into late adolescence. Sanders and Soares (1986), however, found that the scores of college undergraduate males and females (17-22 years of age) on spatial relations measures were sometimes significantly related to the subjects' reports of when they reached puberty relative to same-sex peers. No maturation-related differences were found on the vocabulary test. Sanders and Soares explained that a scale rating of the relative timing of puberty may provide a better measure of the relevant developmental variables than does a specific benchmark event in puberty (menarche, first nocturnal emission, and first regular shaving).

Meyer-Bahlburg, Bruder, Feldman, Ehrhardt, Healey, and Bell (1985) compared 12 girls (mean age = 8.4 yrs.) who had shown signs of puberty before nine years of age and 12 normal controls, pair-matched for age and I.Q. Results showed no relationship between verbal abilities and maturation status. Lower spatial ability as measured by the Weschler Block Design and Object Assembly subtests was associated with early maturing girls. However, a relationship was not obtained between maturation status and the PMA Spatial Relations test. A slight inferiority of right-hemispheric function was suggested by poor left-ear performance on the Staggered Spondaic Word Test by the early maturing girls, but not by the other two tests of hemispheric lateralization. Because the evidence supporting the brain lateralization hypothesis lacked robustness, Meyer-Bahlburg et al. pointed out a number of plausible psychological mechanisms that could aid in explaining the link between maturation and spatial ability: parental socialization, sex role conformity, and practice with spatial activities.

Because biological explanations for the gender difference in spatial ability focus on the timing of physiological changes associated with puberty, it was important to establish typical maturation milestones for girls of Chinese and Caucasian heritage, the two ethnic groups in this investigation. Two studies using data collected in 1970 were located for comparison purposes. Age of menarche was utilized as the criterion for maturation. Ko, Heer, and Wu (1985) reported that a sample of Taiwanese females (N = 5,707) reached menarche at a mean age of 14.87 years. The mean age of menarche for a sample of white females in the United States (N = 1652) was 12.6 years of age (Udry, 1979). The average white female matured more than two years ahead of the average Taiwanese female.

Several recent researchers have challenged the importance of spatial ability in mathematics performance. Gallagher (1989) suggests that visual-spatial skill probably does not play a dominant role in problem-solving on the math portion of the SAT--the area where boys clearly surpass girls. While Weiner and Robinson (1986) found no gender differences in spatial ability among mathematically gifted seventh and eighth graders (77 boys, 62 girls), they did find that boys had significantly higher mathematical reasoning ability on the SAT-M. Weiner and Robinson conclude, "Overall evidence suggests that the hypothesis that girls reason less well mathematically because of a deficit in spatial skills may not hold for mathematically able youth" (p. 86). The relationship between maturation and spatial abilities does seem to be fairly consistently supported for the general population, however.

Affective and Attitudinal Factors in Gender Differences.

The role of attitudes and beliefs in gender differences in mathematics performance has been studied extensively (Hyde, Fennema, Ryan, Frost & Hopp, 1990). Meyer and Koehler (1990) conclude that the following affective variables have been demonstrated to have consistent links with the gender difference: confidence, usefulness, sex-role congruency, fear of success, and attributions of success and failure.

Two models explaining the role of affective variables in gender differences in mathematics achievement have been proposed. Each suggests that failure to participate in mathematics learning experiences contributes to the gender difference. Eccles et al. (1985) have developed the Model of Academic Choice which can be applied to gender differences in mathematics participation. Factors in the conprehensive model include: (1) differential aptitudes of the child, (2) cultural milieu, (3) socializers, (4) past events, (5) child's perception of socializers' attitudes and expectations, (6) child's interpretations of past events, (7) child's goals and general self-schemata, (8) child's task specific beliefs, (9) child's perception of task value, and (10) expectancies, all of which contribute to achievement behaviors. Eccles and her colleagues argue that differential course taking is the critical factor in the gender difference that appears in high school.

Fennema and Peterson (1985) developed the Autonomous Learning Behaviors model to explain gender differences in performance of complex mathematics tasks. The autonomous student is viewed as one who increasingly assumes control of his/her own learning. She/he chooses to work independently on higher level mathematical tasks. In the model, external/societal influences affect the individual's internal beliefs, specifically confidence, usefulness, sex-role congruency, and attributional style. The internal beliefs in turn influence the development of autonomous learning behaviors which contribute to sex-related differences in high-level cognitive skills. The societal influences are also seen as contributing directly to autonomous learning behaviors.

There is a concensus among researchers that differential socialization by parents is an important factor (Eccles & Harold, 1991; Visser, 1987). Visser, in a survey of South African parents (1186 fathers, 1320 mothers), found that (1) high school math participation is important for sons, but not for daughters; (2) parents agreed that math is useful; (3) fathers had more positive attitudes toward math; and (4) fathers were more inclined to stereotype math as a male domain. No evidence was found to support the idea that children model their behavior after that of the same-sex parent. Eccles and Harold (1991) found that American parents of kindergarteners and fifth- and sixth-graders gender-type mathematics as a male domain. Other researchers report that male children get more encouragement regarding math and that parents and teachers have different expectations for males' and females' mathematical achievement (Benbow, 1988; Meece, Parsons, Kaczala, Goff, & Futterman, 1982; Raymond & Benbow, 1989). In a comparison of precocious math students and modestly gifted math students in the United States, Raymond and Benbow (1989) found a trend for mothers to be more often cited as the primary source of support for verbal activities and fathers to be more supportive of their children's mathematical pursuits. Visser (1987) found that from sixth grade on, fathers were more likely to help children with math homework. Mothers helped more often with other subjects.

Parsons et al. (1982), in a survey of mathematics attitudes of children and their parents, found that parents held sex-differentiated perceptions of their children's math aptitude, despite the fact that their sons' and daughters' math achievement was similar. Parents thought that their daughters found math more difficult, but tried harder than their sons. The authors concluded that children's attitudes were more influenced by parents' attitudes about their abilities than by their own past performance. There appears, then, to be a difference between cultures regarding parental attributions. Chinese parents uniformly attribute success to hard work in both sons' and daughters' achievement, whereas American parents differentially attribute their sons' success to ability and their daughters' success to hard work. Eccles and Harold (1991), citing their longitudinal research, concluded that parents influence the child's self-perception more than the child influences the parent's perception of the child. Parents as role models did not seem to have a direct effect on American and South African children's performance (Parsons et al., 1982; Visser, 1987).

Another environmental variable that has been proposed as bearing on gender differences in math and science achievement involves the relationship between children's spatial abilities and the toys they play with (Tracy, 1987). Citing the paucity of research in this area, Tracy speculates, "For those students with little concrete experience in spatial skills (perhaps children who do not have a masculine sex role orientation?), some areas of science and mathematics may become too abstract too soon; thus mastery of the concepts is not achieved" (p. 134).

In their meta-analysis (70 studies) of effects of attitudes and affect on gender differences in mathematics, Hyde, Fennema, Ryan, Frost, and Hopp (1990) conclude that "gender differences in mathematics attitude and affect are small. The one exception is the stereotyping of math as a male domain" (p. 310). Evidence indicated that males are more likely than females to stereotype math. Only small differences were shown among males and females in levels of math anxiety. Two important omissions in the research on gender differences in mathematics attitudes and affect were noted: (1) Studies on gender and attributions of success and failure in mathematics; and (2) Studies on gender roles and stereotypes across ethnic groups.

One study that has explored the role of ethnicity in gender differences is an investigation of mathematics achievement among schoolchildren in Hawaii. Brandon, Newton, and Hammond (1987) found a small gender difference in math achievement test scores favoring girls in fourth (*d* =.12), sixth, (*d* = .15), eighth (*d* = .22) and tenth (*d* = .27) grades. Differences are reported in effect size (*d*). Two important results emerged from this data: (1) The difference favoring girls, although not robust, increases with age; and (2) gender differences favoring girls were significantly fewer and smaller for the Caucasian subsample, and more frequent and larger for the Japanese-American, Filipino-American and Hawaiian samples. Girls have generally been reported as performing better in math in the elementary school years, but the advantage typically decreases, rather than increases, around eighth or ninth grade. Brandon et al. suggested that sex differences in mathematics vary by ethnicity along a continuum ranging from moderate differences favoring girls (Hawaii) to large differences favoring boys (United States). Other researchers disagree that the differences in the United States are large (Hogrebe, 1987; Hyde, 1981; Hyde, Fennema, & Lamon, 1990; Plomin & Foch, 1981). In the Brandon et al. study, the focus is on mathematics achievement rather than aptitude. The largest differences have shown up on tests of mathematics aptitude, e. g., SAT-M. The authors recommended that sociocultural factors be taken into consideration in future studies of gender differences.

Society, in general, could benefit from a clearer identification of correlates of girls' math achievement. Uncovering reasons for the gender difference that exists in the Caucasian-American population may lead to specific recommendations for parenting and teaching practices. American women's career opportunities are limited by lack of competence and confidence in math. Occupations in computer science, actuarial science, business, engineering, physical sciences, and social sciences require well-developed mathematics abilities.

Considerable work has already been done in unraveling possible explanations for gender differences as well as for cultural differences in mathematical achievement. But there are very few studies that deal with the role of ethnicity in gender differences. How do sociocultural factors affect the mathematics achievement of girls? Ethnicity as a variable is often not considered in studies of gender differences in mathematics achievement, but it is the variable which can probably best illuminate the large gap between Chinese-American and Caucasian-American females in the mathematics domain. This study in comparing two ethnic groups within the United States--one in which girls perform successfully in math and one in which girls have traditionally performed less successfully--seeks to enlighten the issue of gender differences in mathematics achievement.

In this investigation of possible social-cultural, cognitive, and personality variables that seeks to explain the Chinese superiority in girls' math achievement, three general hypotheses will be examined:

1. There will be significant differences between Chinese-American and Caucasian-American fifth and sixth grade girls with respect to overall math achievement, spatial relations performance, personality factor measures, and attitudes. Specific predictions follow:

    a) Chinese-American girls will score higher than Caucasian-American girls on tests of mathematics achievement.

    b) Chinese-American girls will demonstrate higher achievement, but not necessarily higher aptitude, in all areas

    c) Chinese-American girls will demonstrate superior performance (higher scores and faster processing) on spatial relations measures.

    d) Chinese-American girls will evidence greater calmness, obedience, confidence, and tranquillity (scales C, E, O, and Q_4) as measured by the Children's Personality Questionnaire.

    e) Chinese-American girls will indicate more positive attitudes toward and higher personal expectancies for mathematics.

2. Parents of Chinese-American girls and parents of Caucasian-American girls will provide significantly different home learning environments. Specific predictions follow:

    a) Chinese-American parents will indicate more direct support for their daughters' math development, e.g., more time helping with homework, providing a specific place to study, more regulation of children's use of time, and minimizing distractions.

b) Chinese-American parents will express more positive attitudes toward math.

c) Caucasian-American parents will be more likely to label math as a male domain.

d) Parental attributions of their daughters' success in math will not differ between the two groups. Both groups will attribute girls' success to effort.

e) Parental teaching styles will differ. Chinese-American parents will use a more directive teaching style; whereas Caucasian-American parents will use a more indirect questioning method.

f) Chinese-American mother-father-daughter triads will display less emotion during the interaction with two math computer programs.

3. Parental attitudes and socialization practices will be correlated with math achievement in their daughters across both groups. Specific predictions follow:

a) Girls' mathematics scores will be closely related to parental expectations and measures of support.

b) There will be a strong direct relationship between parental estimates of their daughters' ability and their daughters' actual mathematics achievement.

c) Girls' perceptions of their parents' attitudes toward mathematics achievement and parents' actual attitudes will be positively related.

d) Girls' attitudes will be more closely related to their mothers' attitudes than to their fathers' attitudes.

e) Mothers' preparation in math will be linked to their daughters' attitudes and success in math.

CHAPTER 3

Method

Subjects

Thirty Chinese-American and 30 Caucasian-American fifth and sixth grade girls were recruited through a variety of sources: a Chinese-American association, churches and synagogues, public schools, Chinese schools, and summer camps in the northern and western suburbs of Chicago, Illinois. A letter (Appendix A) containing a brief description of the study and a request for volunteer subjects, was distributed to potential subjects. In addition, the researcher telephoned potential subjects through lists supplied by teachers, camp administrators, and families already committed to participating in the study. Chinese-American families were more successfully recruited through the recommendation of a friend from their ethnic group. They were unlikely to volunteer for a research study request aimed at the general public. Participation was limited to two-parent families in which at least one parent held a graduate degree and both parents were living in the home.

A very select sample was drawn for two reasons: (1) the education level of Chinese-Americans in the United States is high, and (2) the greatest gender differences in mathematics occur among the most gifted United States students. According to a report issued by the Bureau of the Census in 1988, Chinese males 33 to 44 years of age, who were residing in Illinois in 1980, had a median education attainment level of 17+ years. The median educational attainment level for Chinese women of the same age was 14.6 years. Education levels in the affluent suburban Chicago area appear to be even higher than the statewide levels.

Family composition was similar; no significant group differences were found for the gender of siblings or the birth order of the subjects. (Refer to Table 1.) The overall sample included 31 first-borns, 22 second-borns, 5 third-borns, and 2 fourth-borns. All the girls were enrolled in suburban public school fifth or sixth grades during the 1989-1990 school year. The Chinese-American girls (M = 5.77) were slightly younger than the Caucasian girls (M = 5.97) when they started first grade, $t\,(60) = -2.34$, $p < .024$. Three original subjects, not included in the final sample of 60, dropped out of the study and were replaced. One of the originals turned out to be Korean, one had an unwilling father, and the parents of the third separated prior to the parent interview.

Chinese-American Sample. The majority of families consisted of parents who had been educated in the uniform public school system in Taiwan through the bachelor's degree level and who had pursued graduate work in the United States. (The implications of the uniform educational system will be discussed in a subsequent section.) Most of the fathers had come to the United States specifically to study science or engineering in graduate school and had stayed on, a pattern very typical of Asian immigrants since the 1970's (Rawls, 1991). One had emigrated from Hong Kong, four from mainland China, and one from Singapore. Fathers had been in the United States for an average of 19 years, and mothers, for 17 years. Twenty-seven of the daughters in the sample were born in the United States and are considered second-generation Chinese-Americans. Twenty-one of the fathers held Ph.D., M.D., or D.D.S. degrees; 6 held M.S., M.A., or M.B.A. degrees; and 3 had earned B.S. degrees as their highest formal degree. The most common areas of specialization included engineering, statistics, chemistry, medicine, and computer science. While most were employed in research, administrative, or academic positions, two of the fathers were restaurant owners or chefs.

One of the Chinese-American mothers had earned a Ph.D.; 16 held M.S. or M.A. degrees; 10 held B.S. or B.A. degrees; and 3 had completed two years or less of college work. The three most common areas of specialization were business (accounting and information systems), pharmacy, and math/statistics. Seventeen of the mothers were employed full-time outside the home; three had part-time positions; and ten were full-time homemakers. Most of the employed mothers worked as computer programmers or analysts, accountants, pharmacists, or restaurant managers.

The subjects included 16 girls who would be entering sixth grade and 14 girls who would be entering seventh grade in the fall of 1990. Four of the girls reported having skipped kindergarten in elementary school; 28 were accelerated in one or more subjects. Eighty per cent of the girls reported having taken dance lessons. All 30 girls had taken music lessons; most reported having begun as preschoolers and having continued active pursuit of their original instruments through the present time. All 30 had taken piano; 19 played the violin; 6 played the flute; and 1 each studied the viola, cello, clarinet, and drums. Several girls reported winning major competitions in the Midwest, as well as playing for audiences in Washington, D.C., Korea, Russia, and several European countries. Many of the girls were studying with prominent teachers in the Chicago area. Sixty-three per cent of the girls played in their middle school orchestras, 17% played in their middle school bands, 67% sang in their school chorus, and 37% participated in dance productions. Seventy per cent had heard a major symphony orchestra concert, while only 7% reported having attended a rock concert.

Ninety-seven percent of the girls reported having received honors of some kind. Eighty per cent had been on the school honor roll, 80% had won music honors, 27% had received sports honors, 23% had received math honors, 20% had gotten writing honors, and 17% had won spelling contests. Schools varied greatly in their awards programs; academic honor recognition did not begin until sixth grade in some districts.

Forty-seven percent of the girls reported having participated on athletic teams, while 10% had had some experience as cheerleaders. Forty percent had attended a professional sports event, many as a part of a school academic awards program. Thirty-seven percent had been involved with student council in their schools, 13% had been Girl Scouts, 10% were 4-H members, and 43% reported having attended regular church events. All of the girls had travelled outside of the state of Illinois, and 97% had travelled outside of the United States, mostly to Taiwan to visit grandparents and other relatives.

Most of the families spoke Chinese in the home. Parents commonly reported that they spoke Chinese to the children and the children responded in English. Both languages were understood and spoken fluently by most family members; however, grandparents were noted to converse only in Chinese dialects.

All of the Chinese-American families lived in single-family homes estimated in value from $125,000-$750,000; many of the homes had three-car garages and spacious lots. The Chinese belief in hard work is reflected in the fact that, in addition to full-time jobs, several parents had secondary jobs, e.g., managing a second restaurant, selling art on weekends, teaching night classes. Any difficulty in scheduling interview appointments was due to the very full work and lesson schedules Chinese families maintained.

The parents appeared to be in their early to late forties. The average family had 2.4 children, with a range of 1-5 children.. The girls in the sample had an average of .7 brothers and .7 sisters. Grandparents were often a part of the household. Only two families were noted to have cats or dogs as pets. Grand pianos were common in the Chinese homes. A number of the homes featured displays of trophies won by their children for musical accomplishments. Of the families who practiced a religion, some were Buddhist and some were Christian.

Table 1

Background Characteristics of Chinese-American and Caucasian-American Samples

Characteristic	Chinese-American	Caucasian-American
Fathers		
with Doctor's Degree	20	8
with Master's Degree	6	16
with Bachelor's Degree	3	4
with less than four years of college	0	2
Mothers		
with Doctor's Degree	1	1
with Master's Degree	16	11
with Bachelor's Degree	10	16
with less than four years of college	3	2
Children per family	2.40	2.53
Girls		
mean birth order	1.70	1.57
age at first grade entrance (in yrs.)	5.77	5.97
accelerated in 1 or more classes	28	22
5th Grade in 1989-1990	16	13
6th Grade in 1989-1990	14	17
music lessons	30	28
travel outside U.S.	29	16
professional sports event attendance	12	22
symphony orchestra attendance	21	11
athletic team participation	14	22
cheerleading participation	3	6
school band participation	5	14
school orchestra participation	19	9
student council member	11	6
honors recipient	29	29
church or synagogue attendance	13	25
Girl Scout participation	4	14
hours of TV per day	1.83	2.70

Caucasian-American Sample. The entire sample had been born and educated in the United States. Eight of the fathers had earned Ph.D., M.D., J.D., D.D.S., or D.V.M. degrees; 16 had M.A., M.S., or M.B.A. degrees; 4 had B.S. or B.A. degrees; and 2 had earned less than a bachelor's degree. The most common areas of specialization included business, medical fields, education, and engineering.

The Caucasian-American mothers included 1 with a Ph.D. degree, 11 with M.A. or M.S. degrees, 16 with B.A. or B.S. degrees, and 2 with less than four years of college. Twelve mothers (40%) had majored in education; three in nursing; and two each in social work, pharmacy, and counseling. Fourteen worked full-time outside the home in the fields of their preparation; seven held part-time positions; and nine were full-time homemakers.

The subjects included 13 girls who would be sixth graders and 17 girls who would be seventh graders during the 1990-1991 school year. Twenty-two girls reported having been accelerated in at least one subject in school; none reported having skipped a grade. Sixty-seven per cent of the girls had taken dance lessons. Twenty-eight girls had taken music lessons. Nineteen had studied piano; 6 had studied clarinet; 5 each had studied violin and flute; 2 played percussion; and 1 each had studied viola, cello, trumpet, French horn, oboe, and baritone. A few girls reported beginning music lessons as preschoolers, but most had initiated lessons within the last three years. Forty-seven per cent of the girls participated in middle school band; 30% in orchestra; 70% in school chorus; and 30% in school dance productions. Thirty-seven per cent reported having attended a symphony orchestra concert; 20% had attended a rock concert.

Ninety-six per cent of the girls had received honors of some kind. The following percentages of girls reported specific honors: honor roll--60%; music--33%; sports--37%; math--37%; writing--23%; spelling--0%. Seventy-three percent of the girls had participated on an athletic team, while 20% reported some cheerleading experience. One of the girls was a national competitor in figure skating; another was a skilled gymnast. Seventy-three per cent had attended at least one professional sports event. Nearly half (47%) had been Girl Scouts, while only 3% had been members of 4-H. Involvement in student council was mentioned by 20%. All had travelled outside the state of Illinois and 53% had travelled outside this country. Eighty per cent reported regularly attending church activities; 3% reported regularly attending synagogue activities.

English was the language spoken in the homes. Most families were of northern European descent with Scandinavian and German heritage being mentioned most often. Three families had at least one Jewish parent, while the majority of the others were Christian. Their single-family homes were estimated to be valued at $125,000 - $500,000 with the average being somewhat lower than the Chinese-American sample. One family lived in a very small apartment, while another lived in a modest condominium. Parents appeared to be in their mid-thirties to early forties, about five years younger, perhaps, than the Chinese parents. The girls had an average of .93 sisters and .60 brothers. The average number of children per family was 2.53, with the range being 1-4. Two families had Down syndrome children and one family had a deaf child. Grandparents were not observed to be living in any Caucasian households. All but a few families had dogs as pets. Some families had multiple cats, birds, and other assorted animals.

The Chinese and Caucasian groups appear to be equivalent with regard to family size, gender of children, birth order of subjects, income level, age, quality of their children's schools, and likelihood of mothers to be employed. The Chinese parents appeared to be slightly older than the Caucasian-American parents, but exact ages were not noted in the data collection. Ethnicity was the main difference between groups. While the Chinese fathers' education attainment level was higher than that of the Caucasians, that artifact appears to be a function of ethnicity. Many of the Chinese fathers were allowed to come to this country for the purpose of obtaining their graduate education. They believed that they had to have one academic degree higher than native-born Americans in order to have an equal chance at a particular job. Perceived limitations in job mobility increased the relative value of education as a means of achieving success (Sue & Okazaki, 1990). Two additional factors are also important. These parents were a select group; they were some of the brightest Taiwanese to begin with. Academic achievement is so highly valued by the Chinese culture, in general. Therefore, most Chinese-American men who got graduate degrees continued to the doctorate.

There was also a difference in parental career choices. Chinese-American parents were more likely to be employed in technical or scientific jobs. Asians are more likely than people of other ethnic groups to have Ph.D.s in chemistry and engineering (Rawls, 1991). Because they are not native speakers of English, many of the Chinese parents chose fields requiring less facility in English, and more facility in math, the international language. An additional factor in the parental career choices is, very clearly, the greater value attached to science and mathematics in China. Caucasian parents (especially mothers) were more likely to have chosen education and other human service careers. There is greater uniformity among Chinese-Americans and greater diversity among Caucasian-Americans in their career choices and educational attainment levels. In most respects, however, the samples can be considered equivalent and typical of the populations from which they were drawn.

Materials

Spatial Relations Test. The Spatial Relations portion of the Primary Mental Abilities Test (Grades 4-6) (Thurstone & Thurstone, 1949) measures the ability to visualize objects and figures rotated in space and the relations between them. Because the test, originally published by SRA, is now out of print, written permission to photocopy the SRT was obtained from Robert Thurstone. The SRT is a group-administered, timed test consisting of 30 problems and 6 practice problems which takes 11 minutes to administer--5 minutes for the directions and practice problems and 6 minutes for the test itself. Subjects look at a standard figure on the left and decide which of the four figures on the right represents a rotation in a plane of the original figure. The test is normed on children ages 8.4 to 13.9. It has been widely used with Japanese, Chinese, and American grade-school children by Foorman et al. (1989) and Stigler et al. (1982), to examine cultural differences in spatial abilities. Meyer-Bahlburg et al. (1985) have employed the SRT to assist in assessing gender differences in spatial ability.

Children's Personality Questionnaire. The Children's Personality Questionnaire (Porter & Cattell, 1975) is a standardized personality measure, factorially derived, and designed for use with children ages 8 through 12. It measures 14 factorially independent dimensions of personality. There are four equivalent forms, A-D, and each form consists of two parts with 70 forced-choice questions apiece. The test is not timed, and it is estimated that each form (a total of 140 questions) takes from 30-40 minutes to complete. Form D was administered in this study. The examiner is supposed to circulate around the room to answer questions about words the children do not know. The test requires a 4th grade reading level.

The 14 bipolar scales measured in the CPQ are: (A) Reserved vs. Warmhearted, (B) Concrete-Thinking vs. Abstract-Thinking, (C) Affected by Feeling vs. Emotionally Stable, (D) Undemonstrative vs. Excitable, (E) Obedient vs. Dominant, (F) Sober vs. Enthusiastic, (G) Expedient vs. Conscientious, (H) Shy vs. Venturesome, (I) Tough-Minded vs. Tender-Minded, (J) Zestful vs. Reflective, (N) Naive vs. Shrewd, (O) Self-Assured vs. Apprehensive, (Q_3) Undisciplined Self-Conflict vs. Controlled, and (Q_4) Relaxed vs. Tense.

One-week test-retest reliability coefficients reported for the 14 CPQ scales range from .55 to .75 on Form D (Porter & Cattell, 1975). Internal consistencies reported for combined C and D forms range from .26 on the *O* scale to .71 on the *G* scale. The O_3 scale (confidence) has much lower reliability than other scales across all forms. Construct validities reported for each scale in the above hypothesis are as follows: *A* scale = .43, *B* scale = .84, *C* scale = .79, *D* scale = .68, *E* scale = .31, *F* scale = .65, *G* scale = .25, *H* scale = .52, *I* scale = .62, *J* scale = .45, *N* scale = .29, *O* scale = .55, Q_3 scale = .20, Q_4 scale = .58. Items were constructed to be as neutral as possible with regard to social desirability. The CPQ has been used with high ability, high-achieving students, has been related to arithmetic achievement, and has been used with children in different countries--primarily Caucasian countries--England, Australia, France, New Zealand, and Switzerland. Norm tables for girls and boys separately and combined are provided in the test manual. Children find the CPQ fun to take.

The Factory--Computer Program. This spatial relationships problem solving program (Kosel & Fish, 1986) was the first program used in the parent-daughter computer interaction. It requires the player to replicate a sample product--a square transformed by the use of three machines: *punch*, *rotate*, and *stripe*. The first option allows the student to experiment with the operation of the three machines. The second option, which was not used in this study, allows the student to build a factory. The third option asks students to look at a product and to work backwards to determine the process used to make the product. The student may select one of three difficulty levels: easy, medium, or hard.

Math Blaster Mystery (Davidson, 1989). Activity #1, "Follow the Steps," was used as the second program in the parent-daughter computer interaction. It is designed to help develop strategies for solving word problems step by step. The last step in each problem involves computation to get the correct answer. There are four levels of difficulty.

Each girl was asked to do the first problem in level one. (Refer to Appendix B.) She was allowed to choose the challenge level of the second problem.

Student Interview. This consisted of eight open-ended questions to be asked in an individual interview after the girl had completed the CPQ at the first session. Some of the questions were adapted from instruments used by Benbow and Raymond (1986) to assess backgrounds of children who excelled in math. The interview was pilot-tested with several children prior to use in the study. Interviews were tape-recorded. (See Appendix C.)

Student Questionnaire. A structured questionnaire of 19 questions about attitudes toward school subjects, student perception of parent attitudes, parent support, and future educational plans was given to the subjects to complete at the first session. Ten to fifteen minutes were required to answer the questions. (See Appendix D.)

Parent Interview. The instrument consisted of 12 open-ended questions designed to be used jointly with both parents. The questions covered child-rearing practices, parent support of their children's education, and parents' high school and college education. The interview was pilot-tested with other parents prior to use in the study and modified slightly. Interviews were tape-recorded. (See Appendix E.)

Parent Questionnaire. This instrument contained 13 structured-answer questions about parent background, attitudes toward school subjects, and support for their daughters' achievement. Some of the questions were selected from instruments used by Benbow and Raymond (1986) and Visser (1987) in their investigations of the relationships between parent attitudes and children's mathematics achievement. Many of the questions are identical to items on the student questionnaire. At the time of the first session, questionnaires were sent home to be completed separately by each mother and father. Parents were asked to supply their daughter's most recent school achievement test scores and June, 1990 school grades as a part of the questionnaire. Completed questionnaires were collected at the time of the home visit. (See Appendix F.)

Apparatus. An Apple IIe computer with dual disk drive and monochrome monitor was utilized for the computer interaction. Girls' interviews were tape recorded using a Panasonic RX-SA60 micro-cassette recorder. A Panasonic SlimlineIV recorder and a RadioShack omnidirectional microphone were used to record parent interviews and computer interactions. Sony audiotapes were used throughout.

Procedure

Data was gathered in two sessions with each subject. Prior to the first session, parents were asked to sign an informed consent form (Appendix G) and to set up a convenient time for the researcher to interview and test their daughters. From mid-June to early October individual or small groups of girls were tested at a large table in a quiet room in a relaxed home setting. Most of the Caucasian-American and half of the Chinese-American girls were tested in the researcher's home. Because of geographical constraints, the other half of the Chinese-American girls were tested in their own homes. It seemed unreasonable to expect the parents living more than ten miles away to transport their daughters to a central testing site. All of the parents of the girls completely removed themselves from the testing situation. During the first segment of the 1 1/2-hour testing session, a brief personal information questionnaire and the Spatial Relations Test were administered. After a five-minute break, the girls were asked to complete the Children's Personality Questionnaire, Form D. Because the CPQ is not timed, girls took varying lengths of time to complete the 140-question inventory. As each finished the CPQ, she was interviewed individually by the researcher in a separate room. Interviews were tape-recorded. At the completion of the interview, each girl was given $5.00 for participating.

As the girls prepared to leave, they were given questionnaires for each parent to complete at home.

The researcher then scheduled an appointment for a home interview with each set of parents. The home visits took place from early July to early October. Parent questionnaires were collected at this time. The format of the home visit consisted of a 30-minute tape-recorded interview with the parents, followed by a parent-child interaction with two computer programs: Factory (Kosel & Fish, 1986), which is a spatial relationships problem- solving program, and Math Blaster Mystery (Davidson, 1989), which is a math word problem program. Each interaction was tape-recorded for later transcription and coding. The parents were asked to sit on either side of their daughter, who was seated at the kitchen or dining room table in front of the computer. The researcher attempted as much as possible to maintain uniform experimental conditions throughout the interactions, but the inevitable dog barks, sibling interruptions, telephone rings, recording equipment failures, power outages, and tornado sirens occurred. (The tornado siren came just as the parent-child triad was finishing the Math Blaster computer interaction. The whole group headed for the basement!)) It is not felt, however, that these random irrelevancies significantly altered the interactions or the results.

The following directions were given for the first computer program:

> This program is called "The Factory." There are three machines in this factory--a punch machine, a rotate machine, and a stripe machine. I want you to test the machines first so that you and your folks can learn how they work. That is option #1--"Test the Machines." Then, after you feel comfortable with those machines, I want you to select #3--"Make a Product." There you will copy a product that the program gives you. (To the parents) Feel free to help her if you like.

After completing #1, "Test the Machines," the daughter selected #3. She could choose to make an easy, medium, or hard product. The goal was to eventually replicate a hard level product. Most girls chose the easy level first, followed by the medium and hard levels. After solution was reached on a hard level problem, the Math Blaster Mystery program was loaded into the computer. After the girl typed her name as requested by the program, the researcher gave the following directions :

> "Follow the Steps" is highlighted. That is the activity I want you to do; so just press "enter." I want you to do problem #1, level #1 first. After you solve that, if you want to move to a harder level, you may. I want you to do a total of two problems on this program.

The following data were coded through visual observation for each participant and recorded by the researcher during the interaction: (a) demonstrations (mainly gestures showing rotation); (b) orientations to the computer (touching, pointing); (c) looks at child (d) looks at father; (e) looks at mother; (f) laughs; and (g) touches child (Figure 1). It must be noted that behaviors c, d, e, and g which were coded through visual observation by the researcher, were possible for only two participants of each parent-child triad. To establish reliability on the above data, the researcher employed and trained a female teacher, who was uninformed of the research predictions, to code the above behaviors (a-g) through visual observation during seven of the interactions (four Chinese and three Caucasian). Agreement of 70% was established through this process. Several original categories were dropped or combined as a result of the interrater experience. Smiles, for example, were too difficult to code reliably. Some subjects smiled through the whole interaction. Originally the researcher had set up separate categories for pointing to the computer screen, pointing to the keyboard, touching the screen, and touching the keyboard. These four were collapsed into a category called "orientations to the computer." The parents and girls

Figure 1

Computer Interaction Coding Form

Observation of Parent-Child Interaction I. D. # _____ Date ______

(Behaviors Coded Visually) **Father** **Mother** **Child**

Demonstrates

Points to keyboard

Points to screen

Touches keyboard

Touches screen

****

Looks at child

Looks at mother

Looks at father

Laughs

Touches child

****

(Behaviors Coded From Audiotape Transcription)

MD
Makes directive statement.

GI
Gives information, explanation.

ANSQ
Answers question

AQ
Asks question

EC
Encouraging comment,praise

DC
Discouraging comment

ASE
Acknowledges statement, exclaims

RA
Reads aloud

seemed to be oblivious to the audio recording and the experimenter's note taking during the interaction. Their behavior seemed completely spontaneous.

The 30-minute audiotapes were transcribed by the researcher and two other transcribers. When this task was completed, the researcher listened to all of the tapes to check the accuracy of the transcriptions. The researcher noted the following three times from the tapes: (a) time spent on the combined easy and medium levels, (b) time spent on the hard level of Factory, (c) time spent on Math Blaster Mystery. Utterances from the transcriptions of the hard level of Factory were coded using the following scheme: MD = makes directive statement; GI = gives information or explanation; ANSQ = answers question; AQ = asks question; EC = encouraging comment; DC = discouraging comment; ASE = acknowledges statement, or exclaims; RA = reads aloud. (See Figure 1.) The above eight-act system was applied to utterances by each father, mother, and daughter. Each of the categories was tallied for each participant and was normalized by dividing by the number of minutes the interaction took. (See Appendix H.)

Intercoder reliability was established through employing and training a female college student unaware of the hypotheses to code the verbal data from seven randomly selected interactions. A four-page coding manual was used. Reliabilities of 85% to 100% were achieved through this process. The most troublesome category was EC--encouraging comment. It was necessary to listen to the tone of voice used by the parent or child to determine whether a comment was encouraging. A second listening to the tape clarified the questions that arose.

To insure confidentiality, all research materials were coded with family ID numbers. Names of the child and parents were excised as soon as the information was coded. The master list of names and ID numbers was kept in a locked file to which only the investigator has access. To avoid misunderstandings and misinterpretation, the investigator did not provide specific information to parents about their daughter's performance . All information obtained was kept confidential and was analyzed anonymously.

Limitations

It was not possible to get a random sample of either Chinese or Caucasian families. The Chinese are unlikely to volunteer for anything aimed at the general public. They are not as familiar with psychological research as they are with biological or physical science research. Because they are a minority and have been victims of prejudice, their willingness to participate was enhanced when a known and respected Chinese leader endorsed the study. Because parental permission and cooperation were required, perhaps only those parents whose children were doing well agreed to participate. It is possible for the previous statement to be more characteristic of Chinese-American parents because of the greater cultural emphasis on high achievement. However, the researcher had no reason to believe that this was the case in this study. The percentage of Caucasians in the suburban population is much greater; therefore, the Caucasian sample was more easily obtained. Most educated Caucasian parents are familiar with psychological and educational research and volunteered readily for the study.

As noted at the beginning of this chapter, the samples obtained were from a very select population. The selection criteria were set up because the researcher knew that the educational levels of the Chinese-Americans living in the area were high. Therefore, the results of this study are not readily generalizable to the general population.

Some of the data gathered was retrospective, especially that about the early childhood period. Parents and girls alike had to depend on their memories for answers to questions about favorite toys, books, and academic courses, for example. Recall memory may not be as accurate as one would wish; people often unconsciously reconstruct the details of specific phenomena over time.

The answers to the questionnaire and interview items were self-report data, which is always subject to certain problems. Questions were phrased so as to be as neutral as possible to avoid response bias. The researcher felt that both cultures were equally comfortable with the methods and procedures used and that parents and girls alike were sincere and honest in their responses. One must assume that people are telling the truth on self-report measures.

It would have been preferable to videotape the computer interactions to facilitate interrater reliability for the data coded visually by the raters. It was very difficult for two observers to observe from the same vantage point in a variety of kitchen and dining room settings. However, introducing a video camera may have influenced the spontaneity of the interactions. The participants tended to forget about the audiotape recording, but the obvious presence of a video camera might have made them more self-conscious. As a practical matter, the researcher had plenty of equipment to handle as it was.

In some ways, it may have been advantageous to administer a uniform mathematics test similar to the one used by Stevenson et al. (1990), rather than depending on previously administered school achievement tests. The data from each subject would have been directly comparable for purposes of statistical analysis. (The problems are specifically addressed in Chapter 4.) However, there would have been some disadvantages to a uniform test. First of all, the subjects would have known that mathematics was the topic under investigation. As it was, no one was aware of what was being assessed until after the computer interaction. Therefore, the resulting data should not reflect any bias in that regard. Second, the school-administered achievement tests provided the researcher with much rich data about the subjects' non-mathematics achievement. It enabled the researcher to view mathematics achievement in the broader context of overall academic achievement. Third, an additional test would have made the data collection sessions intolerably long. As it was, the subjects were not fatigued at the close of the testing session.

For added validity, it would have been desirable to have obtained a subjective assessment of personality from the girls' teachers for comparison with the objective personality questionnaire. Had the researcher been able to use a large school system for the study, it would have been feasible to ask teachers to rate the girls on a scale of personality characteristics. Because the data was collected over the summer from girls in at least twelve different school districts, however, that possibility seemed too cumbersome.

Because boys are not included in the design of this study, statements regarding gender differences within cultures cannot be made. A future study will explore contexts of achievement for boys in these two cultures.

CHAPTER 4

Results

Hypothesis I

There will be significant differences between Chinese-American and Caucasian-American fifth and sixth grade girls with respect to overall math achievement, spatial relations performance, personality factor measures, and attitudes toward math.

Achievement Measures. Because the girls came from different suburban school districts, achievement test scores were taken from five different tests: Stanford Achievement Tests, SRA, Iowa Tests of Basic Skills, Metropolitan Achievement Tests, and California Tests of Basic Skills. All tests contained a math computation subtest and a composite math score. Four of the tests contained separate math applications and math concepts subtests. The CTBS and the Iowa tests, however, combined the two in a subtest of math concepts and applications. A multivariate analysis of variance performed on the achievement cluster consisting of the following scores--reading comprehension, spelling, math computation, concept of numbers, math applications, total math, and total language--was not significant, $F(8, 43) = 1.59$, $p = .157$. Missing values for particular subtests proved to be problematic in that the MANOVA procedure rejected eight cases (seven Chinese and one Caucasian) on the basis of missing values. Univariate F-tests on the remaining 52 cases showed a significant difference in spelling and a marginally significant difference in concept of numbers. The mean scores for spelling were 90.44 for Chinese-Americans and 80.35 for Caucasian-Americans, $F(1, 50) = 5.90$, $p < .025$. The means for number concepts were 94.30 for Chinese-Americans and 90.17 for Caucasian-

Americans, $F(1, 50) = 3.61$, $p = .063$.

Independent t-tests (see Table 2) performed on the achievement measures indicated significant differences in the predicted direction between groups on the mathematics

Table 2

Mean Achievement Subtest Percentiles and Spatial Relations Test Scores

	Chinese-American		Caucasian-American		
Test	N	Score	N	Score	t
Word Study Skills	17	85.6 (14.2)	30	76.8 (17.5)	1.75*
Reading Comprehension	26	91.0 (9.3)	30	88.7 (13.8)	n.s.
Vocabulary	25	85.9 (13.5)	29	84.9 (14.8)	n.s.
Spelling	26	91.3 (9.3)	29	80.3 (18.0)	2.88**
Language	21	93.8 (5.8)	29	90.3 (8.9)	1.70*
Concept of Numbers	26	94.7 (4.7)	29	90.2(9.4)	2.29*
Math Computation	27	93.8 (7.8)	29	87.5 (14.7)	2.01*
Math Applications	26	93.5 (7.6)	29	91.5 (10.2	n.s.
Social Science	20	85.5 (11.6)	18	85.5 (12.6)	n.s.
Science	20	87.5 (10.5)	18	87.2 (13.1)	n.s.
Using Information	21	91.8 (5.6)	28	85.0 (14.4)	2.25*
Total Reading	21	88.9 (9.1)	28	90.4 (10.1)	n.s.
Total Math	28	96.0 (4.4)	29	92.3 (8.8)	1.97*
Total Language	28	93.8 (7.7)	29	90.4 (11.0)	n.s.
Spatial Relations Test	30	127.4 (14.2)	30	118.6 (16.2)	2.24*

*$p < .05$. **$p < .01$.

Note. Percentile ranks were taken from five different achievement tests: Stanford, Iowa, California, SRA, and Metropolitan. Each test battery had a different combination of subtests, resulting in variation in N's. Standard deviations are reported in parentheses.

measures: number concepts, computation, and total math.

Chinese-Americans outperformed the Caucasian-Americans in number concepts, $t(42.35) = 2.29$, $p < .025$. The Chinese-American mean for math computation was significantly higher than the Caucasian-American mean, $t(43.28) = 2.01$, $p < .025$. And the Chinese-American mean for total math was higher than the Caucasian-American mean, $t(41.54) = 1.97$, $p < .05$. There was significantly greater variability among Caucasian-Americans on all achievement measures; therefore, the degrees of freedom reported are for separate variances. One-tailed probabilities are used because it was predicted that Chinese-American girls would do better on math achievement measures.

Significant differences were also noted in spelling, but not in reading comprehension or total language. In spelling, the Chinese-American mean was higher than the Caucasian-American mean $t(43.06) = 2.79$, $p < .01$. However, no significant difference was seen between the percentile ranks of the two groups in reading comprehension, $t(51.17) = 0.72$, $p = .463$. And Chinese-American girls did not perform significantly better than Caucasian-American girls in total language, $t(50.09) = 1.32$, $p = .194$.

A multivariate analysis of variance performed on an achievement cluster consisting of social studies, science, math, and language arts semester grades was not significant, $F(5, 54) = 1.67$, $p = .157$. Univariate results approached significance for semester grades in math; the Chinese-American mean was 4.23 and the Caucasian-American mean was 3.92, $F(1, 58) = 3.70$, $p = .059$. Grade points were computed as follows: A = 4.00 points; B = 3.00 points; C = 2.00 points, with .5 point added to a grade obtained in an accelerated class. Twenty-four Chinese-American girls and 16 Caucasian-American girls reported being accelerated in math. While the main purpose of this paper involves the math domain, between-group differences in domains other than math were predicted. It is interesting that a significant difference favoring Chinese-American girls also emerged for language arts semester grades; the mean of the Chinese-American sample was 4.30, and that of the Caucasian-American sample was 4.05, $F(1, 58) = 4.36$, $p < .05$.

Computer Interaction: Computation. In the computer interaction with the Math Blaster Mystery program, Chinese-American mother-father-daughter triads (M = 7.08 minutes) solved the first problem significantly more quickly than did Caucasian-American triads (M = 8.15 minutes), $t(42) = -1.68$, $p < .05$. The first problem was a word problem involving computation (Appendix B).

Spatial Relations Measures. Chinese-American girls obtained higher scores on the Spatial Relations Test (see Table 2). The Chinese-American mean was significantly higher than the Caucasian-American mean $t(58) = 2.24$, $p < .025$. While a multivariate analysis of variance performed on an achievement cluster of semester grades and the SRT was not significant, $F(5, 54) = 1.67$, $p = .157$, univariate results were significant for the Spatial Relations Test; $F(1, 58) = 5.02$, $p < .05$.

Computer Interaction : Spatial Relations. It was predicted that Chinese-American girls would demonstrate faster processing times on spatial relations measures. The computer interaction with the Factory program was utilized to assess processing time. The Chinese-American parent-child triads took an average of 11.48 minutes to get from their first exploration of the program to solution of a hard level problem. The Caucasian-American triads required a mean of 14.19 minutes. The difference in processing times approached significance, $t(45) = -1.58$, $p = .063$. It was observed that the Chinese-American parents offered help less frequently than did the Caucasian-American parents. This will be explored further in a subsequent section.

Personality measures. The personality patterns that emerged from the multivariate analysis of variance performed on the Children's Personality Questionnaire scores revealed expected differences between the two groups, F(14, 45) = 4.25, $p < .0001$. Significant univariate effects were found for Factors C, D, F, I, J, and O (see Table 3).

Table 3

Mean Scores for the Children's Personality Questionnaire

Factor			Chinese-American	Caucasian-American	*F*
Low Score		High Score			
Reserved	vs.	Warm-hearted (A)	5.4 (1.4)	5.2 (1.4)	n.s.
Concrete-Thinking	vs.	Abstract-Thinking (B)	7.5 (1.5)	7.5 (1.2)	n.s
Affected by Feeling	vs.	Emotionally Stable (C)	6.6 (1.5)	7.4 (1.4)	4.55*
Undemonstrative	vs.	Excitable (D)	3.6 (1.7)	4.6 (1.7)	5.17*
Obedient	vs.	Dominant (E)	4.6 (1.7)	5.1 (1.3)	n.s.
Sober	vs.	Enthusiastic (F)	3.9 (1.5)	5.5 (1.5)	16.51***
Expedient	vs.	Conscientious (G)	5.6 (1.6)	5.7 (1.7)	n.s
Shy	vs.	Venturesome (H)	5.2 (1.8)	5.4 (1.8)	n.s.
Tough-Minded	vs.	Tender-Minded (I)	5.4 (1.9)	3.8 (1.4)	14.64***
Zestful	vs.	Reflective (J)	3.6 (1.9)	2.8 (1.4)	3.98*
Naive	vs.	Shrewd (N)	3.5 (1.1)	4.1 (1.5)	n.s.
Self-Assured	vs.	Apprehensive (O)	4.6 (1.9)	6.2 (1.7)	11.85***
Undisciplined Self-Conflict	vs.	Controlled (Q_3)	6.4 (1.1)	6.3 (1.1)	n.s.
Relaxed	vs.	Tense (Q_4)	4.6 (1.7)	4.7 (1.8)	n.s.

*$p < .05$. **$p < .01$. ***$p < .001$.
Note. Standard deviations are reported in parentheses.

The Chinese-American sample tended to be more affected by feelings (Factor C) than the Caucasian-American sample, $F(1, 58) = 4.55$, $p < .05$. Chinese-American girls tended to be less demonstrative and excitable (Factor D) than Caucasian-Americans, $F(1, 58) = 5.17$, $p < .05$. Chinese-American girls tended to be more sober and prudent (Factor F) than Caucasian-American girls, $F(1, 58) = 16.50$, $p < .0001$. Chinese-American girls tended to be more tender-minded (Factor I) than Caucasian-American girls, $F(1, 58) = 14.64$, $p < .0001$. Chinese-American girls tended to be more circumspect and reflective (Factor J) than Caucasian-American girls, $F(1, 58) = 3.98$, $p = .051$. Chinese-American girls tended to be more confident and self-assured (Factor O) than Caucasian-American girls, $F(1, 58) = 11.85$, $p < .001$.

Leisure Activities. The two groups of girls responded similarly when asked, in an open-ended question, how they liked to spend their free time. (The number in parentheses indicates the frequency of citation.) Chinese-American girls named reading (22), playing with friends (13), watching TV (7), and going shopping (5) as their preferred leisure-time activities. Caucasian-American girls mentioned reading (19), playing with friends (14), playing games (8), and playing outside (7) most often. Collapsing all the sports-related activities into one category showed Caucasian-American girls (25) mentioning sports more often than Chinese-American girls (15) did.

Math Attitudes. The predicted differences in attitudes toward mathematics were partially borne out by the results. When asked to rate how much they liked mathematics on a scale of strong like (1) to strong dislike (5), the Chinese-American girls' mean rating was 1.60; the mean rating for Caucasian-American girls was 2.00, $t(44.13) = -1.42$, $p = .081$. When asked to rank nine school subjects from most favorite (1) to least favorite (9), Chinese-American girls' mean rank of mathematics was 3.14; Caucasian-American girls' mean was 4.00, $t(53.49) = -1.33$, $p = .094$. While neither of the attitude measures met the

.05 level of significance, the results may indicate a trend toward more positive attitudes regarding math on the part of Chinese-American girls. Variability was greater among Caucasian-American girls' ratings and rankings of math; therefore the degrees of freedom reported are for separate variances. No Chinese-American girl expressed a dislike for math, while 17% of the Caucasian-American girls did. The percentage of girls expressing a strong like for math was 53% in each group. The only other subject area with a large discrepancy in variability was social studies, which Chinese-American girls (M = 1.64) rated significantly higher than Caucasian-American girls (M = 2.33), $t(44.96) = -2.61$, $p < .01$.

When the girls were asked how many years of high school math they would like to take, Chinese-American girls (M = 3.62) indicated plans to take significantly more mathematics than Caucasian-American girls (M = 2.90), $F(1, 56) = 6.12$, $p < .025$. Several Chinese-American girls volunteered that their fathers would make them take math all four years. When one of them was asked, "If you had a choice, what would you do?" she replied, "I'd do the same thing because math is important." Another girl laughed as she said, "I probably don't have a choice, considering my parents. One Chinese-American girl said, "I don't really like math." Seven of them said, "I like math." A total of six Caucasian-American girls spontaneously expressed dislike of math. One Caucasian-American girl reflected the opinions of several others when she said, "I don't like math. I'm good at it, but I don't like it." Another said, "The least amount possible. Numbers don't get along with me." Another responded, "Only the minimum requirements. I hate math." Several others spontaneously said, "I hate math." Nine girls volunteered, "I like math a lot."

Two indices were used to ascertain the girls' perceived competence: (a) a question about the difficulty of various school subjects for them, and (b) the choice of a more difficult level for the second problem on Math Blaster Mystery (challenge-seeking behavior). No significant between-group differences emerged in the girls' responses (on a five-point scale) to the item, "Indicate how difficult each of the following is for you." Chinese-Americans (M = 2.12) and Caucasian-Americans (M = 2.25) held similar attitudes about the difficulty of math for them, F(1, 47) = 16, p = .687. Twenty-three Chinese-Americans rated math as "very easy "or "easy" and two rated it as "difficult." Nineteen Caucasian-Americans thought math was "very easy" or "easy," while five rated it as "difficult "or "very difficult."

During the computer interaction, the girls had the choice of moving to a more difficult level or staying at the easiest level for the second problem in Math Blaster Mystery. It was thought that Chinese-American girls might more frequently seek the challenge of a harder level. However, the two groups actually made similar choices: 61% of the Chinese-American girls sought a greater challenge, while 64% of the Caucasian-American girls elected a higher level of difficulty.

Girls in the two ethnic groups responded differently to an open-ended question asking what careers they might choose. Chinese-American girls' top four choices were as follows: medicine (25%), architecture (13%), education (11%), and writing (9%). Caucasian-American girls chose the following: education (28%), medicine (14%), art and design (9%), and music and dance (8%). Chinese-American girls choices reflected more interest in scientific careers, which traditionally have been considered more masculine. Caucasian-American girls were more likely to choose traditionally feminine careers in education and the arts.

In summary, Chinese-American girls outperformed Caucasian-American girls in mathematics achievement and spatial relations measures as well as in most non-math areas. In addition there were striking personality differences. Chinese-American girls' responses indicated tendencies to be more affected by feelings, less demonstrative, more sober, more tender-minded, more reflective, and more self-assured than Caucasian-American girls. While there was only a trend for Chinese-American girls to exhibit more favorable attitudes toward math, their expectations for taking future math courses were significantly higher.

Hypothesis II

Parents of Chinese-American girls and parents of Caucasian-American girls will provide significantly different home learning environments.

Direct Parent Support. On some measures, Chinese-American parents showed more direct support for their daughters' achievement. Chinese-American parents reported that 63% of the girls studied at a desk in their room or in a study; the corresponding Caucasian-American percentage was 27%. Twenty-seven per cent of Chinese-American and 30% of Caucasian-American girls studied at the dining table; 7% of Chinese-Americans and 37% of Caucasian-Americans reported studying all over the house.

Chinese-American parents reported more restriction of their daughters' television viewing. Seventy-three percent of Chinese parents and 43% of Caucasian parents imposed both content and time limitations. Content limits only were set by 10% of Chinese and 30% of Caucasian parents. Chinese-American girls ($M = 1.83$) reported watching significantly fewer hours of television per day than did Caucasian-American girls ($M = 2.70$), $t(58) = -2.43$, $p < .01$.

In answering the question of who helps the daughter with her mathematics homework, Chinese-American mothers and fathers reported a somewhat greater role for the mother than did Caucasian parents. Chinese-American mothers (and fathers in parentheses) reported the following: 33% (27%) said mothers helped, 33% (60%) said fathers helped, and 27% (7%) said both parents helped. There was closer agreement between Caucasian mothers' and fathers' reports. Among Caucasian-American mothers (and fathers in parentheses), 17% (23%) reported mothers helped; 50% (53%) reported fathers helped, and 30% (23%) said both parents helped.

A different pattern emerged for literature homework. More Chinese-American than Caucasian-American fathers were reported as helping with literature homework. There was greater agreement among Chinese mothers and fathers. Chinese mothers' (and fathers' in parentheses) reports indicated the following: 30% (30%) said mothers helped, 20% (23%) said fathers helped, 13% (3%) said both parents helped, and 13% (13%) said siblings helped. Among Caucasian-American mothers (and fathers in parentheses), 63% (47%) said mothers helped with literature homework; 3% (7%) said fathers helped, and 27% (33%) said both parents helped.

In summary, Chinese-American parents were more likely to report that their daughters studied at a desk away from family activities, and that they were more restrictive regarding television viewing limits and more egalitarian in giving homework assistance to their daughters. The Caucasian-American parents tended to divide assistance with homework along traditional sex-typed lines. Fathers were more likely to help with math homework and mothers were much more likely to help with literature.

In the interview, parents were asked to name ways that they had facilitated their daughters' reading, math, and science development. (See Appendix J.) The number of ways each couple mentioned was tallied. No significant differences were found between the mean numbers of ways Chinese-American and Caucasian-American parents reported having facilitated math and reading, but a marginally significant difference did emerge for ways of facilitating science. The Chinese-American parents ($M = 4.38$) named fewer ways of facilitating science than did the Caucasian-American parents ($M = 5.43$), $\underline{t}(57) = 2.37$, $\underline{p} < .025$. Overall, parents named significantly fewer ways of facilitating math ($M = 4.12$)

than ways of facilitating reading (M = 4.83) and science (M = 4.92), ts(58) = -2.71, -2.86, ps < .01, .01.

The qualitative analysis of parents' answers is more revealing. A number of the Chinese parents reported preteaching math to their daughters, enrolling them in special private Chinese math programs, requiring them to do a number of extra math problems daily, playing tapes of the multiplication tables when their daughters were preschoolers, checking their daughters' math homework daily, and assigning math problems during summer and holiday school breaks. Most who indicated they had done preteaching had begun at the preschool and primary levels. They explained their belief: if you keep a young child ahead of her classmates, she will gain a lasting sense of competence in math. Fifty per cent of the Chinese-American parents reported giving daily supplemental mathematics homework. Several reported that by the time the girls were in fourth grade, they had enough math homework from school. Several also voiced their belief that music and math are related abilities and expressed confidence that music training would enhance math acquisition and memory. Two mothers had obtained the math books used in fifth and sixth grades in Taiwan or Singapore. A number expressed displeasure with the way math is taught in the public schools in this country and concern that their daughters would be behind in math if they were to go back to Singapore or Taiwan. Several voiced the need for daily practice in calculating without the use of calculators, explaining that junior high was early enough for calculators. Three pairs of Chinese-American parents spontaneously pointed out that they did not give extra homework to or do preteaching of their daughters.

One of the families reported having recently joined the Kumon Mathematex home teaching program (Reingold, 1990). The program, which originated in Japan in 1958, seeks to increase speed and accuracy in calculation through a series of graduated worksheets and timed tests. Students must achieve 100% on a timed test before they can move to the next level of problems. The parents in this case required their daughter to do five pages of math (100 questions) per day. Parents who enroll their child are expected to correct the child's work immediately and to take the children for regular progress tests when they have reached the criterion level on their home timed tests.

In contrast, the Caucasian-American parents were more likely to report facilitating their daughters' math development through indirect experiences: imaginative play, games, puzzles, and practical experiences. They were more apt to have bought electronic math learning aids like Speak 'n Math and Dataman. Nine of the families had used flash cards; one reported using them every night. One parent reported using worksheets. One mother (reflecting her own attitude) said, "We're aware that math isn't as much fun," so they tried to make it fun. The focus of Caucasian-American parents seemed to be on building attitudes toward math and basic foundations for math concepts, rather than on developing basic skills in math.

Early Childhood Environment. The parents and girls were asked independently about what toys were favorites during the preschool years. Caucasian-American parent responses included construction toys (blocks) (11), books (11), miniature people and animals (6), stuffed animals (12), dress-ups (10) , tricycles (8), and drawing supplies (9) much more often than did Chinese-American parent responses. Chinese-American parents more often reported dolls (17), guns (2), games with rules (4), and "never played with toys" (2) Collapsing across ethnic groups, parents named dolls (27), stuffed animals (19), construction toys (16), dress-ups (13), drawing supplies (13), books (11), and puzzles (11) most frequently. The parents' answers may reflect what the children played with most often, while the girls' responses may indicate their emotional favorites.

The girls' responses differed somewhat from those of their parents. Caucasian-American girls named miniature people and animals (9), drawing supplies (5), and musical toys (3) more often than Chinese-American girls. Chinese-American girls named dolls (15), construction toys (blocks) (8), and "never played with toys" (3) more often that Caucasian-American girls. Across both ethnic groups, dolls (26), stuffed animals (26), construction toys (13), and miniature people and animals (12) were most commonly remembered as favorites by the girls. Traditionally feminine toys were named more often than traditionally masculine toys by parents and daughters in both ethnic groups.

A big difference emerged in the parents' reports of frequency of reading aloud to their daughters as preschoolers. Daily reading was reported by 90% of Caucasian-Americans and 47% of Chinese-Americans. Three to four times per week was reported by 3% of Caucasian-American parents and 13% of Chinese-American parents. Seven per cent of each group reported reading aloud once or twice a week. Thirty-three per cent of the Chinese-American parents reported reading to their daughters rarely or never. Many of those who did not read aloud explained that they did not want their daughters to pick up their accent when reading English. Some parents read to their daughters in Chinese.

Ninety-seven percent of Caucasian-American and 80% of Chinese-American parents reported that their daughters enjoyed being read to. Three percent of Caucasian-American and 20% of Chinese-American parents said their daughters did not enjoy being read to.

Parents' Math Attitudes. A 2 x 2 multivariate analysis of variance involving the between-subject factor of ethnicity and the within-subject factor of gender of parent was performed on mothers' and fathers' ratings (on a scale of strong like (1) to strong dislike (5)) of their liking for nine school subjects. Main effects were found for both ethnicity, $F(9, 42) = 3.69$, $p < .01$, and gender of parent, $F(9, 42) = 5.48$, $p < .0001$. Three significant univariate effects involving ethnicity emerged. Chinese-Americans liked literature ($M = 2.46$) and foreign languages ($M = 2.83$) less well than did Caucasian-

Americans (Ms = 2.00, 2.31), Fs(1, 50) = 6.86, 7.15, ps < .025, .01. However, Chinese-Americans (M = 1.94) liked mathematics better than Caucasian-Americans (2.40), F(1, 50) = 6.11, p < .025. Four significant effects involving gender of parent emerged. Fathers liked computer courses (M = 1.94), physical education (M = 2.17), mathematics (M = 1.86), and science (1.50) significantly better than mothers (Ms = 2.58, 2.69, 2.48, 2.40), Fs(1. 50) = 10.18, 8.67, 7.57, 28.51, ps < .01, .01, .01, .0001. No significant interactions occurred.

Student perceptions of both their mothers' and their fathers' liking for mathematics did differ between groups. Chinese-American girls (M = 1.17) perceived a stronger liking for mathematics in their fathers than did Caucasian-American girls (M = 2.00) in their fathers, F(1, 49) = 8.98, p < .01. Chinese-American girls (M = 1.35) perceived a stronger liking for mathematics in their mothers than did Caucasian-American girls (2.52) in their mothers, F(1, 49) = 24.06, p < .0001. Chinese-Americans showed much less variability on all these measures.

Spontaneous expressions of dislike for math during the interview or interaction were more common among the Caucasian-American mothers. In at least two cases, mothers and their daughters independently expressed hatred for math. Only one Chinese-American mother expressed a dislike of math, whereas at least six Caucasian-American mothers voiced their extreme dislike of math. The following example,which occurred during a the Math Blaster computer interaction, and while a storm was brewing outside, serves to illustrate:

Mother: Oh, I hate this!

Researcher: What? The storm outside?

Mother: No, I don't like the math--fractions--figuring problems.

Several Caucasian-American fathers made reference to their wives' lack of math skill by such comments as, "Even your mom can do this problem," or "She's not very number-oriented." One father teased, "Don't you remember that from trig?" and the mother laughed, "Who? Not me!" Two Caucasian-American fathers, both of whom had been very strong math students, expressed concern about their daughters' math attitudes. One of the girls, although she scored in the 99%ile in math on her achievement tests, did not like math, and wished to become a dancer.

A 2 x 2 multivariate analysis of variance involving the between-subject factor of ethnicity and the within-subject factor of gender of parent was performed on mothers' and fathers' high school and college preparation in math and science. Multivariate main effects were found for both ethnicity, $\underline{F}(4, 53) = 8.22$, $\underline{p} < .0001$, and gender of parent, $\underline{F}(4, 53) = 5.86$, $\underline{p} < .001$. Two significant univariate effects involving ethnicity emerged. Chinese-Americans took more high school science (M = 3.96) and math (M = 3.94) than did Caucasian-Americans (Ms = 3.18. 3.36) $\underline{F}$s(1,56) = 24.48, 25.63, $\underline{p}$s < .0001. There were four significant univariate effects involving gender of parent. Fathers took more high school science (M = 3.67), more college science (M = 4.09), more high school math (M = 3.81), and more college math (M = 2.69) than did mothers (Ms = 3.45, 2.71, 3.48, 1.66), $\underline{F}$s(1,56) = 4.47, 16.11, 7.08, 12.53, $\underline{p}$s < .05, .0001, .01, .001.

An interaction was found for race by parent, $\underline{F}(4,53) = 5.05$, $\underline{p} < .01$. Three significant univariate effects were found: for high school science, $\underline{F}(1,56) = 7.94$, $\underline{p} < .01$; for high school math, $\underline{F}(1,56) = 8.77$, $\underline{p} < .01$; and for college math $\underline{F}(1,56) = 5.25$, $\underline{p} < .05$. While the two groups of fathers had nearly equivalent mathematics backgrounds, a significant difference appeared in the mothers' backgrounds. Caucasian-American (and Chinese-American in parentheses) fathers averaged 3.70 (3.93) years of high school math and 2.83 (2.48) years of college math. A comparison of mothers, on the other hand, revealed that Caucasian-American (and Chinese-American in parentheses) mothers averaged 3.03 (3.97) years of high school math and 1.17 (2.18) years of college math. It is important to note that Chinese-American mothers had completed a total of two years more of math than their Caucasian-American counterparts and had taken more rigorous mathematics courses. Chinese-American mothers had only somewhat less math preparation than their husbands.

A multivariate analysis of variance on parents' answers (on a 5-point scale) to the question "How difficult were the following academic subjects for you?" was significant, $F(11, 37) = 3.66$, $p < .001$. Caucasian-American mothers ($M = 2.60$) viewed mathematics as more difficult for them than did Chinese-American mothers ($M = 2.00$), $F(1, 47) = 4.43$, $p < .05$. Three other univariate differences emerged from this analysis. Chinese American mothers viewed literature ($M = 3.16$) and foreign language ($M = 3.20$) as more difficult for them than did Caucasian-American mothers (M's = 1.75, 2.17, respectively), Fs(1, 47) = 14.70, 11.11, p's < .0001, .01. The only significant difference that emerged for fathers was in the area of literature. Chinese-American fathers ($M = 3.12$) rated literature as more difficult for them than did Caucasian-American fathers ($M = 2.29$), $F(1, 47) = 9.97$, $p < .01$.

No significant between-group differences emerged in the mothers' and fathers' ratings of difficulty of math for their daughters. All parents, Chinese-American ($M = 1.87$) and Caucasian-American ($M = 2.07$) mothers, $t(58) = -.90$, $p = .187$, and Chinese-American ($M = 2.00$) and Caucasian-American ($M = 2.03$) fathers $t(55) = -.15$, $p = .442$, rated math as somewhat easy for their daughters.

Career Suitability. A 2 x 2 multivariate analysis of variance involving the between-subjects factor of ethnicity and the within-subjects factor of gender of parent was performed on mothers' and fathers' responses to a question asking the subjects to rate ten careers on their gender suitability. A five-point scale was used, with #1 representing "more suitable for men", # 5 representing "more suitable for women," and the midpoint representing equal suitability. A multivariate main effect was found for ethnicity, F(10, 37) = 3.95, $p < .001$. Four significant univariate effects were found. Chinese-Americans rated engineering and computer science (M = 2.43) as more suitable for men than did Caucasian-Americans (M = 2.77), F(1, 46) = 4.53, $p < .05$. Chinese-Americans (M = 2.45) rated physical science as more suitable for men than did Caucasian-Americans (M = 2.81), F(1, 46) = 5.7, $p < .025$. Chinese-Americans (M = 3.34) rated social science as more suitable for women than did Caucasian-Americans (M = 3.02), F(1, 46) = 14.42, $p < .0001$. Chinese-Americans (M = 3.75) rated careers in foreign languages as more suitable for women than did Caucasian-Americans (M - 3.19), F(1, 46) = 12.25, $p < .001$. The comparison for careers in math approached significance. Chinese-Americans (M = 2.57) rated careers in math as more suitable for men than did Caucasian-Americans (M = 2.85), F(1, 46) = 3.67, $p = .062$. No other main effects or interactions were found. Mothers and Caucasian-Americans had a tendency to rate all careers nearer to the midpoint than did fathers and Chinese-Americans. Overall, careers in engineering and computer science, math, physical sciences, law, business, and natural sciences were rated as slightly more suitable for men; whereas, careers in art, music, social science, and foreign language were judged as more suitable for women by both groups.

In an open-ended question, parents were asked to give three preferences for careers for their daughters. The four choices most frequently mentioned by Chinese-American parents were medicine (19%), business (15%), law (7%), and engineering and computer science (7%). Thirty per cent of the responses indicated no preference. Caucasian-American parents preferred careers in education (22%), medicine (12%), business (8%), and music and dance (4%). Fifty-one per cent of the responses indicated no preference, reflecting the American emphasis on self-determination. All four of the Chinese career choices were in areas they had rated as more suitable for men, whereas Caucasian choices were equally divided between careers they had rated as more suitable for men and careers rated more suitable for women.

Expectations. Chinese-American parents had higher educational aspirations for their daughters than did Caucasian-American parents. Parents were asked to indicate the lowest educational attainment level with which they would be satisfied in regard to their daughters. In response, 43% of the Chinese-American fathers said bachelor's degree, 37% said master's degree, and 17% said doctoral degree. Among Chinese-American mothers, 57% said bachelor's degree, 43% said master's degree, and 0% said doctoral degree. Caucasian-American mothers and fathers had similar expectations. Thirteen per cent of Caucasian-American mothers said vocational or trade school, 67% said bachelor's degree, and 20% said master's degree. Caucasian-American fathers gave the following responses: high school graduation--7%, vocational school--7%, one year of college--3%, bachelor's degree--60%, and master's degree--20%.

Attributions. Parents in the two cultural groups differed in their attributions for success. Contrary to the researcher's expectations, Caucasian-American parents were more likely than Chinese-American parents to attribute their own success and the success of others to hard work. A 2 x 2 multivariate analysis of variance involving the between-subject factor of ethnicity and the within-subject factor of gender of parent was performed on the attribution variables. A significant multivariate main effect for ethnicity was not found $F(2, 57) = 2.30$, $p = .109$, but univariate results were significant. On a 3-point Likert scale, with #1 representing hard work, #2 representing both hard work and ability, and #3 representing ability, Chinese-American mothers and fathers, respectively, attributed their own success (Ms = 2.17, 2.70) and the success of others (Ms = 2.20, 2.63) to ability, more than hard work. Corresponding means for Caucasian-American mothers and fathers, respectively, were 1.77 and 1.53, F(1,58) = 3.84, p = .055 for their own success, and 1.50 and 1.60, F(1, 58) = 4.58, p < .05 for the success of others. Caucasian-American parents in this well-educated sample were more likely to attribute success to hard work than were the Chinese-American parents. Parental attributions for their daughters' success, however, would be purely speculative since the researcher did not ask that question specifically.

Learning Atmosphere. Chinese households were, as predicted, quieter places for the interviews and interactions. Television sets and pets furnished more background noise for the Caucasian-American families. The computer interaction tapes provided objective evidence of the quieter learning atmospheres in the Chinese-American homes. Caucasian-American parents and children talked more and louder during the interaction. Chinese-American parent-child triads made an average of 11.07 utterances per minute during the Factory hard level interaction, whereas the mean for Caucasian-American triads was 17.61 utterances per minute. Collapsing across ethnicity, Chinese-Americans accounted for 38.6% and Caucasian-Americans accounted for 61.4% of the total verbalizations. If the entire interaction tape had been coded, the difference might been even more striking.

Parental Teaching Styles. A multivariate analysis of variance on a cluster of fourteen factors from the computer interaction was highly significant, F(14, 36) = 3.77, p < .001. (See Table 4.) On univariate tests, one of the behaviors which had been coded visually, e.g., "Mother looks at father," emerged as significantly different between ethnic groups for both Factory and Math Blaster Mystery. The following scores are reported in occurrences per minute. Among Caucasian-American parents, mothers looked at fathers more often than Chinese-American mothers looked at fathers, Fs(1, 49) = 4.31, 5.87, ps < .05, .025. In all other categories which had been coded visually, the Caucasian-

American means were higher, but because the Caucasian-American variability was greater, the differences were not statistically significant. The Chinese-American parents appeared to be more task-oriented, focusing their attention on the computer screen and on the problem

Table 4

Mean Scores for Computer Interaction

Factor	Chinese-American	Caucasian-American	*F*
Mother looks at father (A)	.031 (.063)	.080 (.099)	4.31*
Father looks at mother (A)	.022 (.041)	.099 (.222)	n.s.
Child laughs (A)	.093 (.136)	.206 (.295)	n.s.
Child answers question (A)	.535 (.510)	1.204 (.927)	9.85**
Mother informational statement (A)	.463 (.547)	.871 (.696)	5.32*
Father asks question (A)	.835 (.736)	1.261 (1.035)	n.s.
Mother asks question (A)	.309 (.404)	.961 (.694)	16.27***
Mother exclamation (A)	.346 (.382)	.834 (.762)	8.02**
Mother encouraging comment (A)	.093 (.157)	.416 (.385)	14.63***
Father encouraging comment (A)	.232 (.284)	.504 (.457)	6.28*
Child discouraging comment (A)	.016 (.046)	.099 (.145)	7.24**
Mother discouraging comment (A)	.023 (.112)	.100 (.150)	4.22*
Father discouraging comment (A)	.000 (.000)	.053 (.128)	4.03*

$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.
Note. Scores reported in occurrences per minute. A = Interaction using Factory.
Standard deviations are reported in parentheses.

to be solved, while Caucasian-American parents seemed to be more social, looking at, smiling at, laughing with, and joking with each other.

The parental teaching styles displayed by the two groups differed. Caucasian-American parents relied to a greater extent on questioning to help their daughters. Caucasian-American mothers asked more questions of their daughters than did Chinese-American mothers, $\underline{F}(1, 49) = 16.27, \underline{p} < .0001$. Caucasian-American daughters answered significantly more questions than Chinese-American daughters, $\underline{F}(1, 49) = 9.85, \underline{p} < .01$. Although there were no significant between-group differences in the directive statements category, an examination of the ratio of questions to directive statements shows that Chinese-American parents made nearly two directive statements (2.21 per minute) for every question (1.14 per minute) they asked. Caucasian-American parents utilized directive statements (2.39 per minute) and questions (2.22 per minute) about equally. From that comparison, it might be said that Chinese-American parents relied to a greater extent on a directive style of teaching.

Affective Displays. An examination of the use of encouraging and discouraging comments by fathers, mothers, and daughters can be interpreted as support for the prediction regarding display of emotion during the interaction. Caucasian-American mothers and fathers used more encouraging comments than did Chinese-American mothers and fathers, $\underline{F}s(1, 49) = 14.63, 6.28, \underline{p}s < .0001, .05$. Note the much greater difference between the mothers in the two ethnic groups. Caucasian-American daughters, mothers, and fathers also made significantly more discouraging comments than did Chinese-American daughters, mothers, and fathers, $\underline{F}s(1, 49) = 7.24, 4.22, 4.03, \underline{p}s < .01, .05, .05$. Caucasian-American mothers made significantly more exclamations and acknowledgements than did Chinese-American mothers, $\underline{F}(1, 49) = 8.02, \underline{p} < .01$). A marginally significant finding emerged from the univariate comparison of children's laughter. Caucasian-American daughters tended to laugh more often than Chinese-Americans, F(1, 49) = 2.92, p = .094. Chinese-American parents usually did not give any verbal praise to their daughter when she reached a correct solution. It was as though the correct solution was expected, and each member of the triad got intrinsic satisfaction or private pleasure from having solved the problem. Caucasian-American parents were more apt to make the moment of solution a time of celebration. On the other hand, Chinese fathers were quick to point out and explain their daughter's errors. The Chinese parents appeared to be less overtly demonstrative during the computer interaction.

Hypothesis III

Parental attitudes and socialization practices will be correlated with math achievement in their daughters.

Relationships between Parental Support and Student Achievement. The prediction that girls' math achievement will be directly related to measures of parent expectations and support was borne out by the data. (See Table 8 in Appendix K.) Indices of parent support used in the correlation with achievement test scores and semester grades were: (a) the number of hours per day girls reported watching television, (b) the lowest level of education mothers would be satisfied with (mothers' aspirations), (c) the lowest level of education fathers would be satisfied with (fathers' aspirations), and (d) the numbers of ways parents reported facilitating their daughters' math development. A marginally significant negative correlation emerged between the number of hours of television watched and the total math achievement test scores, r(57) = -.21, p = .055. The greater the amount of time reported watching television, the lower the total math achievement test scores were likely to be. The only other factor significantly correlated with hours of TV was the lowest level of education with which mothers would be satisfied, r(60) = -.38, p < .001. Thus, daughters of mothers who held higher educational aspirations for them reported spending less time viewing television.

Five achievement factors--math computation, $r(54) = .26$, $p < .05$; total math, $r(55) = .37$, $p < .01$; concepts of number, $r(53) = .34$, $p < .01$; math applications, $r(53) = .31$, $p < .025$; and math grades, $r(58) = .40$, $p < .001$--correlated moderately with the fathers' aspirations for their daughters. Fathers' higher aspirations for their daughters' education were related to higher math achievement. Stronger relationships were found to exist between math achievement and the mothers' aspirations. All five math achievement measures--computation, $r(56) = .42$, $p < .001$; total math, $r(57) = .52$, $p < .0001$; concepts of number, $r(55) = .43$, $p < .001$; math applications, $r(55) = .30$, $p < .025$; and math grades, $r(60) = .53$, $p < .0001$--were related positively to mothers' aspirations. Therefore, mothers' aspirations for their daughters appear to be more closely linked to math achievement at this age than are fathers' aspirations.

To determine whether this aspiration-achievement connection was limited to the domain of mathematics, correlations were obtained between the lowest level of education for their daughters with which fathers and mothers would be satisfied (aspirations) and semester grades in language arts, social studies, and science, as well as math. (See Table 9 in Appendix L.) Fathers' ($r(58) = .40$, $p < .001$) and mothers' ($r(60) = .53$, $p < .0001$) aspirations correlated fairly strongly with semester grades in math, but less strongly or not at all with semester grades in the other three subjects. The aspirations of fathers (and mothers in parentheses) were correlated with grades in the other three subjects as follows: language arts, $r(58) = .06$, $p = .327$, ($r(60) = .21$, $p = .054$); social studies, $r(58) = .10$, $p = .227$, ($r(60) = -.08$, $p = .274$); science, $r(58) = .25$, $p < .05$; ($r(60) = .24$, $p < .05$). Correlations with science were significant, but the correlations between parents' aspirations, and in particular, mothers' aspirations with math achievement were much stronger.

Parent estimates of the difficulty of math for their daughters (perceived competence) and their daughters' math achievement.were found to be negatively related. The correlations of fathers' estimates of the difficulty of math for their daughters with the five measures of their daughters' math achievement are as follows: computation, *r*(53) = -.35, *p* < .01; total math, *r*(54) = -.33, *p* < .01; concepts of number, *r*(52) = -.40, *p* < .01; math applications, *r*(52) = -.36, *p* < .01; and math semester grades, *r*(57) = -.58, *p* < .001. Similar correlations emerged for mothers' estimates of the difficulty of math for their daughters and their daughters' math achievement scores: computation, *r*(56) = -.46, *p* = .0001; total math, *r*(57) = -.40, *p* < .001; concepts of number, *r*(55) = -.34, *p* < .01; math applications, *r*(55) = -.27, *p* < .025; and math semester grades, *r*(60) = -.55, *p* < .0001. The strongest correlations among the achievement variables were obtained between parent estimates of difficulty and semester mathematics grades. In summary, parents who rated math as less difficult for their daughters tended to have daughters who received higher achievement scores and higher semester grades in math.

Relationships of Personality Factors to Achievement and Aspirations. Out of 90 correlations generated among personality factors as measured by the CPQ and math achievement and aspirations measures, 27 emerged as significant. (See Table 5.) Not surprisingly, Factor B (concrete-thinking vs. abstract-thinking) was correlated weakly to moderately with the following seven achievement and aspirations variables: lowest level of education with which mother would be satisfied, *r*(60) = -.29; math computation subtest, *r*(56) = .24; total math scores, *r*(57) = .30; concepts of number subtest, *r*(55) = .38; math applications subtest, *r*(55) = .47; semester math grades, *r*(60) = .32; and spatial relations test, *r*(60) = .35. The more abstract thinking girls tended to have higher scores in math achievement measures and, surprisingly, to have mothers with lower aspirations for them. Also, abstract thinking is significantly associated with scores on concepts of number, math applications, and computation. It seems that math applications and concepts of number are more closely linked to abstract thinking.

Table 5

Correlations of CPQ Factors with Girls' Math Achievement

	LoLv EdMo	LoLv EdFa	TtlTm Fac	Mth Compu	Ttl Mth	Conc Nos	Mth Appl	Math Grade	SRT
1. CPQ-B	-.29	-.09	-.17	.24*	.30*	.38**	.47***	.32**	.35**
2. CPQ-D	.20	.09	.02	-.16	-.17	-.03	.03	-.32**	-.17
3. CPQ-E	.26	.00	.17	-.05	-.16	-.12	-.09	-.30**	-.03
4. CPQ-F	.03	.15	.46**	-.06	-.11	-.25*	-.01	-.26*	-.15
5. CPQ-H	-.02	-.01	.24*	.10	.14	.06	.20	-.01	-.10
6. CPQ-I	-.17	-.18	-.17	.21	.27*	.50***	.35**	.41***	.17
7. CPQ-J	.08	.15	-.02	-.25*	-.10	-.04	-.15	.03	.11
8. CPQ-N	.02	.13	.16	-.12	-.26*	-.19	-.20	-.43***	-.12
9. CPQ-O	.21	.03	-.02	-.29*	-.37**	-.26*	-.26*	-.26*	-.10
10. CPQ-Q_3	-.17	-.22	.03	.21	.34**	.27*	.47***	.22*	.06

*$p < .05$, **$p < .01$, ***$p < .001$.

Note. LoLvEdMo = Lowest level of education with which mother would be satisfied, LoLvEdFa = Lowest level of education with which father would be satisfied, TtlTmFac = Time required to reach solution at hard level in "Factory" computer program, MthCmpu = Student's percentile rank on math computation achievement test, TtlMth = Student's percentile rank on total math achievement test, ConcNos = Student's percentile rank on concepts of number achievement test, MthAppl = Student's percentile rank on math applications achievement test, MthGrade = Student's spring, 1991 semester math grade, SRT = Student's score on Spatial Relations Test, CPQ-B = Concrete-Thinking vs. Abstract Thinking dimension on the Children's Personality Questionnaire, CPQ-D = Undemonstrative vs. Excitable, CPQ-E = Obedient vs. Dominant, CPQ-F = Sober vs. Enthusiastic, CPQ-H = Shy vs. Venturesome, CPQ-I = Tough-Minded vs. Tender-Minded, CPQ-J = Zestful vs. Reflective, CPQ-N = Naive vs. Shrewd, CPQ-O = Self-Assured vs. Apprehensive, CPQ-Q_3 = Undisciplined Self-Conflict vs.Controlled

Factor D (undemonstrative vs. excitable) was linked to only one achievement variable; a significant negative correlation emerged between factor D and math semester grades, r(60) = -.32. This moderate correlation can be interpreted as indicating that girls who were less demonstrative tended to get higher math grades.

One significant but weak correlation was obtained between Factor E (obedient vs. dominant) and an aspiration measure: lowest level of education with which mother would be satisfied, r(60) = .26. The more obedient or submissive the daughter, the lower the level of education with which the mother would be satisfied.

Factor F (sober vs. enthusiastic) was correlated with four achievement variables: highest level of education to which student aspires, r(60) = -.25; total time required for solution on hard level of Factory, r(50) = .46; concepts of number, r(55) = -.25; and semester math grades, r(60) = -.26. This suggests that the personality dimension of soberness and seriousness is associated with higher educational aspirations on the part of the student, faster solution times on Factory, higher scores on the concepts of number subtest, and higher semester grades in mathematics.

One achievement variable was found to be associated with Factor H (shy vs. venturesome). Girls who were more venturesome or bold were somewhat more likely to require a greater amount of time to reach solution on "Factory," and those who tended to be shy were likely to take less time, r(50) = .24. It may be that those who were shyer listened more to their parents' advice, and those who were more venturesome tried to figure it out on their own. Or it may be that the entire triad tended to be either shy or venturesome and that the more venturesome triads did more talking, thus increasing the time required for solution.

Correlations with Factor I (tough-minded vs. tender-minded) yielded four significant relationships with math achievement measures. The more tender-minded girls were associated with higher scores on the total math subtest, r(57) = .28; the concepts of number subtest, r(55) = .50; the math applications subtest, r(55) = .35; and semester grades in math, r(60) = .41.

It is important to clarify the meaning of the terms "tender-minded" and "tough-minded." A person traditionally viewed as "tender-minded" demonstrated the characteristics of empathy, attention to human concerns, emotional sensitivity, intuition, gentleness, and imagination. On the other hand, the term "tough-minded" generally referred to a personality which was unsentimental, practical and logical, empirical, hard, and realistic (Porter & Cattell, 1975; Rychlak, 1985). Women and girls score much higher (suggesting more tender-mindedness) on this continuum than do men and boys (suggesting more tough-mindedness) (Porter & Cattell, 1975).

The personality dimension labeled zestful vs. reflective (Factor J) was significantly associated with only one achievement measure, score on the math computation subtest. A weak, negative correlation was obtained, r(56) = -.25, which can be interpreted as meaning that a girl who was more zestful tended to score higher on the computation subtest.

Two achievement measures were associated with Factor N (naive vs shrewd): total math, r(57) = -.26, and semester grades in math, r(60) = -.43. Girls who were more astute, socially aware, ingenious, and alert to the reactions of others were less likely to get higher grades in school.

Factor O (self-assured vs. guilt-prone) was significantly related to five measures of achievement: math computation, r(56) = -.29; total math, r(57) = -.37; concepts of numbers, r(55) = -.26; math applications, r(55) = -.26; and math semester grades, r(60) = -.26. Those relationships suggest that girls who are more self-confident and secure are more likely to achieve at higher levels in math.

Four weak to moderately strong significant correlations were obtained with Factor Q_3 (undisciplined self-conflict vs. controlled). The personality dimension of control and social precision was associated with higher achievement in total math, r(57) = .34; concepts of number, r(55) = .27; math applications, r(55) = .47; and semester grades in math, r(60) = .22.

In summary, the personality traits of abstract thinking, tender-mindedness, social naivete, and self-control were most strongly associated with higher mathematics achievement. Less strong associations were obtained with the tendencies to be undemonstrative, serious, and self-assured.

Attitudes. Support was found for the prediction of a positive relationship between girls' perceptions of their parents' attitudes toward mathematics and the parents' actual attitudes. (See Table 6). Pearson correlations seemed to indicate a stronger relationship between girls' perceptions of their mothers' attitudes and their mothers' actual attitudes, r(56) = .58, than between their perceptions of their fathers' attitudes and their fathers' actual attitudes, r(60) = .24. It appears that girls of this age have more accurate perceptions of their mothers' actual attitudes than of their fathers' actual attitudes toward math.

Strong support was found for the prediction that girls' attitudes will be more closely related to their mothers' attitudes than to their fathers' attitudes. Moderate positive correlations emerged between the girls' liking for math and the mothers' liking for math, r(56) = .40; and between the girls' liking for math and the girls' perceptions of their mothers' liking for math, r(60) = .43. Non-significant correlations were found for both corresponding father variables: between the girls' liking for math and their fathers' liking for math, r(60) = .05, and between the girls' liking for math and the girls' perceptions of their fathers' liking for math, r(60) = .10.

Table 6

Intercorrelation Matrix of Mathematics Attitudes and Attainment Levels

	2	3	4	5	6	7	8
1. StuLikeMath	.40***	.33**	-.15	.40***	.05	.43***	.10
2. StuHSMath		.20	-.05	.20	-.14	-.15	.16
3. MomHSMath			.08	.48***	-.00	.53***	.13
4. DadHSMath				-.22	.48***	.09	.26*
5. MomLikeMath					-.13	.58***	.05
6. DadLikeMath						.00	.24*
7. StuPercepMom							.34**
8. StuPercepDad							

*p < .05. **p < .01. ***p < .001.

Note. StuLikeMath = Girls' ratings of math, StuHSMath = Years of high school math girls plan to take, MomHSMath = Years of high school math mothers took, DadHSMath = Years of high school math fathers took, MomLikeMath = Mothers' ratings of math, DadLikeMath = Fathers' ratings of math, StuPercepMom = Girls' perceptions of how much their mothers liked math, StuPercepDad = Student perceptions of how much their fathers liked math.

An examination of the link between the number of high school math courses the parent had taken and the parental attitudes toward math reveals moderately strong positive relationships. The correlations obtained between fathers' liking for math and the number of high school math courses taken, $r(55) = .48$, and mothers' liking for math and the number of high school math courses taken were nearly identical, $r(59) = .4o$. It appears that the more math courses the parent had taken in high school, the better the parent reported liking math.

In order to examine whether girls' attitudes toward other academic subjects were similarly related to their parents' attitudes, correlations were obtained between mothers', fathers', and daughters' attitudes toward science and language arts, as well. The only significant correlation turned out to be the previously noted relationship between the daughters' liking for math and their mothers' liking for math, r(56) = .40, p < .001. All other correlations were non-significant. It appears that the sharing of parent-daughter attitudes toward academic subjects is isolated to mothers and mathematics. This seems to be an important finding.

Relationships between Attitudes and Achievement. Evidence was found to support the prediction that the mothers' preparation in math will be associated with their daughters' attitudes and achievement in math. (See Table 7.) A strong moderate correlation was found between the number of high school math courses the mother had taken and the student perception of mother's liking for math, r(59) = .53. A weaker, positive correlation was found for fathers' high school math and the student perceptions of fathers' liking for math, r(59) = .26. Student math achievement measures were also more closely related to mothers' high school preparation in math than to fathers' high school preparation. Moderate positive correlations between mothers' high school math preparation and the following achievement measures were found: computation, r(55) = .33; total math, r(56) = .45; concept of numbers, r(54) = .40; and math applications, r(54) = .33. Correlations found between fathers' high school math preparation and their daughters' math achievement measures were weak, negative, or non-significant: computation, r(55) = .03; total math, r(56) = -.04; concepts of number, r(54) = -.07; and math applications, r(54) = -.01. The high school preparation of mothers appears to be much more predictive of daughters' attitudes and achievement, than does the high school preparation of fathers.

Table 7

Intercorrelation Matrix of Mathematics Attitudes, Achievement, and Spatial Relations Test

	2	3	4	5	6	7	8
1. StuLikeMath	.07	.50**	.34**	.52**	.33**	.43***	.10
2. SpatialRelations		.35**	.47**	.40**	.32*	.12	.16
3. Computation			.77***	.63***	.33*	.25.	.05
4. Total Math				.68***	.45**	.35**	-.04
5. SemGradeMath					.36**	.25	.13
6. MomHSMath						.53***	.13
7. StuPercepMom							.34**
8. StuPercepDad							

*p < .05. **p < .01. ***p < .001.
Note. StuLikeMath = Girls' ratings of math, SpatialRelations = Score on Spatial Relations Test, Computation = Percentile rank in computation subtest , TotalMath = Percentile Rank on the composite of math achievement test scores, SemGradeMath =Student's most recent semester math grade, MomHSMath = Years of high school math mothers took, StuPercepMom = Girls' perceptions of how much their mothers liked math, StuPercepDad = Student perceptions of how much their fathers liked math

The relationships between achievement in other academic domains and measures of parent attitude were explored to determine whether the mother-daughter attitude-achievement connection existed in areas other than mathematics, specifically science and language arts. (See Table 9 in Appendix L.) Correlations were obtained for semester grades in math, science, and language arts and fathers' and mothers' liking for those subjects. The only significant correlation emerging from this analysis was the correlation between the mothers' liking for math and their daughters' semester grades in math.

Correlations for fathers' liking and grades for all three academic areas were very weak and non-significant, as were relationships between mothers' liking and science and language arts grades.

Relationships between parents' domain-specific attitudes and achievement test scores were examined to further investigate this phenomenon. Significant correlations were found between the mothers' liking for math and the girls' scores on the computation ($r(52) = .34$, $p < .01$) and total math ($r(54) = .37$, $p < .01$) subtests. (See Table 8 in Appendix K.) All correlations obtained between fathers' liking for math, science, and language arts and the corresponding subtests were very weak and non-significant. (See Table 9 in Appendix L.) The correlations between mothers' likings and science and language arts subtests were similarly weak and non-significant. Again, the only relationship that emerged was between the mothers' math attitudes and their daughters' math achievement.

CHAPTER 5

Discussion

Abundant support was found for all three major hypotheses. First, the predicted significant differences did emerge between Chinese-American and Caucasian-American girls with regard to overall math achievement scores, spatial relations measures, personality factors, and attitudes. Second, the home learning environments of the two groups differed significantly in regard to types of direct parent support, parental attitudes, learning atmosphere, parental teaching styles, and display of emotion. And third, the attitudes and socialization practices of the parents, particularly the mothers, were associated with math achievement in their daughters.

Achievement Measures

It must be pointed out that all of the girls in the study were achieving at very high levels. In fact, one-third of the girls achieved at the 99%ile in math; one-fifth of the girls achieved at the 99%ile in reading comprehension; one-fourth of the girls achieved at the 99%ile in total language. Chinese-American girls scored significantly higher than Caucasian-American girls on subtests measuring concepts of number, computation, total math, and spelling. Ceiling effects were probably operative on the achievement test measures.

The Chinese emphasis on repeated practice is evident in their spelling and math computation superiority. It is interesting that these bilingual children, for whom English is not native, spell significantly better than their Caucasian counterparts. It may be that the children devote greater attention to the precise details of the construction of English words.

They may make more conscious use of cognitive and linguistic strategies for remembering the details of the language (John-Steiner, 1985). It may reflect superior visual memory on the part of the Chinese girls. Most of the Chinese girls have attended Chinese schools on Sundays and have had instruction in writing Chinese characters, so they may be attuned to very subtle differences in written representations. In her recent novel about Chinese-American women, Tan (1989) writes, "...shapes and details, which I never seem to notice until they are pointed out to me, always mean something to Chinese people." (p. 197). It may also be simply that there is more emphasis on memorization as a mode of learning in their culture. Several Chinese parents voiced their beliefs that memorizing the number facts early in childhood was very important to the learning of mathematics. There has been a corresponding deemphasis on memorization in teaching young children in the middle-class Caucasian-American culture (Bredekamp, 1990; DeVries & Kohlberg, 1987; Peck, McCaig, & Sapp, 1988). The ability to memorize easily and well certainly facilitates both mathematics computation and spelling performance. On the other hand, the higher performance of the Chinese children may be a result of higher achievement motivation in general.

Chinese-American girls' mean percentile ranks were higher in all but one (total reading) subtest, but variability was much greater among the Caucasian-American girls. Stevenson et al. (1990) reported greater variability on mathematics measures for American as compared to Beijing schoolchildren. His explanation was twofold: (a) teachers in China followed a national curriculum and devoted a uniform amount of time to mathematics; and (b) there was more uniformity in socioeconomic status among Beijing children. However, neither explanation applies to this study, because the subjects all attended very similar suburban schools and came from the same socioeconomic group. It may rather be a manifestation of the traditional emphasis on individual freedom and choice in the

Caucasian-American culture, whereas, the Chinese-American culture tends toward a more collective orientation which highly values achievement, in general, and mathematics achievement in particular.

The two groups of girls received very similar grades for academic subjects in the 1990 spring semester. Chinese-American girls earned slightly higher grades and were more likely to be accelerated in mathematics. Chinese-American girls also earned slightly higher grades in language arts, which probably reflects the superior spelling performance of the Chinese-Americans. The average for each group represented A work, however.

One of the original predictions related to achievement, that Chinese-American girls would demonstrate faster processing times, was not directly assessed. The only processing time measures were those noted during the mother-father-daughter interactions with the two computer programs. Using the program Math Blaster Mystery, the Chinese-American triads took significantly less time to solve the first word problem (Chinese-American mean = 7.08 minutes; Caucasian-American mean = 8.14 minutes). During the interaction, the Chinese parents seemed to do less reading aloud, to let the daughter do more of the thinking, and to intrude less often in the solution process. Sigel's (1991) term for that type of parental teaching behavior is "high level distancing." On the basis of this measure, one can say only that the Chinese triads were faster. In future research, it would be wise to include a measure of the students' processing times.

Spatial Relations Measures

As predicted, the Chinese-American girls scored significantly higher on the spatial relations measures. The group means on the Spatial Relations Test differed by nearly nine points. Could it be that Chinese-American girls have genetically superior visual-spatial abilities? The Chinese-American girls appeared to be later maturing than the Caucasian-American girls. Many of the Causian-American girls were showing outward signs of breast development, whereas the Chinese-American girls generally were not. This observation can be corroborated by the results of the studies on age of menarche among Taiwanese and white girls reported in Chapter 2. In 1970, the mean age of menarche among Taiwanese girls was 14.87 years (Ko et al., 1985); in 1970, the mean age of menarche among white girls in the United States was 12.6 years (Udry, 1979). A two-year difference in age of maturation could be a factor in the spatial relations difference obtained. Later maturing girls have demonstrated superiority in spatial relations tasks in a number of studies (Diamond et al., 1983; Meyer-Bahlburg et al., 1985; Newcombe & Bandura, 1983; Waber, 1976, 1977). The fact that the later-maturing Chinese-American girls performed significantly better than the earlier-maturing Caucasian-American girls on spatial relations measures might indicate support for the maturation hypothesis.

Or perhaps, the pictographic nature of Chinese written language plays a part. The Chinese-American girls may be more attuned to subtle differences in rotation as a result of experience with Chinese calligraphy and art. Every little flourish and mark in a Chinese character means something. Because all the Chinese-American girls have attended Chinese school and have learned to make Chinese characters, they may have more experience with spatial tasks.

The hypothesis that superior spatial abilities are related to the toys preschoolers play with and, particularly, to traditionally masculine toys (Tracy, 1987) was not supported by the retrospective evidence in this study. The two most popular toys, dolls and stuffed animals (cited 98 times by parents and daughters), are traditionally feminine. Blocks and construction toys came in third (named 29 times). However, for Chinese-American girls who performed better in mathematics, dolls were named more often (32 times) than they were for Caucasian-American girls (21 times). And blocks and construction toys were named more often by Caucasian-Americans (16 times) than by Chinese-Americans (13 times). The picture might change if one were able to somehow calculate the relative amounts of time the girls had actually spent in doll play and block play. The Chinese-American girls, who preferred dolls and traditionally feminine toys, had significantly higher spatial relations scores.

The Chinese-American girls (with their parents) were more efficient in learning the Factory computer program--a spatial relationships program. The Chinese-Americans averaged 11.77 minutes from the beginning to the solution of a hard level problem. The Caucasian-American triads averaged 14.26 minutes. Chinese-American parents tended to communicate only information that was necessary for solution during the interaction; whereas, Caucasian-American triads did more social (non-task-oriented) talking. The triads were not informed that they were going to be timed. Perhaps some of the Caucasian-American triads felt no sense of urgency, whereas Chinese-Americans tended to try to solve the problem as quickly as possible.

Personality Differences as Measured by the CPQ

Chinese-American girls emerged with a personality constellation, as measured by the Children's Personality Questionnaire, that was different from that of their Caucasian-American counterparts. While both groups fell within the normal range on all dimensions, there were six factors that distinguished the two groups. On factor C, the Chinese-American girls endorsed items reflecting a tendency to be slightly more affected by feelings than Caucasian-American girls. Both groups scored above the mean for the norm group of American girls, however.

The factor D dimension shows Chinese-American girls to be less demonstrative and excitable than Caucasian-American girls. Girls scoring lower on this scale are less easily distracted and more constant and deliberate. They are less apt to seek attention or to show off. They are less demanding and more patient. It would seem that a lower score on this dimension would incline girls to focus their attention on the task at hand and to, perhaps, benefit more from traditional formal instruction. Chinese children are socialized to be persistent, careful, and self-effacing (Foorman, 1989; Hess et al., 1987; Lin & Fu, 1990). Their collective orientation results in individuals who work to bring respect to the family and culture, rather than attention to themselves. Asian society, in general, values a child who is self-controlled; whereas, American society tends to encourage emotional expression on the part of children (Hess et al., 1987; Park, 1983). The Chinese-American girls (M = 3.6) scored closer to the mean for the norm group (M = 3.5) than did the Caucasian subjects (M = 4.6).

One of the predicted group differences on the submissiveness vs. dominance (Factor E) dimension did not materialize. It was thought that Chinese-American girls would score as significantly more submissive or obedient than Caucasian-American girls. While the scores were in the expected direction, the difference was not statistically significant. Both groups of girls scored above the mean for the norm group. Both groups were potentially more likely to be leaders than followers.

A highly significant difference resulted from the group comparison of scores on the F factor--sober vs. enthusiastic. Chinese-American girls (M = 3.9) scored below the mean for the norm group (M = 4.94); whereas, Caucasian-American girls (M = 5.5) were above the mean. Chinese-American girls endorsed items reflecting a tendency to be more sober, taciturn, serious, and quiet than Caucasian-American girls. Research shows that higher scores on this dimension are associated with easier, less-punitive home environments; whereas lower scores are linked to home environments with more exacting standards (Porter & Cattell, 1975). It is probably true that the Chinese-American parents hold more exacting standards for their children's performance, but it cannot be said that they were more punitive.

Another highly significant difference emerged on the scale measuring tough-mindedness vs. tender-mindedness (Factor I). Caucasian-American girls (M = 3.8) endorsed items showing less inclination to be sentimental, fanciful, and anxious about themselves, and more inclination to be practical and self-reliant. On the other hand, the answers of the Chinese-American girls (M = 5.4) indicated a tendency to be more affection-seeking, kindly, gentle, imaginative, intuitive, and more anxious about themselves. The norm group mean is 3.86. Higher scores on this factor are associated with more artistic personalities. The fact that many of the Chinese-American girls are already accomplished musical performers may be of interest in this respect. This factor has also sometimes been regarded as a masculinity-femininity dimension, as defined by traditional American culture. The dimension appears to correspond with the concepts of *yang* (masculine, active) and *yin* (feminine, passive) in the traditional Chinese culture (Farmer et al., 1986; Saso & Chappell, 1977; Tweddell & Kimball, 1985). Cattell and Porter (1975) maintain that a more protective and sometimes, more fastidiously cultured, home environment is associated with higher scores on this factor. It seems likely that a culture which emphasizes independence and self-reliance would produce children who score lower on this dimension. Statistical tests indicated that the Chinese-American girls score higher on mathematics achievement tests and select responses indicating more tendermindedness on a personality measure than do the Caucasian-American girls. In addition, the personality dimension of tender-mindedness is correlated with math achievement. This relationship suggests that the more tender-minded (traditionally feminine) Chinese-American girls score higher on mathematics than do the more tough-minded (traditionally masculine) Caucasian-American girls. These results run counter to the American stereotype of math as cold and unemotional, and more suited to males. Among Chinese-Americans, it appears that math is accepted as appropriate for either gender.

Both Caucasian-Americans and Chinese-Americans fell below the norm group mean (4.28) for Factor J--the zestful vs. reflective dimension. While the Chinese-American girls (M = 3.6) endorsed items that indicated a slightly greater inclination than Caucasian-American girls (M = 2.8) to act individualistically, they both appeared to like to go with the group and to work on group enterprises, very typical behavior for early adolescents in the United States.

A highly significant difference resulted on Factor O--self-assured vs. guilt-prone. It appears that the responses of the Chinese-American girls (M = 4.6) indicated a tendency to be more self-confident, resilient, expedient, serene, and placid than Caucasian-American girls (M = 6.2). The norm group mean was 4.51. The Caucasian-Americans' answers indicated more sensitivity to other people's approval or disapproval and a stronger sense of obligation. Higher scores on this scale are associated with stronger religious upbringing (Porter & Cattell, 1975). This greater tendency to be guilt-prone may be a function of the stronger religious upbringing of the Caucasian-American sample. Note the differences between groups with regard to religious service attendance; 25 of the Caucasian-American sample and 13 of the Chinese-American sample participated in church or synagogue regularly. In addition, the Chinese culture emphasizes keeping an optimistic, balanced, harmonious perspective (Farmer et al., 1986; Saso & Chappell, 1977; Tweddell & Kimball, 1985; Wan, 1980). It is entirely possible that the Chinese-American parental emphasis on developing early competence (achievement) through memorization and drill increases their daughters' confidence. Meyer (1986) found confidence to be the affective variable most predictive of future math achievement and participation. She concluded that confidence was more appropriately understood as an outcome rather than as a determinant of achievement.

It should be noted that the two groups did not differ on factor B--the crystallized intelligence dimension. Crystallized intelligence is that aspect of intelligence that results from formal learning. In fact, the means for both groups were identical (7.5) and were one standard deviation above the norm group mean of 5.48.

In summary, the personality dimensions of greater calmness, seriousness, reflectiveness, and self-assurance appeared to be more typical of Chinese-American girls. These same personality traits were associated with higher math achievement. Perhaps the Chinese-American parents foster personality characteristics in their children that are more conducive to the development of competence in mathematics and other academic areas. The specific links will be discussed further later. Meyer (1986) tentatively concluded that affective variables may have a more important influence on the achievement and participation in math of females than of males. The ability to remain calm is an asset in solving complex problems of any type. The more complex the problem, the lower the optimal level of physiological arousal necessary for solution. High levels of arousal disrupt performance on a difficult or less well-learned task (Myers, 1990). The tendency to be more quiet, patient, and serious would aid a student in profitting from traditional formal instruction. One Chinese-American father laughed as he said, "Children in China are all ears and no mouth; children in America are all mouth and no ears!"

Girls' Attitudes Toward Math

The Chinese and Caucasian girls' perceptions of their math competence did not differ significantly on the two measures utilized in this study. One might have expected a difference because of recent findings (Stevenson et al., 1990, Stevenson, 1991) that Chinese students in Beijing rated math as more difficult for them than did students in the United States. Two measures of perceived competence were used in the current study. One indicator was the girls' direct rating of the difficulty of math for them. The majority of girls in both groups rated math as “easy” or “very easy” for them. Another indicator of perceived competence is the likelihood of seeking out a challenge (Phillips, 1991). Girls from both cultures were equally likely to engage in challenge-seeking behavior; 60-65% of girls selected a more difficult level for the second problem on Math Blaster Mystery, indicating accurate appraisals of their high competence.

In cross-national studies, Stevenson et al. (1990) and Lee and Graham (1991) found that Chinese students in Bejing and Taipei perceived mathematics as a more difficult subject than did American students in Chicago and Minneapolis, even though American students were performing at much inferior levels. The explanation involves the student’s perception of his/her own performance relative to the whole group. In China, where the overall level of math competence is much higher, a student is likely to conclude that math is a more difficult subject. Here in the United States where typical math performance is much lower, students think of math as an easy subject. Chinese students set much higher standards for themselves. American students are often satisfied with just passing a course. Second-generation Chinese-American students, and Caucasian-American students in this study, however, have similar perceptions of the difficulty of math for them. The reason that the perceptions of the two groups were similar probably lies in the fact that, for the most part, the subjects in this study are highly competent and attend schools with similar curricula and levels of competition and achievement.

While Chinese-American girls tended to like mathematics more and to rank mathematics more favorably than did Caucasian-American girls, the difference signified only a trend. Caucasian-American girls were much more variable in their responses. There was a clear difference, however, in the girls’ expectations for mathematics participation in high school. Chinese-American girls (M = 3.62) expected to take significantly more years of math in high school than did Caucasian-American girls (M = 2.90). While some of the

Chinese girls alluded to the fact that their parents would make them take more math, most also agreed that they, too, felt math was important. Only one of the Chinese-American girls expressed a dislike for math--either on the rating scale or in the interview, while several Caucasian-American girls did. It may be that Caucasian-American girls feel freer to express likes and dislikes, whereas Chinese-American girls, coming from a culture that focuses on the positive, may be less likely to think in terms of liking or disliking. One of the Chinese mothers articulated three of the tenets of the Buddhist philosophy, "Be happy. Be positive. Don't be critical." It is also probable, though, that because the Chinese parents uniformly stress competence in mathematics, the children are more likely to become competent and thus have more positive attitudes toward and higher expectations of math. Another consideration is that the girls may be reflecting their mothers' attitudes toward math. In American society, an otherwise well-educated woman has no qualms about publicly revealing her lack of competence in math. Among Caucasian-Americans it is acceptable (and sometimes expected) for women to be incompetent in mathematics.

Chinese-American girls' choices of future careers reflected a greater math-science orientation than did Caucasian-American choices. Math and science orientation was evident in 38% of the top Chinese choices and 14% of the top Caucasian choices. A recent article in the popular press (Allis, 1991) purports that Asian-American college students, however, are increasingly shunning the science track to avoid the stereotype of the science-oriented "nerd" and to assert their individuality against parental pressure to enter a career with guaranteed economic security. Whether this is a general trend should be investigated. It is very likely that with greater acculturation to the United States society, Chinese-American young people will be seeking greater diversity in fields of study.

Parent Support for Daughters' Achievement

Chinese-American and Caucasian-American parents both showed significant, but different types of support for their daughters' achievement. Chinese-American parents more directly regulated their children's home study. They expressed more restrictions of their daughters' television viewing, both in terms of content and time. They were more apt to report that their daughters studied at a desk in a quiet place and that mothers played a greater role in helping with math homework. While both groups named equal numbers of ways of facilitating their daughters' development in math and reading, the types of facilitation varied. Chinese-American parents took a more direct teaching role in providing math experiences: giving daily math worksheets, supervising the special Kumon Mathematex home teaching program, preteaching their children during summer and holiday vacations, and playing musical multiplication tapes to their preschoolers. Their belief that early practice and thorough memorization leads to mastery and understanding is reflected in the methods they use to teach their children. Meyer's (1986) conclusion that confidence is more appropriately understood as an outcome, rather than as a determinant, of achievement coincides with the belief of the Chinese parents that early mastery produces confidence.

Two of the families reported forcing their children to do extra math (or daily music practicing), supporting their actions by saying that tears now will turn into gratitude later. Several other parents required their children to write an essay daily during the summer on a topic of the mothers' choice. They expressed concern that children would lose their skills over the summer if they didn't have some structured assignments. They believed that parents have a better perspective on what is best for their child; the child's preferences at the time are not a consideration. It is important to note that the parents who expressed the idea of forcing their children are the exception, rather than the rule. In general, Chinese-American parents preferred guiding their children with gentleness in the desired direction, carefully molding and shaping them in such a way that they would stay happy. The parents have been observed to use gentle tones of voice and gentle physical contact to move a young child to the direction the parent wishes him/her to go. One father said, "We never overreact." As Chinese-American families become more acculturated into American society, however, the children may become less compliant because they see their peers having more freedom of choice and control over their own lives. These parental guidance techniques, which are now serving them well, may become less effective in the future.

Caucasian-American parents were more inclined to use indirect methods of teaching their children. In the United States, many teachers in the early primary grades for many years advised parents against directly teaching reading or math to their children. It was commonly expressed that parents didn't know how to teach and might interfere with the methods used by the kindergarten and first grade teachers. Historically, the maturational view of child development held by Gesell and the progressive ideas of John Dewey greatly shaped middle-class American culture's views of appropriate educational practice for children (Braun & Edwards, 1972; Gardner, 1989; Maxim, 1989). Children's formal learning was considered the domain of the schools. The predominant view of learning from the late 1970's through the 1980's was Piagetian -- learning through exploration and discovery. In addition, many middle-class Americans view creativity, self-reliance, and independent thinking as very important outcomes of the childrearing process. For these reasons, parents who wanted to support their children's learning generally provided enriched environments and many "hands-on" experiences, but did little direct teaching of their children. It was felt that early childhood was the time to build attitudes toward learning, rather than competence in specific academic skills. Summer vacations were often looked upon as a much-needed break from the rigors of formal learning. The Vygotskian approach which is currently popular among academicians supports parental guidance of children's learning. Some of the more responsive and receptive educators are embracing this view, but, unfortunately , there is always a great lag in translating a new theory into practice. (In the author's experience, the methods textbooks for college early childhood education courses are still not reflecting a Vygotskian orientation.)

The Chinese and American views of appropriate education were strikingly different. Howard Gardner (1990) states:

> The contrast between our two cultures can also be conceptualized in terms of the fears we both harbor. Chinese teachers are fearful that if skills are not acquired early, they may never be acquired; there is no comparable hurry to inculcate creativity. American educators fear that unless creativity has been acquired early, it may never emerge; on the other hand, skills can be picked up later. (p. 283)

Some Chinese-American parents also indicated spontaneously that they wanted to keep their daughter busy doing productive things so that they didn't become interested in boys and other activities typically appealing to preadolescent youth. Flanagan (1991) reported that dating is much less important to adolescents in Taiwan than to adolescents in the United States. Chinese-American parents do appear to exercise a greater amount of control over their daughters' lives than do Caucasian-American parents. The girls themselves, however, answered similarly to three items in the student questionnaire regarding parental supervision. On a 5-point Likert scale, 26 Chinese-American and 27 Caucasian-American girls responded "very true" or often true" to the item "My mother keeps close track of how I am doing in school." In a similar item regarding fathers, 22 Chinese-American and 23 Caucasian-American girls responded "very true" or "often true." Responses to the item "My parents almost always know where I am and what I'm doing" were similar between groups; 25 Chinese-American and 29 Caucasian-American girls responded "very true" or "often true."

It is interesting in that regard to note that a rather high proportion (about one-fourth) of the Chinese-American girls cited "watching TV" as one of the ways they liked to use their free time. Because many of them had very restricted viewing hours, e.g., only on Friday or Saturday nights in some cases, the salience of television might have been exaggerated for them. By the same token, the Caucasian-American children who were allowed to watch more hours of television per day, cited television viewing as a preferred free time activity less often.

Chinese-American girls cited reading as a preferred free-time activity a little more often than Caucasian-American girls, although it was the most frequently named single free-time activity among both groups. One might not have predicted that outcome from the responses of the parents to the question, "How often did you read to your daughter in the preschool years?" Daily reading was reported almost universally by the Caucasian-American parents, whereas one third of the Chinese parents reported reading to their daughters rarely or never. Some reported not having time to read, and others chose not to read for fear they would convey their accent to their child when they read in English. Several of the Chinese-American parents reported that older siblings read to the younger ones. One mother volunteered on a daily basis in the children's room at the local library when her children were preschoolers. One resourceful mother hired a nine-year-old Caucasian neighbor girl (who wanted to be a teacher) to come in to read to her three-year-old daughter for an hour three times a week. This was a wonderfully beneficial arrangement for both children, with the result being that the Chinese-American child read fluently when she was four. A number of Chinese-American parents reported that their daughters learned to read as three- and four-year-olds without direct instruction from them. Many of them felt that the preschool programs which their daughters attended provided sufficient exposure to stories and children's books. It is interesting that 22 of the Chinese-

American girls, as compared with 16 of the Caucasian-American girls, were in accelerated reading classes. That phenomenon may be another manifestation of the Chinese-American tendency to strive for the highest level and a result of the parents' own education in a very competitive system.

Chinese-American mothers indicated more positive attitudes toward math than did Caucasian-American mothers. The Chinese mothers both rated and ranked math more favorably than did Caucasian-American mothers. The fathers in the two cultural groups showed no significant differences in their ratings and rankings of math. An explanation for the cultural difference in the mothers' attitudes lies, perhaps, in the mothers' differential educational experiences. The Chinese mothers were all educated in the uniform public school systems of Taiwan, Hong Kong, or Singapore where competence in math is valued highly. One of Chinese-American fathers (a neurologist) said, "In Taiwan, you are viewed as smarter if you do well in science and math. Literature has a lower value, while the arts and drama have the lowest value." In those countries, math is required during the four years that correspond to high school years in the United States and for the first year of college. Therefore, the Chinese mothers have virtually all had mathematics through the first year of calculus. Mean numbers of years of math taken by Chinese-American mothers in high school and college, respectively, were 3.97 and 2.14. An additional factor influencing the mothers' acquisition of math was the competitive nature of those same school systems. Very competitive exams were given in junior high for placement in senior high schools and in senior high school for placement in colleges. People with higher scores were placed in the better schools and allowed to major in their choice of disciplines; so there was a great deal of pressure and incentive to achieve well. The mothers' better preparation in and mastery of mathematics might very well cause them to view math more positively.

Caucasian-American mothers, on the other hand, attended high schools where only one to two years of mathematics was required. Mean numbers of years of math taken by Caucasian-American mothers in high school and college, respectively, were 3.03 and 1.17. While a few (4) of the mothers took calculus, most of those who had college math took math methods for elementary teachers, general math, accounting, or statistics. There were significant between-group differences in both duration and content of math preparation. Chinese-American mothers had studied mathematics for an average of two years longer than Caucasian-American mothers and had more often studied the traditional math sequence through calculus. The added competence gained from the more rigorous preparation and the mothers' success at competition may have built self-confidence in mathematics and engendered more positive attitudes. Chinese-American mothers probably feel more secure about their math knowledge and are more confident about helping their daughters with mathematics homework. Fennema and Peterson (1985) found one reason that males outperform females on math tests during high school and college is that males take more advanced math courses. The data in the current study indicate that the Chinese-American mothers' better preparation in mathematics may be a key factor in their daughters' superior achievement in mathematics.

Mothers and fathers in both cultures rated the difficulty of math for their daughters similarly--close to 2.00 (somewhat easy) on a 5-point Likert scale. Caucasian-American fathers and Chinese-American fathers and mothers also rated the difficulty of math for themselves as close to 2.00 on a 5-point Likert scale. But the Caucasian-American mothers' mean rating of the difficulty of math for themselves (M = 2.6) was significantly different. Caucasian-American mothers' perceptions of their own competence in math appear to be significantly below that of Chinese-American fathers and mothers and Caucasian-American fathers. It is also significantly below their perceptions of their daughters' competence (M = 2.07) and their daughters' perceived competence (M = 2.13). Mothers' perceived competence in math is significantly lower than every other measure of perceived math competence in this study. This appears to be another manifestation of our cultural stereotype about math as being inappropriate for females.

Some of the Caucasian-American parents seemed to be giving their daughters a mixed message about performance in mathematics. Some fathers tried hard to encourage their daughters' mathematics development, while mothers openly expressed their own dislike of math and thus, may have discouraged the daughters. In other cases, fathers joked about their wives' lack of competence in math, while the wives appeared to enjoy the attention. Other mothers played the "helpless role," by addressing questions such as the following to their husbands in the interview: "What was that last math course I took that you helped me pass?" It appears that even among educated Caucasian-American parents, the perception of math competence as masculine, or lack of math competence as feminine, has not disappeared.

Not surprisingly, there was greater agreement about the importance of achievement in math among the Chinese-American parents. The girls appeared to be getting a consistent message. Mastery of mathematics was viewed as important for both sexes. This researcher noted only one instance where a mother expressed a dislike for math (and it was done quietly). Because mothers were competent in math, there was no basis for family jokes about it. (The Chinese families appeared to be less inclined to joke anyway.) It may be that because family harmony is strongly valued, Chinese parents do not publicly express disagreement. Whatever the reason, the Chinese-American girls appeared to be getting a less ambiguous message.

It is interesting to note that Caucasian-American women were more likely to rate all careers as equally suitable for either gender, reflecting their acceptance of the nonsexist rhetoric that has been popular since the 1970's. However, their observed behavior seemed to be inconsistent with their expressed attitudes. Their choices of careers for their daughters, as well as their daughters' choices of careers, also reflected traditional feminine values more strongly. On the other hand, Chinese-American fathers were more apt to express traditional gender stereotypes in regard to career suitability; engineering and computer science, math, and the physical sciences were all clearly indicated as more suitable for men. These same fathers, however, chose careers for their daughters that they regarded as more suitable for men. One Chinese-American father said, "In Taiwan, the highest careers are engineer and doctor. Parents never encouraged their kids to be actors, musicians, or writers."

Chinese-American parents had higher educational aspirations for their daughters than did Caucasian-American parents. A bachelor's degree was clearly the lowest educational level with which any Chinese-American parent would be satisfied. Several Caucasian-American parents indicated they would be satisfied with high school graduation, vocational school preparation, or less than four years of college. This probably reflects the greater value placed on freedom of choice and individuality in American culture, as well as the belief that there are more possible routes to success for Caucasian-Americans. It may also be that some Caucasian-American parents still believe it is less important for a woman to be prepared for a successful career, whereas Chinese-American parents clearly want their daughters to fully develop their potential for achievement in a high status career. They seem to want their daughters to be able to compete equally with males in the workforce.

The oft-cited attribution difference between Chinese and American parents (Chalip & Stigler, 1986; Hess et al, 1987; Holloway & Hess, 1985; Stevenson et al, 1986; Stigler et al., 1982) was demonstrated in reverse in this study. This difference in attributions, stated simply, is that the Chinese are more likely to attribute success to hard work, whereas

Americans are more likely to attribute success to ability. However, the Chinese-Americans in this study were more apt to attribute their own and others' success to ability, whereas, the Caucasian-Americans were more likely to attribute success to hard work. Because the Caucasian-Americans were a well-educated group, they knew first-hand about the hard work necessary to finish a graduate degree, for example. The majority of them were of Northern European heritage and probably continue to embrace the work ethic of their forefathers. An additional consideration relates to the sensitivity of the questions; the questionnaire may not have been sensitive enough to pick up subtle differences in attitudes. An instrument specifically designed to assess differences in attributions for success in math might elicit the attribution difference cited in other studies. Perhaps the ordinary American citizen in the general population still does attribute success to ability, but it seems this particular Caucasian-American sample may value the role of effort more than ability in achievement.

Parental Teaching Styles

Analysis of the computer interaction revealed a number of differences in teaching styles between cultures. Caucasian-American parents used verbal mediation more frequently, displayed more emotion, and relied more on questioning than did Chinese-American parents. Chinese-American parents depended more on directive statements than on questions to help their daughters solve the computer problems, whereas Caucasian-American parents used questions and directive statements equally. Caucasian-American parents and children talked more and louder during the interactions. Caucasian-American mothers asked significantly more questions, made significantly more exclamations and acknowledgements, and made significantly more encouraging and discouraging comments than did Chinese-American mothers. Caucasian-American girls answered significantly more questions than Chinese-American girls. Chinese-American parents' utterances were shorter; their speech was more economical. Chinese-American parents appeared to be more task-oriented, looking at each other less often and attending to the computer monitor for longer spans of time. That might indicate that the Chinese-Americans depend more on the visual mode, whereas Caucasian-Americans rely more on the auditory mode for teaching, learning, and thinking.

Weiner and Robinson (1986), in a study of mathematically gifted boys and girls in the United States, concluded that girls may be predisposed to a left brain or verbally mediated approach to the solution of mathematical problems. Perhaps the verbally mediated approach is utilized by Caucasian-American girls, but not by Chinese-American girls who appear to use spatial information more. Another possible explanation could be that because English was not the native language of the Chinese-Americans, they were inclined to use it less. They tended to use only the language elements essential to conveying explicit meaning, without elaboration. One of the couples lapsed into Chinese occasionally during the computer interaction. It appeared that Caucasian-American triads seemed to verbalize their thought processes, whereas the Chinese-American triads were more private with their thinking. (Perhaps the parents were thinking in Chinese.) Two of the quickest Caucasian-American girls told their parents to be quiet during the interaction. The Chinese-American parents gave their daughters more sustained quiet time for thinking through the problem: Sigel (1991) termed this parental behavior "high level distancing." He found high level distancing strategies to be more commonly used by parents when teaching math. Talking by the parent may interfere with the child's concentration on the problem.

The Caucasian-American triads appeared to be more social and emotionally expressive. The parents looked at each other more often and the girls laughed more often. They were more likely to use terms of endearment to address their daughters. Members of

Caucasian triads interrupted each other more often. In some cases, the mother (often one who didn't like math) assumed leadership during the interaction, even when the father clearly had more background in and a more positive attitude toward math. A possible causal influence was the fact that the researcher was a Caucasian female and the Caucasian mothers may have been unconsciously or consciously performing. It may have been because the mother generally assumed the greater role in helping with homework and felt that to be her domain. The fact that Caucasian-Americans parents used encouraging and discouraging comments more often was another indication that there was more emotion overtly displayed by the Caucasian-American triads.

It was noted that sarcastic comments were used by several Caucasian-American parents, but by no Chinese-American parents. Three examples follow: (a) "Use your brain. God gave it to you." (b) "Read faster." (c) "Well, I thought I'd have to sit here another half hour!" While these remarks may be the mothers' attempts at humor, in actuality, they are also interpreted as hostile attacks on the daughter. Chinese-American parents were not observed to make comments like these; their verbal input seemed sincere, precise, and task-oriented. Is this another way in which Caucasian-American parents are giving mixed messages to their daughters? One wonders whether sarcastic interchanges ever occur among Chinese-American parents and their children. How do girls of this age interpret the sarcasm? Capelli, Nakagawa, and Madden (1991) point out that sarcastic remarks are perceived by American elementary school children as being "mean."

Chinese-American parents did not give their daughters verbal praise after they correctly solved the Factory problems, whereas Caucasian-Americans expressed frequent and high praise. Recent research on the effects of praise (Parsons et al., 1982) indicates that children begin to discount praise when it is given indiscriminately by teachers. The excessive and noncontingent use of praise may result in a child who is satisfied with average performance or who is dependent upon extrinsic reinforcement. It appeared that the Chinese-American girls received intrinsic satisfaction from the correct solution of a problem. Another factor that may help to explain the dearth of praise on the part of the Chinese-American parents is their strong cultural emphasis on humility. Because the Chinese parents wanted to appear humble, they may have been reluctant to say anything that could be interpreted as pride or arrogance in the presence of the researcher. (In the portion of the parent questionnaire which asked about honors or recognition received, it was noted that the Chinese-American parents were very modest in reporting rather outstanding accomplishments.)

Chinese-American parents were more likely to directly correct their daughters' errors committed during the computer problem-solving sessions. Caucasians were more likely to give indirect comments, as though they were afraid to say, "No," or "That's wrong." The cultural difference in the interpretation of negative feedback was recently addressed by Stevenson (1991). It seems that people in the Chinese culture attribute a child's errors to his not yet having learned the material; whereas, in the United States, criticism regarding a child's errors is interpreted as failure. This likely affects a child's sense of self-efficacy in the following way: a Chinese child will continue to persist in trying to learn the task, believing,that she is capable of eventual mastery. The American child, on the other hand, may tend to avoid the situation in which she erred, believing that she is incapable of mastery.

Parents in the two cultures may perceive the relationship between self-esteem and competence differently. Caucasian-American parents may be more concerned with not diminishing their children's self-esteem, and, as a result, they may be more inclined tó give copious praise. Chinese-American parents frequently have been observed trying to motivate their children by comparing their performance with those of other Chinese children who are doing well, whereas in the United States, child guidance experts (Read, 1960; Read & Patterson, 1980) in the last 30 years have cautioned Caucasian-American parents and teachers against comparing children's performance with others. Chinese-American parents may feel that self-esteem is a natural outgrowth of one's competence, whereas middle-class Caucasian-American parents often view competence as stemming from self-esteem.

Chinese-American parents work to develop competence in remarkably uniform ways. Most of them believe that early childhood is the time to begin developing musical abilities. The Chinese-American parents in the study expressed the belief that developing competence in music would enhance their child's development. One mother said, "If they learn endurance through music practice, they will develop it for other things. We believe it is important to train endurance, patience, and self-discipline. We are not expecting her to be a star, but we want to see how high she can go." Another mother said, "We believe that music as a discipline helps math skills and memory. There is a hierarchical structure developed when a child memorizes a five-page piece, for example." Two other parents said that because music lessons were not available to them as children, they wanted to provide their children with the opportunity they did not have. Actually, many of them had learned the music they know by being involved as dedicated Suzuki parents The parents had also probably been influenced by the strong traditional value attached to music for many generations. The educational curriculum of Confucious included music as one of the six subjects to be taught (Wan, 1980). (The others were history, poetry, language, li, and I Ching). The purpose of music was affective--to regulate and moderate the excesses of emotions and thus to build moral character.

Correlates of Mathematics Achievement

What student and parental variables were demonstrated to be significantly associated with math achievement in the fifth and sixth grade girls? As indicated in the previous chapter, the correlational evidence for significant links between parent, especially mother, variables and student variables is abundant. Parental aspirations for their daughters' education emerged as moderately strongly linked with their daughters' achievement. Correlations between fathers' aspirations and measures of daughters' math achievement ranged from .31 to .40. Stronger relationships, correlations ranging from .30 to .53, were observed between mothers' aspirations and measures of daughters' math achievement . The strongest correlations for fathers (.40) and mothers (.53) were obtained between parent aspirations and semester math grades. The weakest significant correlations for fathers (.26, .31) were between father aspirations and math computation and math applications, respectively. The corresponding maternal variables produced correlations of .42 and .30. Mothers' aspirations were correlated more strongly than fathers' aspirations with all the math achievement measures, except the math applications subtest; therefore, mothers' aspirations for their daughters emerged as more strongly associated with their daughters' math achievement. It is interesting to note that corresponding relationships between parental aspirations and achievement in other academic domains were non-significant. What is it about math that makes it so unique? It seems to have acquired a particular salience, such that girls' success in and attitudes toward math are much more closely related to maternal factors than to paternal factors. Is it stereotyped as a male domain more strongly than other academic areas?

The amount of time a student reported watching television was negatively correlated with two measures--weakly with scores on the total math achievement subtest and moderately with the lowest level of daughters' education with which mothers would be satisfied. Because nearly half of the mothers were not employed full-time outside the home, they probably had greater responsibility for enforcing television viewing limits than did the fathers; therefore, the higher the educational aspirations of the mother for the daughter, the fewer hours of television she may allow the daughter to watch. It may also be that the daughters of mothers who have higher aspirations are busier practicing, reading, and pursuing other constructive interests. Mothers who have higher aspirations may themselves watch less television, and the daughters may imitate their mothers' behaviors.

Personality Factors as Correlates of Mathematics Achievement. What personality variables materialized as correlates of mathematics achievement? As one would expect, the crystallized intelligence measure (Factor B) was moderately positively linked to mathematics achievement measures such that the girls with more highly developed abstract-thinking skills tended to score higher in math. Chinese-American and Caucasian-American girls were equally likely to be abstract thinkers.

A weak moderate correlation emerged between Factor D (undemonstrative vs. excitable) and math semester grades. Chinese-American girls, who were less excitable and demonstrative and less easily distracted (statistically demonstrated through MANOVA procedures), tended to get higher semester math grades (as shown by t-tests). It may be that Chinese children have an initial predisposition to lower levels of physiological arousal, which would aid them in concentrating on a task. Freedman (1979) found that Chinese infants in a hospital nursery were significantly calmer than Caucasian infants.

The tendency to be more sober or serious (Factor F: sober vs. enthusiastic) was correlated weakly with two math achievement measures: concepts of number, and semester math grades. In addition, soberness and seriousness were linked weakly to higher student educational aspirations and moderately to faster solution times on the Factory computer program. Chinese-American girls endorsed answers indicating a greater degree of soberness and seriousness than did Caucasian-American girls.

The personality variable related most strongly to math achievement was Factor I (tough-minded vs. tender-minded). Moderate correlations were obtained between the tendency to be more tender-minded and superior performance on concepts of number, math applications, and semester math grades. The Chinese-American girls' responses indicated that they were likely to be significantly more tender-minded (sensitive, dependent, overprotected) than the Caucasian-American girls. If one takes the traditional American view of tender-mindedness as more feminine, this finding does not support the notion of a link between the personality dimension of femininity and lower math achievement. In fact, it appears to contradict it. The tendency toward tough-mindedness (masculinity) is related to lower math achievement in the total sample of girls, and Caucasian-American girls' responses indicated a tendency to be more tough-minded. The notion that girls need to somehow be socialized in a more masculine way to succeed in mathematics is not supported. There is a cultural difference in that math is regarded as important for both sexes and is not as gender-stereotyped among the Chinese. While the Chinese-American parents rated careers in mathematics as more suitable for males, the strong motivation for career success appears to override traditional gender stereotypes. Braun and Chao (1978) found that "Asian-born Chinese men make a distinction between purely social behaviors and socioeconomic ones" (p. 201). The Chinese-Americans might be better able to accept the idea that an individual possesses both instrumental (yang) personality attributes and expressive (yin) attributes. The issue of gender appears to be more central to Caucasian-Americans.

The tendency to be naive rather than shrewd (Factor N) was associated moderately with higher semester grades in math and weakly with percentiles on the total math subtest.

That relationship suggests that girls who are more socially aware, astute, ingenious, calculating, and alert to the reactions of others tended to achieve lower grades in math; whereas, girls who are more naive, emotionally genuine, completely direct, and spontaneously outspoken tended to receive higher marks in math. Chinese-American and Caucasian-American girls did not differ significantly on this factor.

The personality dimension of self-confidence and security (Factor O) was related weakly to five measures of math achievement: math computation, total math, concepts of number, math applications, and semester math grades. This suggests that more self-confident, secure girls were more likely to achieve at superior levels in mathematics. The difference between Chinese-American and Caucasian-American girls on this dimension was highly significant; Chinese-American girls' responses indicated a greater likelihood of being self-assured, and they concomitantly achieved at higher levels in math.

The personality dimension of self-control and social precision (Factor Q_3) was associated with higher achievement in four of the math measures: total math, concepts of number, math applications, and semester math grades. Chinese-American and Caucasian-American girls did not differ significantly on this factor; both groups scored above the norm group mean for control and social precision.

In summary, the personality dimensions most strongly associated with higher achievement in mathematics were abstract thinking, tender-mindedness, naivete, and self-control. Of those factors, the only one which showed a significant between-group difference was tender-mindedness. Chinese-American girls' responses indicated a tendency to be more tender-minded than Caucasian-American girls. Also associated, but to a lesser degree, were the tendencies to be undemonstrative, serious, and self-assured. All of these tendencies were demonstrated to a significantly greater degree by the responses of the Chinese-American girls. There appears to be less tendency to stereotype mathematics as masculine among the Chinese-Americans. Therefore, the personality characteristics suggestive of higher math achievement and demonstrated more strongly by Chinese-American girls are tender-mindedness, undemonstrativeness, seriousness, and self-assurance. This personality factor cluster does not conform to the American stereotype of a highly successful math student.

Relationships among Attitudes and Achievement. Fathers and mothers appeared to be somewhat accurate in estimating the difficulty of math (perceived competence) for their daughters. Correlations obtained among fathers' and mothers' estimates of the difficulty of math for their daughters and their daughters' actual math achievement ranged from -.33 to -.58 for father measures, and from -.27 to -.55 for mother measures. Correlations involving fathers were stronger for concepts of number (-.40), math applications (-.36), and math semester grades (-.58), while correlations involving mothers were stronger for math computation (-.46), total math (-.40), and math semester grades (-.55). It should be pointed out that the computation subtest was the math subtest most closely correlated with total math scores ($r = .78$). Fathers and mothers may have been thinking of different math skills when they made their estimates. The concept of math to mothers may have conjured up visions of computation, and to fathers, the concept of math may have meant something more abstract. Among correlations obtained between estimates of difficulty and measures of math achievement, those involving semester grades emerged as the strongest for both fathers (-.58) and mothers (-.55), suggesting that parents base their estimates more strongly on semester grades than on achievement tests. The school marks of students are highly visible evaluations of their performance (Pallas, 1991), and probably are a major influence in shaping parents' beliefs about their daughters' competence.

Girls' perceptions of their mothers' attitudes toward math were more accurate than their perceptions of their fathers' attitudes toward math. While positive correlations were obtained for both, there was a noteworthy difference in magnitude. The correspondence between the girls' perceptions of their mothers' attitudes and their mothers' actual attitudes ($r = .58$) was much stronger than the relationship between their perceptions of their fathers' attitudes and their fathers' actual attitudes ($r = .24$). The girls in this study apparently gauged their mothers' attitudes toward math much more precisely than their fathers' attitudes. Girls at this age are probably more attuned to their mothers' attitudes and behavior for several reasons: (1) they are entering puberty and have a heightened awareness of behaviors of admired same-sex persons; and (2) they have probably spent more time with their mothers through the years and have had more exposure to their mothers' behaviors and attitudes.

Striking support was found for the prediction that the girls' math attitudes (liking for math) would be more closely related to their mothers' attitudes than to their fathers' attitudes. Moderate positive correlations were found between girls' attitudes and both their mothers' actual attitudes ($r = .40$) and their perceptions of their mothers' attitudes ($r = .43$). The corresponding correlations between girls' attitudes and their fathers' attitudes were non-significant. This finding adds to the accumulating evidence in this study that mother variables are more closely related to daughter variables, and strongly suggests that the girls at this age have adopted their mothers', rather than their fathers', attitudes toward math. This is unfortunate because fathers have better preparation in and better attitudes toward math.

Additional moderately strong correlations were obtained between the number of high school math courses mothers ($r = .48$) and fathers ($r = .48$) took and the parents' reported liking of math. One cannot say whether the positive attitudes affected course selection, or whether the courses taken affected attitudes, but the fact remains that more positive attitudes were held by parents who had taken more math courses. Because the

Chinese-American parents were required to take four years of math in high school, the latter seems to be the more plausible explanation--that the courses taken improved competence, which engendered a stronger liking for math. One must keep in mind that the collective cultural attitudes toward the importance of math are probably also very influential.

Is this link between mothers' attitudes and their daughters' attitudes toward academic subjects general or specific to the domain of mathematics? Correlational evidence strongly suggests that the relationship exists only for mothers and daughters in the mathematics domain. Nonsignificant correlations were obtained between mothers' attitudes and daughters' attitudes in science and language arts, and between fathers' attitudes and daughters' attitudes in math, science and language arts. Middle-class Caucasian-American women express negative math attitudes openly and more strongly than attitudes toward other academic subjects probably because it is viewed by many as appropriately feminine to do so. Those attitudes are incorporated into the girl's developing sense of herself as a female. In this regard, Hollinger (1985) recommends assisting young adolescent girls to recognize that they can possess attributes traditionally regarded as masculine (math achievement) and still be feminine.

In examining the relationship between attitudes and achievement, it becomes clear that once again, mother variables appear to be more important predictors of their daughters' math achievement than are father variables. The mothers' high school preparation in math correlated moderately strongly ($\underline{r} = .53$) with the girls' perception of their mothers' liking for math. The girls, whose mothers had taken more math in high school, tended to perceive that their mothers liked math more, while girls, whose mothers had taken fewer math courses in high school, perceived that their mothers liked math less. There was a weaker, but statistically significant relationship for fathers on the corresponding variable--a correlation of .26.

A comparison of the relationships obtained between the number of mothers' and fathers' college math courses and their daughters' perceptions of the parents' liking for math shows only one significant, but rather weak relationship--again with the mother variable. A correlation of .26 was found between the number of college math courses taken and the girls' perception of the mothers' liking for math.

Mothers' high school math preparation was found to be associated with girls' successful performance on mathematics achievement tests and on the spatial relations test, whereas, fathers' high school math preparation did not seem to be linked at all to any of the achievement measures. Moderate positive correlations ranging from .33 to .45 indicate a meaningful relationship between the mothers' preparation and the girls' performance. A similar result emerged from the comparison of mothers' high school math and performance on the SRT; a significant correlation of .32 was obtained, while a negative correlation (r = -.29) arose from a comparison of fathers' college math and daughters' performance on the SRT. It seems to be clearly demonstrated that girls' attitudes are much more strongly associated with mothers' attitudes. According to psychoanalytic theory, girls are identifying with their mothers through an emotional attachment. Social learning theory suggests that the girls have imitated or modeled behaviors of salient adults around them--their mothers, female teachers, older girls, and television personalities--and that they have been differentially reinforced for behaviors deemed culturally appropriate to their gender (Katz, 1987). Cognitive theorists would say that the girls have adopted behaviors that they view as congruent with their gender-role identities. The child's own perception of the sex-role congruency of mathematics achievement is an important factor influencing mathematics participation (Eccles et al. 1985; Fennema & Peterson, 1985). If the girl perceives math achievement as being incongruent with her feminine identity, she will not elect to take higher math in high school. Each of these theoretical positions on the dynamics involved in the similarity of mothers' and daughters' attitudes offers a partial explanation. A combination of all three--emotional attachment, modeling, and cognitions--seems likely.

It is interesting to note that previous studies (Parsons et al., 1982; Visser, 1987) found no support for the hypothesis that children's attitudes toward mathematics are similar to attitudes of the same-sex parent. The evidence for that phenomenon in this study is very convincing. How can the difference in results be explained? The previous studies, conducted in the United States and South Africa, used large samples of the general school population, whereas the sample in this study is smaller and is drawn from high-achieving families. The better-educated parents may have had more clearly differentiated preferences for school subjects. When attitudes are clearer, relationships are easier to obtain. Second, the methods used to obtain information about parental attitudes differed. In the two previous studies, questionnaires were mailed out to the families, whereas in this study, parents were interviewed in addition to being asked to complete questionnaires. The parents, because of the personal contact, may have given more serious thought to the questions asked. Third, the degree of commitment to their children's education probably differs among samples. It is likely that there is more parental interest and involvement in their children's academic development in the well-educated families of this study as compared to the general population surveyed in the previous studies. Fourth, it may be that gender stereotyping is not as strong among Afrikaans-speaking students in South Africa. Fifth, subjects' knowledge that math was the variable under investigation in the prior studies may have influenced the outcome.

Psychological Costs. Are there psychological costs inherent in a highly achievement-oriented culture? Are parents pushing their children toward high levels of achievement? Are the children likely to suffer undesirable side effects from the pressure to achieve? Gardner (1989) and Stevenson (1991) found evidence that children in China, Taiwan, and Japan are healthy, creative, robust, and active. Crystal and Fuglini (1991) noted the pervasive image in the American media that Asians are under great psychological pressure because of their strivings to achieve. The high suicide rate in Japan is often cited as evidence that the United States system is superior in producing psychologically healthy individuals. In actuality, the suicide rate among adolescents in the United States is higher than that in Japan. Crystal and Fuglini's (1991) longitudinal data show a picture of similar psychological health in all three countries. The cultural differences lie in the manifestations of the symptoms of psychological distress. In Taiwan, adolescents said they become depressed more often; in the United States, young people reported being stressed more often; and in Japan, youth are reportedly less satisfied with their lives. In an investigation of the sources of psychological stress, depression, and dissatisfaction, Chen (1991) found that peer relations were the most important source of stress and depression among American teenagers, while schoolwork was most important among Chinese. Flanagan (1991) concluded that to the American adolescent and his/her parents, everything is important--good grades, many friends, dates, sports success, and part-time jobs. To Chinese adolescents in Taiwan, good grades, many friends, and success in sports are much more important than dates and part-time jobs. The Chinese youth have a much more consistent focus on academics. The Americans perceived correctly that there was a cost to pursuing the well-rounded image, but they were willing to pay that cost.

What evidence is there from the data in this study that there might be a psychological cost to the higher emphasis on achievement among the Chinese-Americans? The only evidence is a few isolated comments by two sets of parents and several daughters related to forcing the child to practice or to do math problems during vacations. A conflict may arise within the parents or daughter because forcing children to learn is not generally reccommended practice in the United States. It may cause conflict when daughters compare what is expected of their peers in the United States with what is expected of them The idea of pushing children to achieve is repugnant to many middle-class Americans who believe in free will and the freedom of choice. But too much choice may be a contributor to stress (and to lower achievement) in the American culture. Children and adolescents may be emotionally healthier when they have more structure and fewer choices. Tan (1989) illustrates in her novel of Chinese-American immigrants,

> "Over the years, I learned to choose from the best opinions. Chinese people had Chinese opinions. American people had American opinions. And in almost every case, the American version was much better."
>
> "It was only later that I realized there was a serious flaw with the American version. There were too many choices, so it was easy to get confused and pick the wrong thing" (p. 191).

Another possible psychological cost may be involved when the child, who despite working very hard, is not able to perform up to the high standards demanded by the culture and the parents. Is this child at risk for serious psychological harm? Are the parents able to adjust their expectations to the level at which the child can function comfortably? There were two Chinese-American families in the study whose daughters had not performed up to the parents' initial expectations for academic work. Although somewhat apologetic at first for their daughters' lack of outstanding scholarship, the mothers soon revealed the daughters' strengths. One set of parents had taken their daughter out of the Young Scholars Program at school because she was not interested in competition. She was very sociable, had a keen interest in animals, and had become very involved in 4-H small animal projects. The parents of the other one had tried to preteach math to her in first grade, but the mother's efforts didn't work. The mother said, "It's hard to force her to be a person she really isn't. We let her explore to find what she is really good at--to fulfill her potential."

The personality profile of the Chinese-Americans girls looked very healthy. They were more undemonstrative and sober than the Caucasian-American girls, which is a direct reflection of their ethnic culture. Tan (1989) says that Chinese mothers show their affection for their children "not by hugs and kisses, but with stern offerings of steamed dumplings, duck's gizzards and crab" (p. 202). The Chinese-American girls also emerged as more self-assured. Perhaps their parents were correct when they voiced their belief that preteaching skills to their daughters would help them become more self-confident. The greater structure provided by their parents may also have contributed to their self-assurance.

Conclusions

The results of this study clearly demonstrate differences in general cultural attitudes, personality, and parenting attitudes and practices which may partly explain the superior mathematics achievement of Chinese-American girls. At the cultural level, beliefs stemming from the Confucian teachings of respect for parents, reverence for education, persistence, hard work, and aspirations to the highest level, may have a strong influence on children's achievement. In addition, the Chinese culture values mathematics and science very highly; careers utilizing math and science are preferred.

Children of Chinese parentage differ in genotype from children of other ethnic groups. Bornstein (1991) writes, "Certain culturally-consistent biological characteristics of infants, such as constitutionally-based characteristics of temperament, could promote parental activities and/or attitudes that vary systematically across cultures" (p. 12). There is some evidence to suggest that Chinese infants have initially calmer temperaments than do

African or Caucasian infants (Freedman, 1979). This temperament involving lower physiological arousal may interact with the child-rearing practices and values of the culture to produce children who are predisposed not only to benefit from traditional formal instruction, but also, to remain calm when faced with a complex problem.

The school systems in Taiwan, China, and Hong Kong have traditionally had uniform curricula, which require every student to take mathematics each year. Because mathematics participation becomes optional in United States high schools, it may cause Americans to view mathematics as less important. In addition to the more rigorous mathematics curriculum, the Chinese parents in this study had experienced high levels of competition to gain admission to the best high schools and to secure an opportunity to attend college. That experience, combined with the cultural emphasis on striving for the best and the perception of lowered social mobility as non-native Americans, contributes to the higher aspirations for achievement that Chinese-American parents have for their children. The Chinese-American parents bring that competitive spirit to their daughters' educational experience in this country, which often culminates in enabling their daughters to get into the most prestigious universities.

The Chinese-American mothers in this study demonstrated better preparation in, more confidence in, and greater liking for mathematics than did the Caucasian-American mothers. Having been educated in a uniform system, the Chinese-American mothers and fathers had very similar backgrounds in high school mathematics and displayed similar attitudes. The Caucasian-American mothers and fathers reported disparate attitudes and preparation in mathematics. The fathers' attitudes and preparation were similar to those of the Chinese-American parents, while the mothers' liking for math, perceived competence in math, and preparation in math were significantly lower. This points out the costs associated with the fact that mathematics is more strongly gender-stereotyped in the Caucasian-American culture.

For the most part, these Chinese-American parents believed that children need to learn skills early in life. Parents took their role as the teachers of their children very seriously; academic achievement was central in their lives and became central in the lives of their children. Parents devoted much attention to the teaching of math, believing that increased competence will lead to increased confidence. They used direct instruction to teach math facts to their preschool and primary grade children. Although very indulgent of their infants and toddlers, they expected their older children to be quiet and respectful when parents were teaching them. They articulated the belief that the parents, with their more mature perspective, are better able than the child to determine what is best for the child.

Chinese-American parents structured their daughters' use of time more closely. They reduced distractions by encouraging study in a quiet place, by eliminating noise and confusion in their homes, and by regulating their daughter's television viewing to a greater degree than the Caucasian-American parents. In the absence of competing stimulation, the girls may be better able to concentrate on their mathematics homework. In addition, the parents direct their daughters' attention to practicing music on a daily basis, believing that a connection exists between music and math learning and that the discipline of repeated practice and memorization carries through to academic pursuits. This focused concentration on academics and classical music also results in less exposure to the gender stereotypes espoused in American popular culture--television and pop music, specifically.

Chinese-American mother-father-daughter triads verbalized significantly less and watched the computer monitor more than the Caucasian-American triads during the computer spatial relations problem solving activities. It may be that Chinese-American girls depend less on the verbally mediated approach to problem solving, and rely more on visual cues. In addition, a greater proportion of the help offered by Chinese-American parents was directive in nature, while Caucasian-American parents utilized questions and directive statements equally.

Although the subjects in both groups were achieving at generally high levels, the Chinese-American girls were achieving at significantly higher levels than the Caucasian-American girls in most of the math measures. They expected to take more math courses in high school, were more likely to choose careers that were math-science oriented, and tended to have more favorable attitudes toward math. Not only were the Chinese-American girls surpassing Caucasian-American girls in math, but they were also achieving better in most of the other subject areas. This leads to speculation about whether the Chinese-American values and parenting practices affect their daughters' achievement in all academic areas. It seems that the emphasis on concentration, discipline, hard work, skill development, and high expectations would apply broadly across subject matter.

The personality characteristic demonstrated to a greater degree by the Chinese-American girls and strongly associated with higher mathematics achievement was tender-mindedness. In addition, the dimensions of undemonstrativeness, seriousness, and self-assurance which were more characteristic of Chinese-American girls were also associated with mathematics achievement. The idea that girls need to be socialized in more masculine ways to achieve in math is not substantiated by this study.

The most strikingly consistent finding and one of the most important findings to emerge from this study involves the strong positive relationship demonstrated between the daughter and mother variables in the math domain and the lack of a significant relationship between comparable daughter and father variables. The daughters' liking for math, perceptions of their mothers' liking for math, and achievement in math were all closely associated with their mothers' attitudes toward and preparation in math, but were unrelated to their fathers' corresponding attitudes and preparation. And further, these close associations were unique to the math domain. The better math preparation, the more positive math attitudes, and the higher perceived math competence of the Chinese-American mothers are associated with higher math achievement and more positive math attitudes in their daughters. Similarly, the poorer math preparation, less positive attitudes, and lower perceived math competence in Caucasian-American mothers are associated with lower math achievement and less positive math attitudes in their daughters. The data obtained in this research clearly show that cultural forces do affect the math achievement of girls; therefore we should think about ways to engineer better "nurture" experiences to improve Caucasian-American girls' performance in math.

It is apparent that the mathematics superiority of the Chinese-American girls can be attributed to a complex interplay of cultural, school, parenting, and perhaps, personality factors. It is no easy task to extract implications for parenting and schooling from the myriad of external and internal influences explored in this study. Many important questions arise which challenge beliefs currently held by middle class parents and educators in the United States. Would more directive teaching result in better foundations for math at the early childhood level? Is it, perhaps, wiser for teachers and parents to focus on the specific teaching of math skills rather than attitudes in the early years? Should we reevaluate our current advice to parents regarding the relationship between self-esteem and competence? Would a uniform requirement of four years of math in high school elevate the importance of math, liking for math, and performance in math among United States students? Would it help if mothers (and other women in the Caucasian-American culture) were to avoid negative verbal expressions regarding math? Would it help if adults could guide girls to the recognition that achieving in mathematics does not equate with being masculine? Should parents set uniform expectations for their daughters' and sons' mathematics achievement? Would closer parental monitoring be possible in the absence of a strong cultural emphasis on reverence for parents?

While many of the factors illuminating the reasons for the differences in math achievement between the Chinese-American and Caucasian-American girls are deeply embedded in their cultures, perhaps, it is possible to reassess our views and to incorporate some of the successful Chinese-American practices into our prevailing notions about parenting and educating our children.

APPENDIX A
Initial Letter to Parents

May 24, 1990

Dear Parents,

I am a Ph.D. candidate in child development at Erikson Institute, Loyola University. I am doing my dissertation research on achievement patterns among 5th and 6th grade girls, and I am looking for volunteers for my study. To keep the educational level of parents uniform, I need girls who are currently in the 5th or 6th grade from families where at least one parent holds a graduate degree.

I plan to interview and test the girls sometime between June and August at their convenience at a central location. I would like to conduct home interviews with parents. About 2 hours of the girls' time and 1 hour of the parents' time will be required of participant families.

All information collected will be kept strictly confidential and will be used for this dissertation only.

I will be most appreciative of any volunteer families. Please complete and mail the form below or call me at 362-0940 if you are interested.

Sincerely yours,

Carol Huntsinger

****

We are interested in participating in the study of 5th and 6th grade girls' achievement patterns.

Student's Name ______________________________ Birth Date ______

Enrolled in _____ grade at ______________ school for the 1989-1990 school year.

Mother's Name ____

Father's Name ____

Address _________________________________ Telephone __________

Educational Attainment   Degree Awarded   College or University
Mother____
Father ____

The best time to interview us is (circle all that apply): early June mid-June late June

early July mid-July late July early August; morning afternoon evening;

Sunday Monday Tuesday Wednesday Thursday Friday Saturday

PLEASE MAIL THE COMPLETED FORM TO Carol Huntsinger
125 Kenloch
Libertyville, Il. 60048 Thank you!

APPENDIX B

First Math Blaster Mystery Problem

Level 1 #1

Larry has been collecting baseball cards for two years. His favorite team is the Chicago Cubs. Out of his 145 cards, 38 are of players are of Cubs. How many cards does he have of players on the other 25 major league teams?

Step 1
What does the problem ask you to find?
A. number of cards he has of players who aren't Cubs
B. number of cards he has of players who are Cubs
C. amount of cards he collects each year
D. number of major league teams that exist

Step 2
What information is needed to solve the problem? (More than one answer may be needed.)
A. number of total cards
B. number of years
C. number of Cubs' cards
D. number of major league teams

Step 3
Select the correct expression.
A. 145 - (25 + 38)
B. 145 - 38
C. 145 + 38
D. 38 - 145

Step 4
Select the correct solution.
A. 103
B. 117
C. 107
D. 113

APPENDIX C

Student Interview

I.D. NO._____

1. What grade will you be in next year?

2. How do you like to spend your free time?

3. What kinds of toys were your favorites when you were little?

4. Have you ever taken music lessons?
    - traveled outside your state?
    - taken dance lessons?
    - visited a museum?
    - traveled outside the U.S.?
    - been to a professional sports event?
    - been to a rock concert?
    - been to a symphony orchestra concert?

5. What activities have you participated in this year?
    - Athletic teams?
    - Cheerleaders?
    - Band or orchestra?
    - Chorus or dance?
    - Student Council?
    - Scouts?
    - 4-H?
    - Church or synagogue activities?
    - Hobby clubs?

5\. Have you ever recieved any honors or awards?

6\. How many math courses do you think you'll take in high school?

APPENDIX D

Student Questionnaire

1. IDENTIFICATION NO. ___________

2. Date of Birth: _____/_____/_____
month day year

3. How many brothers and sisters live with you in your house?

Brothers ______ Sisters ______

4. What is your birth order (first born, youngest, etc.)? _______________

5. Please mark the following statements about your parents.

	Very True	Often True	Sometimes True	Rarely True	Not True
a. My mother keeps close track of how well I am doing in school.	0	0	0	0	0
b. My father keeps close track of how well I am doing in school.	0	0	0	0	0
c. My parents almost always know where I am and what I'm doing.	0	0	0	0	0

6. What type of school do you attend now?

_____ public _____ private, religio_____private,non-religious

7. How old were you when you started first grade? ______

8. Have you skipped any grades? ____Yes ____No

9. Have you been accelerated in any subject? ____Yes ____No
If yes, what subject/s?
____

10. During week days, about how many hours per day do you watch TV? (MARK ONE.)
_____ Don't watch any.
_____ Less than 1 hour
_____ 1 to 2 hours
_____ 2 to 3 hours
_____ 3 to 4 hours
_____ 4 to 5 hours
_____ More than 5 hours

11. What is the highest level of education you would like to complete?

High school	0
Vocational School	0
College	
1 year	0
2 years	0
3 years	0
4 years	0
Master's degree	0
Ph.D. or M.D.	0

12. When you are an adult, what occupations might you choose?____

13. How much time do you spend on homework each day for the following subjects?

	Science	Math	Foreign Lang	Social Studies	Lang Arts	Music
No homework is ever assigned.	0	0	0	0	0	0
She has homework but doesn't do it.	0	0	0	0	0	0
Less than 1/2 hours per day	0	0	0	0	0	0
1/2 to 1 hour per day	0	0	0	0	0	0
1 to 1 1/2 hours per day	0	0	0	0	0	0
1 1/2 to 2 hours per day	0	0	0	0	0	0
2 to 3 hours per day	0	0	0	0	0	0
Does not apply	0	0	0	0	0	0

14.	Mother	Father	Teacher	Friends
Who encourages your enjoyment of				
mathematics?...........	0	0	0	0
science?.................	0	0	0	0
reading?.................	0	0	0	0
writing?..........	0	0	0	0
foreign language?......	0	0	0	0
computers?.............	0	0	0	0
music?..................	0	0	0	0
art?......................	0	0	0	0

Who helps you with your homework in	Mother	Father	Teacher	Friends
mathematics?..........	0	0	0	0
science?................	0	0	0	0
reading?................	0	0	0	0
writing?..........	0	0	0	0
foreign language?......	0	0	0	0
computers?............	0	0	0	0
music?................	0	0	0	0
art?.....................	0	0	0	0

15. How much do you like the following subjects? In the "Rank" column, please rank the subjects with #1 being the most preferred.

	Strong Like	Moderate Like	Neutral	Moderate Dislike	Strong Like	Rank
Art..........................	0	0	0	0	0	____
Computers................	0	0	0	0	0	____
Foreign languages........	0	0	0	0	0	____
Gym........................	0	0	0	0	0	____
Literature..................	0	0	0	0	0	____
Mathematics..............	0	0	0	0	0	____
Music......................	0	0	0	0	0	____
Science....................	0	0	0	0	0	____
Social Studies............	0	0	0	0	0	____
Writing...................	0	0	0	0	0	____

16. When people get good grades, do you think that it is due more to hard work or to ability?

17. Indicate how difficult each of the following is for you.

	Very easy	Somewhat easy	Neither easy nor difficult	Somewhat difficult	Very difficult
Art.............................	0	0	0	0	0
Computers	0	0	0	0	0
Foreign languages............	0	0	0	0	0
Gym...........................	0	0	0	0	0
Literature.......................	0	0	0	0	0
Mathematics..................	0	0	0	0	0
Music............................	0	0	0	0	0
Science..........................	0	0	0	0	0
Social Studies..................	0	0	0	0	0
Writing..........................	0	0	0	0	0

18. What do your parents want you to do after high school?

Mother ____

Father

____

19. Where do you usually do your homework?

____

20. How much do you think your parents enjoyed the following subjects? CIRCLE THE NUMBER USING THIS KEY: 1 = Very much 2= moderately 3 = neutral 4 = disliked 5 = hated.

	Mother	Father
mathematics	1 2 3 4 5	1 2 3 4 5
science	1 2 3 4 5	1 2 3 4 5
language arts	1 2 3 4 5	1 2 3 4 5
social studies	1 2 3 4 5	1 2 3 4 5
foreign language	1 2 3 4 5	1 2 3 4 5
computer courses	1 2 3 4 5	1 2 3 4 5
music	1 2 3 4 5	1 2 3 4 5
art	1 2 3 4 5	1 2 3 4 5

21. Are men or women better suited to professions in the following fields? Circle the point corresponding to your belief.

Men **Women**

Engineering & Computer Science <--|-----|-----|-----|-----|-->

Music <--|-----|-----|-----|-----|-->

Art <--|-----|-----|-----|-----|-->

Mathematics <--|-----|-----|-----|-----|-->

Sciences: natural <--|-----|-----|-----|-----|-->

physical <--|-----|-----|-----|-----|-->

Social Sciences <--|-----|-----|-----|-----|-->

Foreign Language <--|-----|-----|-----|-----|-->

Business <--|-----|-----|-----|-----|-->

Law <--|-----|-----|-----|-----|-->

APPENDIX E

Parent Interview

I.D. NO.

1. What toys were your child's favorites during the preschool and early school years?

2. Did ________ enjoy being read to as a preschooler?
   How often did you read to her?
   What were some of her favorite books?

3. Where and when does __________ usually do her homework? Does she do homework for all subjects in the same place?

4. What have you done to facilitate her development in reading? In math? In science?

5. What kinds of character traits do you try to develop in your children?

6. How do you actively cultivate them?

7. How do you identify your ethnic background?

8. What science courses did you take in high school and college?

   What literature courses did you take in high school and college?

   What foreign language courses did you take in high school and college?

   What math courses did you take in high school and college?

9. Some people say it's important for one parent to stay at home with a baby. Others say it is important to continue your career -- that babies can thrive in substitute care. How do you feel about this?

10. Which of you is more likely to communicate with your child's school?

11. Do you oversee your child's television viewing?
    What guidelines do you use?

APPENDIX F

Parent Questionnaire

Identification No.______

1. In the space below, please indicate the highest educational level completed by each parent, degree earned, major field, and institution awarding degree.

	Highest level of educ.	Degree	Major	Institution
Mother:	________________	________	____________	_________________
Father:	_________________	________	____________	_________________

2. Mother's present occupation _______________________________________

Mother's previous occupations ______________________________________

Father's present occupation ____

Father's previous occupations ______________________________________

3. Have you or any of your relatives won any awards or honors?

	Father		Mother		Relatives	
	Yes	No	Yes	No	Yes	No
For academic excellence?	0	0	0	0	0	0
For artistic excellence?	0	0	0	0	0	0
For career excellence?	0	0	0	0	0	0

Please explain any "Yes" answer and, if a relative, please indicate relationship to you and your child.

____

____

4. Were you born in the United States? If "no," how long have you lived in the United States?

	yes	no	Number of years in U. S.
Father	0	0	___
Mother	0	0	___

5. What is the country of your origin? ______________________________

6. What language do you speak in your home? ______________________________

7. How much did (do) you like the following? In the "Rank" column, please rank the subjects with #1 being the most preferred.

	Strong Like	Moderate Like	Neutral	Moderate Dislike	Strong Like	Rank
Art..........................	0	0	0	0	0	____
Computer courses........	0	0	0	0	0	____
Foreign languages........	0	0	0	0	0	____
Physical education........	0	0	0	0	0	____
Literature..................	0	0	0	0	0	____
Mathematics..............	0	0	0	0	0	____
Music.......................	0	0	0	0	0	____
Science.....................	0	0	0	0	0	____
Writing....................	0	0	0	0	0	____

8. To whom does your child go for help with homework in

	Mother	Father	Other adult	Sibling	Friend
Art?...................................	0	0	0	0	0
Computer courses?............	0	0	0	0	0
Foreign languages?............	0	0	0	0	0
Literature?........................	0	0	0	0	0
Mathematics?....................	0	0	0	0	0
Music?..............................	0	0	0	0	0
Science?............................	0	0	0	0	0
Writing?...........................	0	0	0	0	0

9. Which careers or fields would you like your child to enter?

First choice ________________________________
Second choice ________________________________
Third choice ________________________________

10. What is the lowest level of educational attainment by your child with which you would be satisfied?

___ less than high school
___ high school graduation
___ vocational, trade or business school
<u>college program</u>
___ 1 year
___ 2 years
___ 3 years
___ 4 years
___ Master's degree

___ Ph. D. or M. D.

11. For each of the items below, please indicate your feelings and behaviors relative to your spouse. Darken the oval in the most appropriate column.

Parent completing question 11: ______ Father _______ Mother

	I more than than spouse	Spouse more than I	Both I and spouse	Neither I nor spouse
Encourages child's enjoyment of				
mathematics............	0	0	0	0
science..................	0	0	0	0
language arts...........	0	0	0	0
social studies............	0	0	0	0
foreign language........	0	0	0	0
computers..............	0	0	0	0
music....................	0	0	0	0
art........................	0	0	0	0
sports...................	0	0	0	0

12. Indicate how difficult each of the following subjects was (is) for you.

	Very easy	Somewhat easy	Neither easy nor difficult	Somewhat difficult	Very difficult
Art..............................	0	0	0	0	0
Computers	0	0	0	0	0
Foreign languages...........	0	0	0	0	0
Physical education..........	0	0	0	0	0
Literature......................	0	0	0	0	0
Mathematics..................	0	0	0	0	0
Music............................	.0	0	0	0	0
Science..........................	0	0	0	0	0
Social Studies..................	0	0	0	0	0
Writing..........................	0	0	0	0	0

13. How difficult do you think each of the following subjects is for your daughter?

	Very easy	Somewhat easy	Neither easy nor difficult	Somewhat difficult	Very difficult
Art..............................	0	0	0	0	0
Computers	0	0	0	0	0
Foreign languages.	0	0	0	0	0
Physical education..........	0	0	0	0	0
Literature......................	0	0	0	0	0
Mathematics..................	0	0	0	0	0
Music............................	.0	0	0	0	0
Science..........................	0	0	0	0	0
Social Studies..................	0	0	0	0	0
Writing..........................	0	0	0	0	0

14. Indicate how you view the following fields in respect to their suitability for men, women, or both.

Men **Women**

Engineering & Computer Science <--|-----|-----|-----|-----|-->
Music <--|-----|-----|-----|-----|-->
Art <--|-----|-----|-----|-----|-->
Mathematics <--|-----|-----|-----|-----|-->
Sciences: natural <--|-----|-----|-----|-----|-->
physical <--|-----|-----|-----|-----|-->
Social Sciences <--|-----|-----|-----|-----|-->
Foreign Language <--|-----|-----|-----|-----|-->
Business <--|-----|-----|-----|-----|-->
Law <--|-----|-----|-----|-----|-->

15. For most people, do you think that achievement depends more on ability or hard work?

____

Do you think your own achievement depends more on ability or hard work?

____

16. How much time does your daughter spend on homework each day?

	Science	Math	Foreign Lang	Social Studies	Lang Arts	Music
No homework is ever assigned.	0	0	0	0	0	0
She has homework but doesn't do it.	0	0	0	0	0	0
Less than 1/2 hours per day	0	0	0	0	0	0
1/2 to 1 hour per day	0	0	0	0	0	0
1 to 1 1/2 hours per day	0	0	0	0	0	0
1 1/2 to 2 hours per day	0	0	0	0	0	0
2 to 3 hours per day	0	0	0	0	0	0
Does not apply	0	0	0	0	0	0

17. What are your daughter's most recent semester grades?
Science ___
Social Studies ___
Math ___
Language Arts ___

18. Please fill in your daughter's fifth grade achievement test scores. The following categories are based on the Stanford Achievement Test report form. If your daughter's scores are from another test e.g., the Iowa Tests of Basic Skills, please adapt the categories.

Test Score Percentile Rank
Stanine

Word Study Skills
Reading Comprehension
Vocabulary
Listening Comprehension
Spelling
Language
Concepts of Number
Math Comprehension
Math Applications
Social Science
Science
Using Information
Total Reading
Total Listening
Total Math
Total Language
Basic Battery Total
Complete Battery Total

APPENDIX G

Informed Consent Form

Project Title: Achievement Patterns among Fifth and Sixth Grade Girls

I, ______________________________, the parent or guardian of ___________________
(Name of signatory) (Name of minor subject)
a minor of___ years of age, hereby consent to her participation in a research project being conducted by Carol Huntsinger.

This study is being conducted to examine achievement patterns among fifth and sixth grade girls and to explore family support for achievement. Data will be gathered in two sessions with each subject. During a one-hour group session, several measures will be administered including the Spatial Relations Test from the Primary Mental Abilities Test which takes 11 minutes, the Children's Personality Questionnaire which may take from 30-40 minutes and a personal history questionnaire which will take 5-10 minutes. These are paper and pencil tests commonly used in research across the country. All are appropriate for children ages 8-12 and are similar to what teachers would use in the classroom. During a second individual session at the time of the parent interview, the girls will be asked to spend 20-30 minutes with two enjoyable computer programs.

Both parents will be asked to complete questionnaires at home and to supply the investigator with their daughter's fifth grade achievement test scores. In addition, the investigator will conduct a 30-minute parent interview at the parents' convenience in their home.

All information obtained will be kept confidential and will be analyzed anonymously.

I understand that no risk is involved, but that in any case I may withdraw my child from participation at any time without prejudice.

____ ____________________
(Signature of parent) (Date)

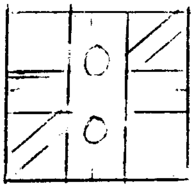
APPENDIX H

Sample Transcript of Mother-Father-Daughter Interaction with the Computer

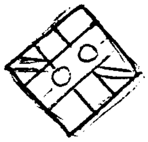
#48 Parent-Child-Computer Interaction with Factory 7-18-90

Mom on left; Dad on right. M = Mom, D = Dad, K = Kristin (daughter), C = Researcher

FACTORY
#1 Test Machines
C: You have to make a choice.
K. selected the punch machine (3 square punches)
K: (reading) Do you want to test another machine?
K. looked at Dad, then Mom
D & M: You make the choice.
K. O.K.
K. selected the Rotate machine (135)
Then K. selected the Stripe machine (medium).
K. reads silently, "Do you want to test another machine?"
Selects No.
K: O.K. What are we going to do now? Hard level begins here,
C: I want you to make a product now; so go to number 3.
K: O.K. (Chose the hard level). ASE
M: (laughed). Said softly, "She likes a challenge." GI
K. laughed.
She selects machines necessary to make the product without a word.



K: What did the rotation one do? (laughs) AQ
M: It rotated it. ANSQ
M. Remember the number of degrees you can rotate? AQ
K: O.K. I don't know, but--------- ANSQ
Selects very quietly 2 round punches, medium stripe, medium stripe.
K: I messed up but I don't care. EC
PRODUCT HAS A FLAW!
K: Oops! ASE
K: I need one of these over there (points to screen). MD
M. and K. laugh.
M. At least you figured it out. EC
K: I'm almost done. EC
M: You need another--- MD
M: That wasn't bad for the first time through! EC
It'll be interesting to see how this one comes out. EC
K. laughed.
K. selects 2 round punches, Medium stripe, 90 rotation, Medium stripe, 45 rotation, Thin stripe (silently).
PRODUCT HAS A FLAW1
K: Oops! ASE
M: Oh, no! (laughs) ASE



Both tilt heads to view product.
M: Hey, wait a minute though. (K. laughs) If you turn that sideways-- MD MD
K: It's kind of--pretty close. Well, this stripe needs to go like that. (K. touches screen.) EC MD

K: O.K. ASE

M: Do you remember now what you did wrong so you can redo? AQ

K: No--(laughs)--no, I don't remember! ANSQ

K selects 2 round punches, Medium Stripe, 90 rotation, Medium stripe (silently)

M: Oooo--- ASE

K: (Looks at Mom) Shhh---- MD

K: Oops! (She erases and redoes the last machine.) ASE

K. selects 2 round punches, Medium stripe, 90 rotation, Medium stripe, 135 rotation, Thin Stripe.

K: (presses "done" and laughs.)

M. (points to screen) You should put the hole in that one. MD

K: Be quiet! MD

PRODUCT HAS A FLAW!

K: Oops! ASE

M: Now, well wait a minute now. If we are---- MD

K: (looks at M. and laughs.)

K: (looks at M. again.)

K: O.K. ASE

Selects more machines quietly. EC

M: There (inaudible)

K.(looks at M.) Shhh---O.K., where was I? (K. wants no help!) MD AQ

M: O.K., I'll be quiet. AS MD

K. selects 2 round punches, Medium stripe, 90 rotation, Medium stripe, 135 rotation, Thin stripe, 45 rotation. (All done silently.)

K: I think I did it this time. Maybe--- EC

K: (looks at Dad) At least it's a square. EC

K: Yay! It's right. EC

M: Kristin! EC

Dog barked at the cheering.

PRODUCT HAS A FLAW! (The width of one stripe was incorrect.)

K: I messed up again. I messed up again. DC DC

M: Do you know what? (M. points to screen.) AQ

K: Yes, I do! Yes, I do! (Touches M. to quiet her.) ANSQ

Dog barked again; so Dad took him out to porch.

K. selected machines again.

K: Oops! (self-corrected her error) ASE

PRODUCT HAS A FLAW!

K: What's the matter with it this time? AQ

M. (points to the thin diagonal line on screen) This. ANSQ

M: So close--- EC

K: Oh-- ASE

Selected silently again: 2 round punches, Thick stripe, 90 rotation, Thick stripe, 135 rotation, Medium stripe, 45 rotation.

K: It should be right this time. EC

M: It is! EC

K: (looks at M.) Shh-- MD

K: Please, please (as product is being made with the machines she selected). EC

M & K (in unison) YAY!!

M: She likes a challenge. GI

D: I'm glad you could get it. EC

APPENDIX I

Completed Coding Form for Representative Transcript

Observation of Parent-Child Interaction I. D. # 48 Date 7-18-90

☐ = occurences per minute

	Father	Mother	Child
Demonstrates			
Points to keyboard		③	②
Points to screen		||| .28		.18
Touches keyboard			
Touches screen				

****

	Father	Mother	Child
Looks at child			
Looks at mother			卌 ⑤ .46
Looks at father			|| ② .18
Laughs		|||| ④ .37	卌|| ⑦ .65
Touches child			

****

(T0 BE CODED FROM TAPE)

	Father	Mother	Child
MD Makes directive statement.		卌|| ⑦ .74	卌| ⑥ .63
GI Gives information, explanation.		|| ② .21	
ANSQ Answers question		|| ② .21	|||| ④ .42
AQ Asks question		||| ③ .32	||| ③ .32
EC Encouraging comment,praise		.11	卌||| ⑧ .84	卌|||| ⑨ .95
DC Discouraging comment			|| ② .21
ASE Acknowleages statement, exclaims		||| ③ .32	卌|||| ⑨ .95
RA Reads aloud			

Factory Hard Level = 9 min. 31 sec.

APPENDIX J

A Compilation of Parent Practices to Facilitate Reading, Math, and Science

Interview Question: How have you facilitated your daughter's development in reading?

Summary of Unique Parent Answers:
1 = Read to her
2 = Go to library
3 = Parent example
4 = Purchased books at bookstores
5 = Purchased phonics and story tapes
6 = Subscribe to magazines and newspapers
7 = Purchased books at school book sales
8 = Asked librarian for suitable books
9 = Borrowed books from friends
10 = Watch TV programs that teach reading
11 = Mom volunteered in children's room at library.
12 = Attended to physical conditions for reading, e.g., light level, comfortable chair
13 = Gave books as gifts
14 = Encourage her to read on a subject of mother's choice and write a 2-page essay daily.
15 = Enroll in library reading clubs
16 = Read long books as a family
17 = Read about plays and musicals we will be attending
18 = Monitor homework
19 = Take to library story hour and activities
20 = Mom finds books on a topic daughter enjoys.
21 = Act on suggestions teacher makes.
22 = Can stay up 1/2 hour after bedtime for the purpose of reading.
23 = Dad reads to her regularly.
24 = Mom still reads to her sometimes.
25 = Encourage her to read to her sibling and to children she babysits for.
26 = Hired older child to read to her as a preschooler.
27 = One night per week is family reading night.
28 = Do family "add-on" stories
29 = Involved in parent-child program when she was a toddler. Directed our attention to parenting and ways to help with reading.
30 = Enrolled in public school summer school reading enrichment programs.
31 = Suggest she take books on our vacation.
32 = For every Babysitters' Club book she reads, she must read a Newberry Award winner. For every 2 teen books, she must read one classic or information book.
33 = Attempt to make her read the classics, but she's not that interested yet.
34 = Dad made hundreds of word flashcards.
35 = Reads in bed with parents.
36 = Nintendo
37 = Talk about how important reading is.
38 = An hour of TV for every hour of reading (not a willing reader).
39 = Told her stories.
40 = Ask friends for ideas on what books are good.
41 = We tried to avoid reading to her because of our accent, but we made sure someone else did.

42 = Transport her to the library.
43 = Check to see if the teacher has recommended booklists.
44 = We make sure they read a lot.

Interview Question: How have you facilitated your daughter's development in math?

Summary of Unique Parent Answers:

1 = Taught her to count
2 = Give extra worksheets and workbooks from teacher supply store.
3 = Drilled--practiced
4 = Help with homework.
5 = Provide orderly, organized environment.
6 = Bought construction toys.
7 = Real life problems--counting money, measuring, making change, figuring tip
8 = Sent to nursery school or Montessori--became interested in numbers, patterns,
9 = Got math books from native country.
10 = Father gives extra math problems to challenge her.
11 = Do the math pages in children's magazines.
12 = Teach her math during the summer and other school vacations to pre-prepare her for the coming semester.
13 = Demonstrate new concepts and how to do homework.
14 = Parent does technical work at home; child observes.
15 = Father wrote simple math computer programs for child to do.
16 = Borrowed singing multiplication facts tapes and played for children.
17 = Older sister played school with her and used old math books.
18 = Keep even temper when problem solving.
19 = She must compute manually; no calculators allowed. Needs to use her head.
20 = Encourage child to think constantly.
21 = Spent travel time (to and from day care, etc.) asking her addition and subtraction problems.
22 = Check her homework.
23 = Keep her occupied with math questions in restaurant while waiting for service.
24 = Bought math computer programs.
25 = Played board games
26 = Logic puzzles
27 = Bought Math Bingo, Little Professor, Math Master, Computron, Speak 'n Math
28 = Inherited--Grandma loves math.
29 = Multiplication tables poster made by Dad or Grandpa.
30 = Map reading (coordinates-spatial orientation). She is navigator for family trips.
31 = Increased parent attention to math because daughter seemed to have difficulty with reasoning. Now she is qualified for the gifted program.
32 = Playing restaurant, store, etc.
33 = Bought her a calculator.
34 = Did lot of categorizing activities when she was young.
35 = Supported her natural interest in math.
36 = Encouraged her to take Math Games in summer school.
37 = L. thought comparing prices at the grocery store was fun.
38 = Encouraged her to get help from anyone she can--our adult friends.
39 = Mom taught her the math in fifth grade--had a poor teacher that year.

40 = Flash cards every night.
41 = Mom helps her to solve her "AAA" math problems.
42 = She handles her own money received from babysitting.
43 = Grandpa gives her logic puzzles.
44 = We tried to make it fun.
45 = Review every day in the summer.
46 = Taught her how to use the adding machine.
47 = She balances our checkbook every month.
48 = We leave everything to the school. We know the teachers and principal.
49 = School gives extra points to kids whose parents help them with homework.
50 = Help her study for tests.
51 = Told her she was good at math.
52 = She can follow in older sister's (brother's) footsteps.
53 = Joined the Kumon Math Program.
54 = Restrict her play with friends after school. She does homework instead.

Interview Question: How have you facilitated your daughter's development in science?

Summary of Unique Parent Answers:
1 = Trips to museums, wildlife preserves, zoo, seashore, botannical gardens, Mammoth Cave, Estes Park, Smithsonian
2 = Point out day-to-day experiences.
3 = Buy encyclopedias and science books.
4 = Parent example.
5 = Plants flowers, trees, garden, houseplants.
6 = We explain when she has a question. Answer her questions.
7 = Help with school projects.
8 = She watches Dad do medical-hospital homework.
9 = I show her how to use references at the library.
10 = Do experiments from children's magazines.
11 = Teach her to observe her environment carefully.
12 = Ask her to think about how a phenomenon happened.
13 = Enroll her in a special summer school science program.
14 = Ask her to learn enough about a topic to teach other family members.
15 = Subscribe to science magazines.
16 = Older sister is a model for science achievement.
17 = Supported her interest in space travel.
18 = Encourage curiosity.
19 = Bought telescope, chemistry set, magnifying glass, model plane kit.
20 = Took her to geology lab of a professor friend.
21 = Dad reminds her of her high aptitude.
22 = Dad was a coach of Odyssey of the Mind.
23 = She helped Dad build a kit car.
24 = Lots of medical talk around the house (Science-type conversations).
25 = Support her collections.
26 = Helps around Dad's dental office and lab.
27 = Shares in projects and reading matter for brother's science interests.
28 = Visited Dad's pharmaceutical lab.
29 = Nature walks with naturalist every chance we can.
30 = Look at stars.
31 = Supported her self-directed desire to invent.

32 = Geology trips to San Francisco, Rocky Mountains, Yosemite, Michigan
33 = Encouraged school extra credit projects.
34 = She researched and planted her own herb garden.
35 = Have pets and other animals on a farm.
36 = Go to Dad's veterinary office.
37 = Backpacking, camping in wilderness.
38 = Works for Girl Scout Badges (Mom is the leader.)
39 = Cooks and bakes.
40 = Science TV programs
41 = Fish tank physics--pump, hoses, siphon
42 = Members of Museum of Science and Industry
43 = Swam with dolphins, snorkeling in Florida Keys
44 = Live on farm or in woods.
45 = Discuss ecosystems when fishing with Dad.
46 = Praise her for her good work.
47 = Talk with Mom's science educator friend.
48 = Skiing as a family.
49 = Inspects frogs in the lake in our back yard.
50 = Ask her to check out books from the library.
51 = Always encourage her participation in science workshops.
52 = Help her narrow down her topic for the science fair.
53 = We support the 4-H program with its many science related projects.
54 = We constantly remind them how important science and math are.
55 = She takes care of her rabbit and birds.
56 = She did a prize-winning earthworm project in 4-H.
57 = We force them to read a little science.
58 = Have a tropical fish aquarium.
59 = Help her study for tests.
60 = Transport her to the library.
61 = Enroll her in the library science workshops.
62 = Plays with carpentry and mechanical things.
63 = We follow the teacher's instructions.
64 = Bought science supplies.

APPENDIX K

Table 8. -- Intercorrelation Matrix of Math Attitudes, Achievement, Attainment, and Aspirations

	2 HrsTV Stu	3 LoLv EdFa	4 LoLv EdMo	5 MoDif Dau	6 FaDif Dau	7 TtlTm Fac	8 TmMth Bl	9 Mth Cmpu	10 TtlMth	11 Conc Nos	12 Mth Appl
1. HiLvEdSt	-.19	-.04	.07	.01	-.06	-.30*	-.04	. 07	.15	.02	.04
2. HrsTVSt		-.18	-.38**	-.09	-.16	-.04	-.04	-.04	.21	-.15	.02
3. LoLvEdFa			.59***	-.20	-.14	-.23	-.03	.26*	.37**	.34**	.31*
4. LoLvEdM				-.36**	-.37**	-.34**	-.06	.42***	.52***	.43***	. 30
5. MoDifDau					.52***	.10	.16	-.46***	-.40***	-.34**	-.27*
6. FaDifDau						-.31*	.16	-.35**	-.33**	-.40**	-.36**
7. TtlTmFac							- 29*	-.06	-.09	-.22	-.08
8. TmMthBl								-.33*	-.26*	-.29*	-.03
9. MthCmpu									.78***	.51***	.45***
10. TtlMth										.72***	.75***
11. ConcNos											.79***
12. MthAppl											

*p < .05, **p < .01, ***p < .001.

Note. HiLvEdSt = Highest level of education student would like to attain, HrsTVSt = Daily TV viewing hours reported by student, LoLvEdFa = Lowest level of daughter's education with which father would be satisfied, LoLvEdM = Lowest level of daughter's education with which mother would be satisfied, MoDif Dau = Mother estimate of difficulty of math for daughter, FaDifDau = Father estimate of difficulty of math for daughter, TtlTmFac = Time required to reach solution at hard level in "Factory" computer program, TmMthBl = Time required for solution of first problem on "Math Blaster Mystery," MthCmpu = Student's percentile rank on math computation achievement test, TtlMth = Student's percentile rank on total math achievement test, ConcNos = Student's percentile rank on concepts of number achievement test, MthAppl = Student's percentile rank on math applications achievement test, StuMthGrade = Student's spring, 1990 semester math grade, StuLike = Student's rating of math, MomLike = Mother's rating of math, FatherLike = Father's rating of math, SRT = Student's score on Spatial Relations Test, MoHSMath = Years of high school math mothers took, FaHSMath = Years of high school math fathers took, StPercMom = Student's perception of how much her mother liked math, StPerFath = Student's perception of how much her father liked math, MoClMath = Number of college math courses taken by mother, FaClMath = Number of college math courses taken by father, StHSMath = Years of high school math students (girls) plan to take.

Table 8--Continued

	13 StuMth Grade	14 Stu Like	15 Mom Like	16 Father Like	17 SRT	18 MoHS Math	19 FaHS Math	20 StPerc Mom	21 StPer Fath	22 MoCl Math	23 FaCl Math	24 StHS Math
1. HiLvEdSt	.16	.24*	.08	.02	.16	.35**	-.05	.18	.22*	.16	-.05	.26*
2. HrsTVSt	-.11	-.16	-.22	-.04	-.03	-.31**	-.05	-.41***	-.14	-.01	.14	.05
3. LoLvEdFa	.40***	.20	.39**	-.04	.31**	.36**	.10	.31**	.03	-.04	.18	.18
4. LoLvEdM	.53***	.42***	.40**	.06	.13	.45***	-.10	42***	-.10	.20	-.25*	.08
5. MoDifDau	-.55***	-.49***	-.26*	-.06	-.18	-.20	-.01	-.18	-.04	-.23*	-.10	-.25
6. FaDifDau	-.58***	-.55***	-.17	-.27	-.04	-.20	-.09	-.18	-.19	-.28*	-.17	-.22
7. TtlTmFac	-.38**	-.22	-.17	-.24*	-.14	-.26*	-.01	-.14	-.26*	-.24*	-.16	-.09
8. TmMthBl	-.07	.01	-.03	-.14	-.33*	-.07	-.04	-.05	-.18	-.18	.12	-.10
9. MthCmpu	.63***	.49***	.34**	.01	.35**	.33**	-.03	.25*	.05	.20	-.23*	.42***
10. TtlMth	.68***	.34**	.37**	-.05	.47***	.45***	.04	.35**	-.05	.18	-.27	.26*
11. ConcNos	.57***	.28*	.20	-.02	.50***	.40***	.07	.30*	.18	.22	-.17	.11
12. MthAppl	.49***	.17	.20	-.03	.43***	.33**	.01	.11	-.08	.16	-.16	.10

*p < .05, **p < .01, ***p < .001.

Note. HiLvEdSt = Highest level of education student would like to attain, HrsTVSt = Daily TV viewing hours reported by student, LoLvEdFa = Lowest level of daughter's education with which father would be satisfied, LoLvEdM = Lowest level of daughter's education with which mother would be satisfied, MoDif Dau = Mother estimate of difficulty of math for daughter, FaDifDau = Father estimate of difficulty of math for daughter, TtlTmFac = Time required to reach solution at hard level in "Factory" computer program, TmMthBl = Time required for solution of first problem on "Math Blaster Mystery," MthCmpu = Student's percentile rank on math computation achievement test, TtlMth = Student's percentile rank on total math achievement test, ConcNos = Student's percentile rank on concepts of number achievement test, MthAppl = Student's percentile rank on math applications achievement test, StuMthGrade = Student's spring, 1990 semester math grade, StuLike = Student's rating of math, MomLike = Mother's rating of math, FatherLike = Father's rating of math, SRT = Student's score on Spatial Relations Test, MoHSMath = Years of high school math mothers took, FaHSMath = Years of high school math fathers took, StPercMom = Student's perception of how much her mother liked math, StPerFath = Student's perception of how much her father liked math, MoClMath = Number of college math courses taken by mother, FaClMath = Number of college math courses taken by father, StHSMath = Years of high school math students (girls) plan to take.

Table 8--Continued

	14 Stu Like	15 Mom Like	16 Father Like	17 SRT	18 MoHS Math	19 FaHS Math	20 StPerc Mom	21 StPer Fath	22 MoCl Math	23 FaCl Math	24 StHS Math
13. StuMthGr	.52***	.32**	.19	.40***	.36**	.22*	.25*	.13	.14	-.02	.42***
14. StuLike		.40***	.05	.07	.33*	-.15	.43***	.10	.22	-.03	.40***
15. MomLike			-.13	.04	.48***	-.22	.58***	-.05	-.24	-.24*	.20
16. FathLike				-.16	.00	.48***	.00	.24	.17	.34**	-.13
17. SRT					.32**	.10	.12	.16	-.05	-.29*	.08
18. MoHSMth						.08	.53***	.13	.23*	-.29*	.20
19. FaHSMth							.09	.26*	.02	.21	-.05
20. StPercMo								.34**	.26*	.13	.15
21. StPercFa									.20	.13	.16
22. MoClMth										.20	-.07
23. FaClMth											-.03
24. StHSMth											

*p < .05, **p < .01, ***p < .001.

Note. HiLvEdSt = Highest level of education student would like to attain, HrsTVSt = Daily TV viewing hours reported by student, LoLvEdFa = Lowest level of daughter's education with which father would be satisfied, LoLvEdM = Lowest level of daughter's education with which mother would be satisfied, MoDifDau = Mother estimate of difficulty of math for daughter, FaDifDau = Father estimate of difficulty of math for daughter, TtlTmFac = Time required to reach solution at hard level in "Factory" computer program, TmMthBl = Time required for solution of first problem on "Math Blaster Mystery," MthCmpu = Student's percentile rank on math computation achievement test, TtlMth = Student's percentile rank on total math achievement test, ConcNos = Student's percentile rank on concepts of number achievement test, MthAppl = Student's percentile rank on math applications achievement test, StuMthGrade = Student's spring, 1990 semester math grade, StuLike = Student's rating of math, MomLike = Mother's rating of math, FatherLike = Father's rating of math, SRT = Student's score on Spatial Relations Test, MoHSMath = Years of high school math mothers took, FaHSMath = Years of high school math fathers took, StPercMom = Student's perception of how much her mother liked math, StPerFath = Student's perception of how much her father liked math, MoClMath = Number of college math courses taken by mother, FaClMath = Number of college math courses taken by father, StHSMath = Years of high school math students (girls) plan to take

APPENDIX L

Table 9

Intercorrelation Matrix of Academic Attitudes, Achievement, Attainment, and Aspirations

	2 HrsTV Stu	3 LoLv EdFa	4 LoLv EdMo	5 StuLike Science	6 StuLike Lit	7 StuSci Grade	8 StuSS Grade	9 StuMth Grade	10 Stu LA Grade
1. HiLvEdSt	-.19	-.04	.07	.09	.12	-.14	-.04	.16	.23*
2. HrsTVSt		-.18	-.38**	.11	-.22	.13	.13	-.11	-.02
3. LoLvEdFa			.59***	.07	.01	.25	.10	.40***	.06
4. LoLvEdM				-.10	.10	.24*	-.08	.53***	.21
5. StLikeSci					-.02	.14	.16	.13	-01
6. StLikeLit						-.14	.00	.12	.30**
7. StSciGrade							.24	.48***	.27
8. StSSGrade								.21	.40***
9. StMthGrad									.46***
10. StLAGrad									

*p < .05, **p < .01, ***p < .001.

Note. HiLvEdSt = Highest level of education student would like to attain, HrsTVSt = Daily TV viewing hours reported by student, LoLvEdFa = Lowest level of daughter's education with which father would be satisfied, LoLvEdM = Lowest level of daughter's education with which mother would be satisfied, StLkSci = Student's rating of math, StLkLit = Student's rating of literature, StSciGrade = Student's spring, 1990 semester science grade, StSSGrade = Student's spring, 1990 semester social studies grade, StMthGrad = Student's spring, 1990 semester math grade, StLAGrad = Student's spring, 1990 semester language arts grade, SciAchTst = Student's percentile rank on science achievement test, ReadCmp = Student's percentile rank on reading comprehension achievement test, SpellTest = Student's percentile rank on spelling achievement test, TotalLang = Student's percentile rank on total language achievement test, MoHSSci = Years of high school science mothers took, FaLikeSci = Father's rating of science, FaLikeLit = Father's rating of literature, MoLikeSci = Mother's rating of science, MoLikeLit = Mother's rating of literature.

Table 9--Continued

	11 SciAch Test	12 Read Comp	13 Spell Test	14 Total Lang	15 MoHS Sci	16 FaLike Sci	17 FaLike Lit	18 MoLike Sci	19 MoLike Lit
1. HiLvEdSt	.08	.15	.09	-.06	.13	.09	.15	-.04	-.21
2. HrsTVSt	.02	.16	-.24*	-.04	-.29	-.10	.13	.00	-.11
3. LoLvEdFa	-.02	.25*	.50***	.35**	.30*	-.14	-.06	-.06	.05
4. LoLvEdM	-.06	.05	.40***	.24*	.22*	-.18	-.01	.01	.07
5. StLkSci	-.03	.04	-.08	-.17	.28*	-.09	-.04	-.03	-.06
6. StLkLit	.18	.40***	.53***	.22	-.11	-.09	-.05	-.02	.09
7. StSciGrade	.15	.20	.24*	.29*	-.07	-.17	.13	-.12	.03
8. StSSGrade	.44**	.41***	.34**	.42***	.08	-.13	-.03	-.08	.03
9. StMthGrad	-.01	.33**	.49***	.39***	.12	-.12	-.07	-.01	-.11
10. StLAGrad	.28*	.47***	.59***	.50***	.15	-.02	.07	-.24	-.02

*p < .05, **p < .01, ***p < .001.

Note. HiLvEdSt = Highest level of education student would like to attain, HrsTVSt = Daily TV viewing hours reported by student, LoLvEdFa = Lowest level of daughter's education with which father would be satisfied, LoLvEdM = Lowest level of daughter's education with which mother would be satisfied, StLikeSci = Student's rating of math, StLikeLit = Student's rating of literature, StSciGrade = Student's spring, 1990 semester science grade, StSSGrade = Student's spring, 1990 semester social studies grade, StMthGrad = Student's spring, 1990 semester math grade, StLAGrad = Student's spring, 1990 semester language arts grade, SciAchTst = Student's percentile rank on science achievement test, ReadCmp = Student's percentile rank on reading comprehension achievement test, SpellTest = Student's percentile rank on spelling achievement test, TotalLang = Student's percentile rank on total language achievement test, MoHSSci = Years of high school science mothers took, FaLikeSci = Father's rating of science, FaLikeLit = Father's rating of literature, MoLikeSci = Mother's rating of science, MoLikeLit = Mother's rating of literature.

Table 9--Continued

	12 Read Comp	13 Spell Test	14 Total Lang	15 MoHS Sci	16 FaLike Sci	17 FaLike Lit	18 MoLike Sci	19 MoLike Lit
11.SciAchTst	.74***	.38*	.33*	-.21	-.08	.03	-.13	-.12
12.ReadCmp		.50***	.48***	-.06	-06	.16	-19	-.09
13.SpellTest			.67***	.28*	-.20	.03	-.19	.01
14.TotalLang				.10	-.16	-.11	-.12	-.06
15.MoHSSci					.10	-.08	.17	-.07
16. FaLikeSci						-.10	-.04	.05
17. FaLikeLit							-.17	.31*
18. MoLikeSci								-.04
19. MoLikeLit								

*p < .05, **p < .01, ***p < .001.

Note. HiLvEdSt = Highest level of education student would like to attain, HrsTVSt = Daily TV viewing hours reported by student, LoLvEdFa = Lowest level of daughter's education with which father would be satisfied, LoLvEdM = Lowest level of daughter's education with which mother would be satisfied, StLikeSci = Student's rating of math, StLikeLit = Student's rating of literature, StSciGrade = Student's spring, 1990 semester science grade, StSSGrade = Student's spring, 1990 semester social studies grade, StMthGrad = Student's spring, 1990semester math grade, StLAGrad = Student's spring, 1990 semester language arts grade, SciAchTst = Student'spercentile rank on science achievement test, ReadComp = Student's percentile rank on reading comprehension achievement test, SpellTest = Student's percentile rank on spelling achievement test, TotalLang = Student's percentile rank on total language achievement test, MoHSSci = Years of high school science mothers took, FaLikeSci = Father's rating of science, FaLikeLit = Father's rating of literature, MoLikeSci = Mother's rating of science, MoLikeLit = Mother's rating of literature.

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The final copies have been examined by the director of the dissertation committee and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the dissertation is now given final approval by the committee with reference to content and form.

The dissertation is, therefore, accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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