ABSTRACT

Title of Dissertation: A CROSS-CULTURAL STUDY ON VARIABLES INFLUENCING GENDER DIFFERENCES IN MATHEMATICS PERFORMANCE

Sayuri Takahira, Doctor of Philosophy, 1995

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The purpose of this dissertation is to investigate gender differences in mathematics cross culturally (Japan and the United States), and to find whether there are gender differences in their sex-stereotyped beliefs about mathematics, attitudes toward mathematics, learning patterns of mathematics, and problem solving strategies/causes of mistakes and whether there are relationships among these variables.

There were 2 studies. In Study 1, two performance variables, efficiency of problem solving strategies and seriousness of causes of mistakes, were developed through protocol analysis. In Study 2, 207 10th grade Japanese high school students and 164 9th to 12th grade American high school students participated. Subjects were administered (1) 5 SAT-Math items, (2) solution strategy and causes of mistake questionnaire, (3) attitude toward mathematics questionnaire, and (4) learning patterns questionnaire.

A 2 (sex) x 2 (nation) analysis of variance and separate within nation univariate analysis by gender were performed on the 12 variables, 3 in each of 4 areas (sex-stereotyped beliefs about math, other attitudes toward math, learning pattern of math, and performance). For Japanese sample, moderate to large gender differences were found in the sex-stereotyping and attitude variables. For the U.S. sample, gender differences were found in sex-stereotyping and learning variables. The direction of the gender differences in sex-stereotyping variables were opposite for the Japanese sample and for the American sample. Among the American sample, females held more egalitarian views toward mathematics than males. In contrast, in the Japanese sample, it is the females who held stronger sex-stereotyped beliefs about mathematics than males. Regardless of students' nationality, there were significant relationships between attitude variables and learning variables.

A CROSS-CULTURAL STUDY ON VARIABLES INFLUENCING GENDER DIFFERENCES IN MATHEMATICS PERFORMANCE

by

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DEDICATION

To my three nieces, Maami, Sayaka, and Madoka,

the next generation of Japanese women.

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INTRODUCTION

During the past two decades, there have been significant improvements in women's participation both in higher education and employment in the United States. Today, women represent more than half of the students in higher education, and over half of all the work force. However, the proportion of women in different fields of occupations or different disciplines in post secondary institutions tells us quite a different story. It is well known that women are still significantly under-represented in mathematics-related occupations, such as engineering and physical science. In spite of the fact that in other male-dominated occupations (e.g., lawyer, physician) females have over one third of the positions, only 9 percent of all engineers were female and only 13% of physical scientists were female in 1992 (NSF Science & Engineering Indicators, 1993). These gender differences in occupation are found in other nations as well and are more prominent in some nations. For example, in Japan, one quarter of those who graduated medical schools were females, whereas, less than two percent of engineering degrees were awarded to female students in 1992 (NSF Science & Engineering Indicators, 1993).

Since Maccoby and Jacklin's (1974) book, it is well documented that there are gender differences (favoring males) on some spatial tests, and on mathematics aptitude tests, although many studies have reported that the gender differences are decreasing over time (Hyde & Linn, 1988; Hyde et al., 1990). Some of the differences such as those found for the mathematics part of the Scholastic Aptitude Test (SAT) are consistent over time and large enough to affect admissions to selective institutions and to mathematics-related disciplines in many institutions in post secondary education. The male-to-female ratio among the students who scored higher than 700 on the SAT was 4-to-1; that is, only one girl scored higher than 700 for every four boys who did so in the mathematics part of the SAT, although the verbal part of SAT shows no significant difference in gender proportion at any achievement levels (1987 College board).

What is more disturbing is the fact that these patterns of gender differences in mathematics were not only found in the United States but also found in other nations as well. According to the Second International Study on Mathematics (SIMS), not all, but most countries participating in the study found gender differences in many areas of mathematics in both 8th and 12th grades (Robitaille & Garden, 1988). Among the nations participating in the study, Japan was one of five nations that have found the largest gender differences in mathematics performance.

Various approaches such as biological, socio-cultural, motivational, and cognitive have been taken to investigate the nature and the sources of the gender difference in mathematics. The biological approach examines the relation between gender differences in brain physiology and gender differences in mathematics. The socio-cultural approach investigates the effect of social variables such as sex-role stereotypes of mathematics performance on male and females in different nations. The motivational approach focusses on gender differences in attitudes toward mathematics (e.g., self-concept of math ability, the value of math, etc.) and looks at the relation between these variables and gender differences in mathematics performance. Finally, there are two types of cognitive approaches. One type investigates the differences in the ways males and females study mathematics. The other type of cognitive approach studies mathematics problem solving strategies used by males and females or errors in mathematics problem solving processes made by males and females.

Although much has been gained by studying variables such as stereotypes and strategies separately, very little is known about how the variables emphasized in different approaches might relate to each other. Moreover, whereas many studies have been done regarding gender differences in mathematics, there is no comprehensive theory which can completely explain these gender differences.

The primary purpose of the present dissertation is to investigate the relation among the psycho-motivational (e.g., attitudes toward math etc.), learning (e.g., study habits) and performance variables (e.g., problem-solving strategy etc.) with respect to gender differences in mathematics. The ultimate goal of this study is to acquire sufficient data in order to eventually build a comprehensive theory. In order to carry out this investigation, attitudes toward mathematics, learning patterns and the problem solving strategies/causes of mistakes of Japanese and U.S. students were studied. The lists of the independent and the dependent variables are provided later in this chapter.

This dissertation itself includes seven chapters and two studies. The first chapter presents an overview of the study as well as the problem statement and the purpose of the study. The second chapter presents a review of the different approaches toward gender differences in mathematics and concludes with general research questions. The third chapter presents a qualitative study (Study 1) that was conducted to reveal the performance variables regarding solution strategy and causes of mistakes. The fourth chapter describes the methodology for Study 2, the main study of this dissertation. The fifth chapter describes the results of a preliminary factor analysis of the data in Study 2. The sixth chapter organizes and presents the main results of Study 2 according to the hypotheses. And the seventh chapter and final chapter contains a discussion of the results and implications of the findings.

This remainder of this chapter includes six sections: 1) independent and dependent variables, 2) definitions of the key terms, 3) assumptions of studies, 4) limitations of studies, 5) significance of the study, and 6) the summary of this chapter.

1.1 Independent/Dependent Variables

The independent variables include such demographic variables as gender and nationality (Japan and U.S.). The dependent variables include variables from two different approaches: motivational and cognitive. The variables in the cognitive approach are divided into two factors, performance and learning. The variables for the performance factor include: 1) scores on mathematics problem solving items, 2) scores on a measure of problem solving strategies, 3) scores on degree of seriousness of the mistakes. The variables for the learning factor include: 1) score for regularity in studying, 2) score for independence in studying, 3) score for other aspects of study habits. The motivational variables are divided into two parts: sex-stereotyped beliefs and attitudes other than sex-stereotyped beliefs. The sex-stereotyping variables include three constructs: 1)beliefs about math as a male domain, 2) utility of math, 3) math-related occupations. The other attitude variables include:1) perception of mathematics ability, 2) value of mathematics, and 3) task difficulty. The detailed descriptions of these variables are presented in chapter 4.

1.2 Definitions of Key Words

One of the weakness in this area of research is the ambiguity of the definitions of terms such as the definitions of ability, performance, achievement, etc. Different researchers define the terms differently and use different measurements. Lack of consensus regarding the terminology among researchers might result in some inconsistencies of findings in the study of gender differences in mathematics. A consensus is particularly important in cross-cultural study. Each culture defines the terms based on their cultural beliefs. For example, the meaning of the term, "ability", in the United States may or may not be the same as the meaning of the term in Japan. In the present study, the author tried to avoid the confusions caused by the ambiguity of the definition of terminology by recognizing the cultural differences and similarities and by defining critically important terms clearly. These terms are described next.

Mathematics Ability

Many researchers such as Halpern (1992) give the term, "ability", a broader meaning than most achievement motivation theorists. Her writing suggests that "ability" not only means "innate or biologically determined trait," but also means "acquired skills through one's experiences." However, in many theories, especially in attribution theory, "ability" is treated as an innate and biologically determined trait that is stable and uncontrollable (e.g., Weiner, 1979). In order to avoid confusion, when the term "ability" implies genetically predisposed traits, it will be specifically indicated as "innate ability". The unmodified term "ability" will refer to combination of both genetically predisposed traits and skills acquired through one's experience.

Mathematical skills

Skills are acquired through environmental input such as everyday classroom experiences, studying hard, and practice.

Mathematics performance and Achievement

Mathematics Performance (achievement) is defined as results on tests which measure one's acquired skill. Such skills may reflect both what one has learned in mathematics classes and one's ability.

The relative importance placed on innate ability versus acquired skills for explaining performance becomes a critical difference in the fundamental philosophy of education between two cultures.

1.3 Assumptions of the study

Many researchers who study gender differences in cognitive ability endorse an interactionist view. This view emphasizes the effects of both innate ability and environment as the causes of gender differences (e.g., Halpern, 1992). Only a few researchers such as Fennema (1981) have emphasized exclusively environmental effects such as sex-role stereotypes as the primary cause of the gender differences in mathematics. Undoubtedly, any empirical study will inherently be biased by the philosophy and the position that the researcher takes on the issue of nature vs nurture.

One basic assumption of the present study is that the nurture view of gender differences in mathematics is probably close to the truth. This assumption is based on the argument that the distinction between "individual difference" and "group difference" is the most important issue regarding the nature and nurture controversy. The author believes that any individual difference in a cognitive ability is probably caused by both innate ability and environmental interaction. However, a gender difference is not an individual difference but a group difference. Therefore, it is possible to assume that the gender difference in mathematics is the result of differential experiences between males and females in their developmental processes. Chapter 2 explores the "nature" v.s. "nurture" view in great detail. In the next section, the limitations of the present study will be discussed.

1.4 Limitations of the Study

Because of the complexity of a study that includes multiple perspectives, there are four major limitations. The first limitation concerns sampling. It would be ideal if the sample in each country were randomly selected in order to represent the population in each country. However, the sample in this study is limited to be a convenience sample. The generalizability of the results of the study may be limited.

The second limitation involves the language of the tests. The mathematics tests and the questionnaires are translated by the author. Some meanings may have been lost when the text was translated from English to Japanese although the author put great effort to ensure the accuracy of the translation.

The third limitation also concerns the difference between the two cultures. The mathematics problem-solving items and most of the attitude questionnaires are developed in the United States. Questions that are sensitive enough to detect gender differences among the students in the United States may not be adequately sensitive to detect differences among Japanese students.

The fourth limitation relates to the fact that only some variables related to gender differences are included. There are so many factors which may relate to the gender differences in mathematics. However, as it is impossible to include all possible cultural and psychological variables, variables which have been studied by previous researchers (Eccles, et. al., 1983) will be included in this study.

The fifth and last limitation is the number of items in this study. The time allowed to administer tests and questionnaires in each class was very limited. Therefore, the number of items and categories of the test instruments is limited in each class in each country.

In spite of these limitations listed above, this study will provide a theoretical guideline to the researcher who studies gender difference in mathematics as well as practical knowledge to mathematics educators who deal daily with students in classrooms. The significance of the study is described in the next section.

1.5 Significance of the Study

This study will make three important contributions to the literature on gender difference in mathematics. First, this study will test the replicability of the results found in the United States in another culture with respect to gender differences in mathematics problem solving strategies (Gallagher & De Lisi, 1994). Gallagher and De Lisi found that males tend to use unconventional strategies that are not taught in math class and that require insight or estimation. Females, in contrast, are more likely to use conventional strategies that are usually taught in math class. It will be interesting if a similar pattern of gender differences in mathematics problem solving strategy is found in other nations as well.

Second, the use of multiple approaches allows us to examine the link between mathematics problem solving strategy choice and various aspects of the attitude variables. If the correlation were found to be positive, one may infer the possible influence of the attitude variables on the strategy choice in problem solving.

The third important contribution is that results of mathematics problem solving strategy choice analysis and error analysis will provide us the possibility of intervention to reduce the gender gap in mathematics. Teachers may be able to teach different types of problem solving strategies and/or point out the possible causes of the mistakes.

1.6 Summary

This first chapter has set out the problem and the variables to be studied in this research. In spite of the improvement in female participation in post secondary education and a variety of occupations in the past two decades, females are still under-represented in mathematics-related fields in post secondary institutions and the work force. One important cause of this problem is gender differences in mathematics performance in high school students. The reasons why high school female students perform poorly in some of problem solving items will be investigated based on the nurture view. The variables included in this study are classified into three categories, socio-cultural, psycho-motivational, and cognitive variables. Although there are some limitations to this study, due to the complexity of the problems and methodology, this study will provide an important theoretical guideline to the researchers who study gender differences in mathematics and may open up to the possibility of practical interventions to the mathematics educators in everyday classrooms.

In the next chapter, these variables will be presented in a review of the different approaches to the study of gender difference in mathematics.

Chapter 2

LITERATURE REVIEW

The purpose of this dissertation is to investigate gender differences cross-culturally, and to look at how motivational, learning, and performance factors influence these gender differences. To carry out this investigation, students from Japan and the United States will be studied to see whether there are gender differences in their attitudes toward mathematics, learning patterns, problem solving strategies, and causes of mistakes and to determine relationships among these variables.

There are two kinds of questions regarding studies of gender differences in mathematics. The first question is what is really different between male and female students in mathematics performance. This question deals with the nature of the gender difference in mathematics and provides us with empirical evidence regarding the role of variables such as age, subject area, and sample characteristics.

The second question concerns the explanation of these gender differences: Why are there gender differences in mathematics performance? Especially, why are large gender differences found for particular tasks, particular ages, and particular samples? Researchers who attempt to answer the latter question usually take one of three approaches: either the genetic/physiological, social/motivational, or cognitive approach.

The "nature versus nurture" dichotomy is an old one in many areas of research in psychology. Researchers who emphasize genetic/physiological factors as the primary cause of the gender difference in mathematics performance are associated with the nature side of this dichotomy. Although they do not deny the effect of environment, they focus on the relationship between genetically predisposed physiological differences and gender differences in mathematics performances. On the other side of this dichotomy is the nurture view, which involves a more social/ psychological (motivational) orientation.

The third approach is the cognitive approach. This approach could be consistent with either the nature or nurture view, depending upon the methods and philosophy that each researcher takes. Although this approach does not have a clear position in the continuum of the nature - nurture dichotomy, the cognitive approach helps us to understand underlying mechanisms in gender differences in mathematics performance.

This chapter is divided into five sections. In the first, the empirical evidence for gender differences in mathematics performance is presented. In the second, the nature view (genetic/physiological approach) is examined. In the third, the nurture view (social/psychological approach) is described. In the fourth, the cognitive approach is explained. In the fifth, the overview of this chapter and the problem statement as well as research questions are posed.

2.1 Empirical Evidence for Gender Differences in Mathematics Performance

2.1.1. Early Studies

Maccoby and Jacklin's book The psychology of sex differences was a very important publication in 1974. The authors looked at previous studies done by researchers before 1974 and identified three cognitive abilities for which gender differences had been found: verbal ability (favoring females), spatial ability (favoring males), and mathematical abilities (favoring males). Their work, however, has been criticized mainly due to the methodological weaknesses of the studies, and Maccoby and Jacklin's interpretation of the data.

In a large study conducted after 1974, Armstrong (1981) gave tests of spatial visualization, problem-solving, algebra, and computation to 1452 13 year-olds from 82 schools, and 1788 12th grade students from 71 high schools. The results of his analysis indicated that for 13 year-olds, females outperformed males on the computational and spatial visualization tasks, and performed equally well as males on problem solving tasks. For the 12th grade students, whereas males outperformed females on all 4 subtests (spatial visualization, problem solving, algebra, computation), only the difference for the problem-solving subtest was statistically significant.

In the middle 80s, Aiken (1986-1987) reviewed the literature on sex differences in mathematics ability. He summarized the evidence of gender differences in mathematics by saying that although there were no significant gender differences in mathematics performances before high school, boys outperform girls in mathematical computation and problem solving tasks in high school. He also explored various explanations of gender differences in mathematics performances such as biological explanations which emphasize the role of genetically predisposed traits and environmental explanations which focus on the systematic differences in socialization process between males and females.

2.1.2 Recent Studies

The most important work regarding gender differences in mathematics is a meta-analysis by Hyde, Fennema, and Lamon (1990). They analyzed studies published between 1964 and 1987, and computed 259 independent effect sizes. They identified three important trends in gender differences in mathematics. Based on the results of their analysis, the three trends are depicted in figure A1, A2 and A3 in appendix A.

The first is an age trend. The magnitude of gender differences in mathematics performance increases with age. The age trend has a close relationship with the complexity of cognitive level of the task, however, because older students learn more complex and abstract mathematics than younger students. In early elementary school years, females have a slight advantage in computational tasks. However, as they enter high school, their tasks are mainly problem solving and reasoning, and it was at this time that gender difference emerge with a moderate effect size favoring males (see figure A1 in appendix A).

The second trend involves sample selectivity. Hyde and her colleagues partitioned the samples in each study into five stratifications according to the ability level of the sample, from low ability to mathematically precocious. They found that "sample selectivity is one of the most powerful predictors of effect size in their multiple regression". Although the average effect size of all studies is very small ($d=0.05$), the magnitude of effect size increases as the sample become more selective. For example, effect size of the gender difference among average students are 0.15, but the effect size among the students who are from highly selective schools was 0.54, a large effect size (see figure A2 in appendix A).

The third trend is a cohort effect. When average effect sizes are compared between the studies that were conducted before 1974 and after 1974, the clear decline in the effect size is apparent. The average effect size of studies conducted before 1974 was 0.3, whereas the average effect size of studies conducted after 1974 was only 0.1 (see figure A3 in appendix A). In sum, any theory of gender differences must account for why the gender difference gets larger with increasing age, complexity of tasks, and sample selectivity, and why it appears to be shrinking over time.

2.1.3 Gender Differences in Variability

Most of previous studies including the meta-analysis study done by Hyde, Fennema, and Lamon (1990) have compared the means between two groups, male and female, with an assumption of homogeneity of variance in two groups. However, Feingold (1992) paid special attention to the difference in variability between the two genders. He indicated three cases of distribution patterns of males and females that might result in male's higher mean. The patterns are shown in figure 4: the case of equal variability, the case of males' greater variability, and the case of females' greater variability. He argued that effect sizes are useful only when the two groups have homogeneous variabilities. He examined the variabilities of male and females on their standardized test batteries. Feingold found that males had consistently bigger variances than females in mathematics reasoning, spatial visualization, spelling, and general knowledge. This indicates that the equal variability assumption does not really reflect the reality and males' greater variability, is more likely to fit the reality of the gender differences in mathematics performance. He suggested that since variabilities affect values of the mean, it is necessary to consider both variability and the central tendency (mean) in order to capture accurately the nature of gender differences in cognitive abilities.

However, Feingold was criticized by Noddings (1992) mainly for two reasons. First, Noddings pointed out that among the cognitive abilities, those which had gender differences in variability are mostly valued by males. However, there are many capacities which do not usually appear in measurement of intellectual abilities, but are valued by females. For example, interpersonal reasoning, oral and written interpretation, and so on, are variables females value more and on which they perform better. The other reason was that Feingold did not offer an explanation of why there are gender difference in variability in certain cognitive measures. Noddings suggested her preference in the latter explanation, and argued for historical and cultural differences between the two genders as the possible cause of gender differences in variability.

In spite of Noddings' criticism, Feingold's finding that males have greater variability in the performance of some of cognitive tasks is an important fact that indicate each researcher must consider the effect of variability as well as central tendency (mean) regarding the gender differences in mathematics performance.

2.1.4 SAT-Math (Mathematics Part of Scholastic Aptitude Test)

According to a report from College Board, the average difference between males and females in SAT-Math scores has been a consistent 46 points since 1972 (College Board, 1991). The average SAT-M was 453 for females and 497 for males in 1991, a difference of 44 points. The average SAT-Verbal score was 418 for females and 426 for males, a difference of only 8 points.

In the meta-analysis by Hyde, Fennema, and Lamon (1990), SAT-math was excluded from their overall analysis of effect sizes and was examined separately. The reason why they did not include SAT-Math in their overall analysis was that the sample of SAT-math would compose more than 20% of all subjects in the overall analysis and would have a disproportionally large effect on the overall analysis.

The results of their analysis on SAT-M showed large gender differences in effect size (d=0.4) favoring males. Although the effect size for overall analysis (including all ages, subjects' areas, selectivity of samples) was 0.13 when the effect size of SAT-M was excluded, the overall effect size increased to 0.3 when the effect size of SAT-M was included. Hyde and her colleagues listed several reasons why only the SAT-M produces such a large effect size consistently. First, they believe that the sample for SAT-M is a moderately-selected sample (at least they are college bound). Second, more females take the SAT than males. Therefore, they assume that males might be from more selected schools than females. Third, the items used in SAT-M are combinations of mathematical problem solving and computational tasks. Therefore, they reasoned the cause of large effect size in SAT-math as follows; "since problem solving tasks produce moderate effect size favoring males even in overall analysis, among those who are college bound (moderately selected sample), probably produce even bigger gender differences" (Hyde et al., 1990).

2.1.5 Gender Differences in Mathematics Class Grades

Kimball (1989) examined previous studies which reported females' superiority in mathematics class grades, instead of standardized tests such as the SAT. Although she could not assess completely accurate features of the gender differences in mathematics class grades due to insufficient data availability, she reported that the size of the gender differences in mathematics class grade ranges from 0.09 to 0.35 favoring females.

One of the studies that provided evidence of females' better performance on mathematics class grades was that by Benbow and Stanley (1982). Their sample included highly selected, mathematically talented youth. It is a well established fact that among those who are highly selected, males outperform females on standardized tests especially on the SAT-M. However, Benbow and Stanley also reported the important fact that females in their sample significantly outperform males on mathematics class grades in high school.

Some evidence with a less selected sample was provided by Pallas and Alexander (1983). They examined 1,842 females and 1,770 male 12th grade students who represent all achievement levels from low achievement students to college bound students. The average GPAs for mathematics courses taken previously were 2.15 for males and 2.30 for females. However, when the averages of an standardized test, SAT-M scores, were compared the opposite was true. The average SAT-M score for males was 425.23, while, the average was 388.45 for females. These data clearly indicates that males usually outperform females on standardized mathematics achievement tests, whereas females achieve higher than males on mathematics class grades.

So far, we have only considered the effect of gender differences in American students. Because the data would be highly relevant to the nature/nurture issue, it is useful to examine cross-cultural work to see the size of gender differences in other countries as well.

2.1.6 SIMS (Second International Mathematics Study)

The second International Mathematics Study was conducted between 1981-1982 in 20 different nations using 8th and 12th graders. The data from each nation showed some conflicting results. At the 8th grade, in five out of 19 nations (Belgium-Flemish, Belgium-French, Finland, Sweden, and Thailand), girls outperformed boys in all five mathematics subtests (Arithmetic, Algebra, Geometry, Measurement, and Descriptive statistics). In the other 14 nations, however, boys outperformed girls in most subtests. The results of the analysis of five major subtests showed that girls tended to perform better than boys in computational-level arithmetic, whole numbers, estimation and approximation, and in algebra. In contrast, boys were more likely to be better in geometry, measurement, and in proportional thinking (Robitaille, 1989). Moreover, some of the items which measure spatial visualization ability produced a very large gender difference (over 30 percentage points higher favoring boys) in almost all participating nations.

For the 12th grade students, the gender difference became more prominent in each nation. Only in one nation, Canada (British Columbia), did girls significantly outperform boys in two of the 11 math subtests. However, in every other nation, boys did better than girls in all of the subtests (Garden, 1989). Among those nations, the largest overall gender differences occurred in Belgium (French), Hungary, Hong Kong, Israel, and Japan. Based on the results of the study, Garden (1989) suggested that the reason for such large gender differences in all participating nations was that "..it appears that in all systems, disproportionally large numbers of girls with high mathematical ability may be electing not to pursue studies in mathematics" (p146). In each of the participating nations, the population of 12th grade was those students who elected advanced math courses. Since advanced courses are not required, male students outnumber female students in each participating nations.

2.1.7 Cross-Cultural Study Between Japan and USA

Although there are many studies that investigate cross-cultural differences in mathematics performance between Japan and the United State (e.g., Stevenson et al., 1986a, 198b; Mayer and Tajika, 1991.), only a few studies have examined gender differences in mathematics performance between Japan and the USA.

In one study, Evans (1993a) assessed gender differences in mathematics achievement and attitudes at the 1st, 5th, and 11th grades longitudinally in 3 cultures: China(Taiwan), Japan, and the United States. She found that there is no consistent gender difference in mathematics performance in 1st and 5th graders. However, by the 11th grade, males outperform females in all countries. The average gender difference in Japan and China was large (an effect size of 0.6). In contrast, the effect size was moderate in the U.S. compared to Asian countries, and differed significantly from zero (d=0.3).

Evans (1993b) also pointed out the importance of the mean difference between countries. Although males did better than females within each countries, Asian females outperform both American males and females. In other words, the difference between countries (effect size of more than 1.0) was much greater than the difference between genders (effect size of 0.3 to 0.6).

2.1.8 Summary of Empirical Evidence

The empirical evidence of gender differences in mathematics performances can be summarized as follows:

1) Age and cognitive trends: The effect sizes of gender differences in mathematics performance increase with age and with complexity of cognitive tasks.

2) Sample selectivity: The sizes of gender difference in mathematics performances are larger among highly ability samples than average ability samples.

3) Cohort effect: The decline of effect size was apparent when average effect sizes were compared between studies conducted before and after 1974.

4) Variability: Males tend to have bigger variability than females in many subareas of mathematics and some other cognitive abilities.

5) Males outperform females in standardized mathematics achievement tests, whereas females tend to be better than males on mathematics classroom grades.

6) SIMS: At the 8th grade, in 14 out of 19 nations, boys outperform girls in all five mathematics subtests. However, in the remaining five nations, girls slightly outperformed boys on some but not all of the mathematics subtests. At the 12th grade, in all 19 nations but one (Canada-British Columbia), boys did better than girls in all of the math subtests. Gender differences in mathematics performance were largest in Belgium(French), Hungary, Hong Kong, Israel, and Japan.

7) Studies between Japan and the U.S.: The effect size for gender differences in mathematics performance was much larger in Japan than in the U.S.. The difference in mathematics performance between nations was much greater than the gender differences in math performances within each nation.

Although this empirical evidence is useful for telling us how males and females differ in mathematics performance, it does not tell us about the reasons for these differences. In the following four sections, various theories of gender differences in mathematics are discussed.

2.2 Nature View: Genetic/Physiological Approaches

There is no doubt that males and females differ genetically. Researchers who take the genetic/physiological approaches hypothesize that the differences in observed behaviors between genders such as gender differences in mathematics performances are primarily determined by genetically predisposed traits.

If one defines the physiological approach as that approach which investigates the relationship between gender differences in brain physiology and gender differences in mathematics performance, then physiological approaches could be subdivided into two subtypes. One approach focus on the role of genetically preprogrammed factors (e.g., hormones) in producing differences in brain morphology. The other focuses on the role of different experience in producing differences in brain morphology.

A physiological approach which focuses on the relation between gender differences in mathematics performance and genetically predisposed physiological differences represents a "nature" view. However, the physiological approach which emphasizes any biological differences caused by the differential experiences of males and females as a cause of gender difference in cognitive ability should belong to the "nurture" view. In this section, only studies which have taken the genetic/physiological approach are reviewed.

There are three hypotheses which derive from the genetic/physiological view as the explanation of gender differences in mathematics performance: 1) the sex-linked recessive gene hypothesis, 2) the brain lateralization hypothesis, and 3) the physiological correlates hypothesis.

2.2.1 Sex-Linked Recessive Gene Hypothesis

Since the early 60s, some researchers have attempted to find correlations between quantitative ability and physiological traits such as eye color (Stafford, 1970) and height (Stafford, 1963). Stafford (1972) suggested that gender differences in quantitative reasoning favoring males might be the result of a gene on the X chromosome, as is the case in red-green color blindness and hemophilia. He hypothesized that "if this is the case, one would expect father-daughter correlations and mother-son correlations to be the largest and father-son correlations to be smallest" (because if the gene for the quantitative ability is on the X chromosome, then, the father could pass it to his daughter but not to his son). He examined his hypothesis based on three studies by Willoughby (1927), Carter (1932), and Stafford (1963). The average correlations of the three studies are following: father-daughter correlation of 0.22, mother-son correlation of 0.30, and mother-daughter correlation of 0.27. These correlations were very small and did not really support his hypothesis.

Moreover, many researchers disagree with his idea that quantitative abilities are determined by a single gene on a X chromosome (Halpern, 1992). Therefore, his hypothesis is not supported by contemporary researchers who are sympathetic to the physiological view.

2.2.2. Brain Lateralization Hypothesis

A second group of researchers are interested in the relationship between cognitive abilities and gender differences in cerebral lateralization. They believe that prenatal exposure to male sex hormones affect the development of right hemisphere dominance. The right hemisphere processes non-linguistic and spatial information and this ability is believed to relate to quantitative ability. Studies that examine lateralization hypotheses focuses on scores of dichotic listening tasks as an indicator of brain dominance.

Lake and Bryden (1976) assessed handedness and sex differences in hemispheric asymmetry with 144 subjects. They found that there was a significant sex difference: males' brains were more clearly lateralized than females'.

Witelson (1976) investigated developmental change in brain organization/structure and cognitive functioning. He examined 25 boys and 25 girls using a test comparing object perception in the left and right hand. He found no differences for girls, but boys did better with left than right hand.

Witelson concluded that for boys, right hemisphere dominance for processing non-linguistic and spatial information occurs around age six. However, for girls, the right hemisphere does not dominate processing non-linguistic spatial information until puberty. This result indicates differential information processing on non-linguistic information between males and females.

Some evidence of lateral preference using dichotic listening tests was provided by Kraft (1982). He administered two dichotic listening tests (digit and environmental sound) to 48 second graders and 48 sixth graders. He found that for non-verbal stimuli, males showed a left-ear advantage which indicates right hemisphere dominance and girls showed a right ear advantage which indicates left hemisphere dominance. He also found that the sex difference in ear preferences (advantage) increased with task difficulty. However, there are some studies that found no significant sex difference in right ear advantage on dichotic listening tasks. For example, Hiscock and Mackay (1985) did not find significant sex differences in a series of five consecutive dichotic listening experiments with a large sample of 447 subjects. Hiscock and Hiscock (1988) not only failed to find a statistically significant sex difference favoring males, but surprisingly they found just the opposite: females showed a significantly greater right ear advantage than males in detecting and localizing dichotic digit names. Based on their results, they argued that sex differences depend on tasks and are only found under some circumstances.

In order to clarify these inconsistent findings, Lewis, Orsini, & Sats (1988) administered three different types of tasks to a large sample of normal subjects. The three types of interference cerebral lateralization tasks were (a) input interference (dichotic listening), and two output interference tasks, (b) motor-motor interference task (concurrent finger tapping and verbal fluency) and (c) motor-cognitive interference task (concurrent finger tapping and silent reading). They found sex differences only on the motor-motor interference task, which supports Hiscock and Hiscock's conclusion (1988) that the sex difference in cerebral lateralization depends on the task.

Even though there is some evidence showing sex differences in brain organization, specifically, (e.g., male's right brain dominance for processing non-linguistic information), it is very difficult to explain how the observed gender differences in mathematics performance is primarily caused by the differential brain lateralization by males and females. Although it is a well established fact that the right brain processes non-linguistic and spatial information, this lateralization view fails to explain how spatial ability relates to mathematics performance. The lateralization hypothesis would be useful only if one can establish a relation between mathematics performance and spatial abilities. In the next section the relationship between gender difference in mathematics performance and spatial abilities is examined.

2.2.3 Relationship Between Mathematics Performance And Spatial Ability

Linn and Petersen (1986) assessed the relationship between gender differences in mathematics performance and spatial abilities based on two criteria: (1) the magnitude of the gender deference in mathematics and spatial ability, (2) the age at which gender differences first appear in mathematics and spatial ability.

If there is any relation between spatial ability and mathematics ability, we expect that the direction and the magnitude of the gender differences would be similar. However, according to Linn and Peterson, this is not the case. The magnitude of gender difference in spatial and mathematics performance depends on the task and the sample. For example, males outperform females by almost 1 standard deviation (SD) in The Vandenberg version of Shepard-Metzler mental Rotation task at any achievement level of samples, but no significant gender differences were found in other spatial tasks. Regarding mathematics performance, males outperform females in SAT-M by a half-standard deviation among high ability high school students but the differences are small among average ability students and other mathematics tests do not generally produce statistically significant differences between genders.

The second criterion concerned the age at which gender differences in mathematics and spatial ability emerge for first time. If there is any relation between spatial and mathematics abilities, we would expect that the gender differences in mathematics and spatial performance would appear at a similar age. However, this also was not the case. Whereas gender differences in spatial ability such as mental rotation were found as soon as they are measurable, a large gender difference in mathematics performance (problem solving tasks) does not emerge until adolescence.

Based on above findings, Linn and Petersen (1986) suggested that although there is a substantial correlation, the relationship between spatial ability and mathematics performance was inconclusive.

2.2.4 Studies Of Mathematically Precocious Students

Benbow (1988) summarized the results of studies done over the past two decades on sex differences in mathematical reasoning ability in intellectually talented preadolescents. In these studies, the SAT-M was used as a measure of mathematical reasoning ability for 12- to 13 year-old students. The results of studies show consistent and large sex differences favoring males in mathematical reasoning ability over the years among those who are intellectually talented in math. For example, the male/female ratio for students who scored over 700 was 13 to 1. Benbow also reviewed studies which examined gender differences in mathematics from various environmental aspects (attitudes toward mathematics, parental expectations, sex-role stereotyping, differential course-taking etc.) and physiological aspects (left-handedness, allergies, prenatal hormonal exposure, and brain lateralization). Based on her analysis of these studies, she concluded that "...physiological correlates, especially the possibility of prenatal testosterone exposure, lend credence to the view that sex differences in extremely high mathematical reasoning ability may be, in part, physiologically determined" (Benbow & Stanley, 1980., Benbow, 1988).

However, she has been criticized by many researchers mainly for the following reasons. First, if the physiological correlates Benbow presented were really causally related to extremely high mathematical reasoning ability, even in part, then these physiological correlates must be related only to mathematical ability and should not be related to non-mathematical ability such as verbal ability (Mayer, 1988). However, Benbow's data did not satisfy this criterion. Most students who score extremely high in the mathematical part of the SAT also tended to score high in the verbal part of SAT. Second, she assumed that the SAT-M measures mathematical reasoning ability. However, According to Hyde et al. (1990), SAT-M was categorized into combinations of mathematical computation and reasoning problems. Therefore, one can not be sure whether gender differences in SAT-Math reflect gender differences in reasoning ability unless she analyzes the items on the SAT-M that were found to have large sex differences among talented students.

2.2.5 Summary of Nature View

The brief summary of genetic/physiological approach is as follows:

1) Sex-linked gene hypothesis : mathematical ability is a recessive gene on the X chromosome that produces male superiority since males have only one X chromosome. However, this hypothesis is no longer supported by contemporary researchers because of lack of sufficient data.

2) Brain lateralization hypothesis: sex hormone-induced brain lateralization might be responsible for the male superiority in spatial abilities that are believed to relate to mathematics performance. However, the causal relationship between spatial abilities and mathematics performance is unclear.

3) Physiological correlates among mathematically talented students: physiological correlates such as myopia, left-handedness, and allergies more frequently appear among the intellectually talented students than average students. However, these students who score high in mathematics reasoning tasks also tend to score high in verbal or non-mathematical tasks. Therefore, one may not be able to conclude that these physiological correlates are responsible, even in part, for the gender difference in mathematics performance.

In recent years, only a few researchers appear to believe the extreme nature view of gender difference in cognitive abilities, such as mathematics abilities. Most researchers are probably interactionists who believe that genetically predisposed biological differences are partially, but primarily responsible for the observed gender differences in mathematics performances. Interactionists disagree, however, as to what percent of mathematical abilities they believe are determined by biology and what percent of ability are determined by environment. Some interactionists would say 20 % (biology) and 80% (environment), while others might say 50% and 50%. The difference between nurture theorists and interactionists is that nurture theorists believe that the gender differences in mathematics performance could be totally produced by environmental factors without influence of genetically predisposed biological differences. In the next section, the various variables of environmental influences are discussed.

2.3 The Nurture View : Environmental Hypotheses as The Explanations of Gender Differences in Mathematics Performances

In contrast to the biological or interactionist view, some researchers take the psycho-socialization approach. They believe that gender differences in mathematics performances are primarily determined by the different ways that males and females are socialized. These differences in socialization, in turn, influence their motivation and attitudes toward mathematics. They investigate effects of various socialization and motivational variables on gender differences in mathematics. Those variables are: (1) parental influence, (2) teachers' treatment, (3) stereotypes of mathematics as a male domain, (4) mathematics self-concept (or math self-efficacy or math self-confidence), (5) attributions for success and failure on mathematics, (6) differential mathematics course taking, and (7) attitude toward mathematics.

2.3.1 Parental Influences

Parents are the most important socializers for children. Several studies have investigated parental beliefs about their child's mathematical ability and their influence on the child's self-perception of his/her ability. A study by Parsons, Adler, and Kaczala (1982) found that although parents of girls and parents of boys did not differ in their rating their daughters' and sons' mathematical ability, parents of girls believed that their daughters had to work harder in mathematics and it was more difficult for them than for boys.

Jacobs (1991) examined how parents' gender stereotypes about mathematical ability influence their beliefs about their child's mathematical ability and indirectly relate to the child's self-perception of mathematical ability and performance. Approximately 400 parents and their 6th and 11th grade children were given questionnaires concerning their beliefs about their child's mathematics achievement and their stereotypes about males and females' relative ability in mathematics. The results of path analysis showed that parents' gender stereotypes had no direct effect on children's self-perceptions of their ability. However, parents' stereotypes influence their beliefs about their child 's ability through the sex of their child. In turn, parents' beliefs about ability of their child directly influence their child's self-perceptions, and both the parents' stereotypes and the child's self-perceptions influence the child's performance.

Although these studies are correlational in nature, the impact of parental beliefs about stereotype and ability on their children seems to be important.

2.3.2 Teachers' Treatment In Mathematics Class

Teachers also have an especially important impact on children is mathematics learning. Several studies indicate that teachers treat boys and girls differently in mathematics class. Becker (1981) examined teachers' interactions with male and female students in geometry class. Based on her observation of 10 geometry teachers in 9th grade, she found consistent patterns for teacher-initiated contact with male students. She also found that teachers encourage male students more often than female students in their academic abilities and pursuit. Seventy percent of such encouragement was directed toward male students compared to only 30 percent of encouragement toward female students. She also found that females received almost 90 percent of nonencouraging or discouraging comments from teachers, although the absolute number of instances of nonencouragement or discouragement was much less than the number of instances of encouragement.

Another study which investigated teachers' differential treatment was by Gore and Roumagoux (1983). They examined teacher wait-time (amount of time which a teacher wait a student's response to his/her questions) between boys and girls in five different mathematics classrooms including 79 boys and 76 girls in 4th grade. The results of their analysis indicated that teachers allowed significantly more wait-time to boys than to girls.

The differential treatment by teachers might have a negative effect on girls' perception of their own abilities (or self-confidence or self-efficacy in mathematics) and ultimately on their mathematics achievement.

2.3.3 Self-Concept Of Mathematics (Self-Efficacy Or Confidence)

The importance of one's perception of one's own ability is well documented in the achievement motivation literature. Among the psychological constructs, self-concept of mathematical ability is one of the constructs for which large gender differences have been found.

Marsh, Parker, and Barnes (1985) examined the self-concept of ability 901 students in grade 7 through 12. They administered the self-description questionnaire II (SDQ II) to boys and girls. They found that males had significantly higher self-concept than females in mathematics, physical ability, physical appearance, general stability and general-self.

A longitudinal study done by Wigfield et. al. (1991) showed a similar result. They examined the beliefs of 1850 6th and 7th graders in four domains (math, English, social activities, and sports). Their results showed that boys had significantly higher math- and sports-ability perceptions than did girls, whereas girls had higher English-ability perceptions than did boys. Boys and girls did not differ in their perceptions of social ability.

These findings are consistent with previous findings that males have higher confidence in their mathematics ability than females do, even though the previous achievement for females was almost the same or sometimes better than males (Fennema & Sherman, 1977,1978; Parsons, Kaczala & Meece 1982).

In a study of mathematics self-efficacy, Randhawa, Beamer, and Lundberg (1993) constructed a structural model of mathematics achievement in relation to mathematics self-efficacy. They examined the fit of this model with 117 male and 108 female 12th grade high school students. Their measurements included two attitude scales, three mathematics self-efficacy scales, and a mathematics achievement test. The results of their analysis indicated that the model identified mathematics self-efficacy as a mediator between mathematics attitudes and mathematics achievement for both male and female students. This study suggests an answer to the question: why do females who have low self-efficacy often perform poorly compare to male counterparts with a similar achievement history?

2.3.4 Attributions For Success And Failure

Causal attribution for success and failure is one of the important psychological constructs in achievement motivation because of its predictive power for future performances. Many researchers have documented gender differences in attributional patterns. For example, Wolleat, Pedro, Beker, and Fennema (1980) examined patterns of causal attribution for success and failure on mathematics task. They found that males attribute their success experiences in mathematics more strongly to ability than do females. In contrast, females attribute their success experiences in mathematics more strongly to efforts than males. A similar pattern difference was found in the attribution for failure. Females are more likely than males to attribute their failure to lack of ability.

However, an early study done by Eccles et. al. (1982) pointed out the methodological difficulty in the study of gender differences in causal attributions for success and failure. They examined 330 students from fifth to eleventh grade and used two types of questions (open-ended or rank-order questionnaire) to see whether the attributional patterns are consistent regardless of question format. The result of their analysis indicated that the attributional patterns differed depending on the question format used. The results of an open-ended questionnaire showed that girls were more likely than boys to attribute both their success and failure to skill, whereas boys were more likely than girls to attribute their success and failure to effort. In contrast, the result of analysis of a rank-order questionnaire was consistent with other studies. Boys ranked ability as a more important cause of success than did girls, whereas girls ranked effort as a more important cause of success than did the boys. As a cause of failure, girls ranked lack of ability more important than did the boys and they ranked the importance of effort higher than did the boys. However, whether these two forms of questionnaires measure exactly the same psychological construct, causal attribution for success and failure, is questionable.

Other researchers have also assessed gender differences in attribution for success and failure in different domains (e.g., math/science and language arts). Ryckman and Peckman (1987) examined 731 boys and 680 girls in grade four through eleven. They found that both boys and girls had more adaptive attributional patterns (attributing success to ability and failure to lack of effort) in language arts than in mathematics/science. However, boys had more adaptive attributional patterns in math/science than girls.

Stipek and Gralinski (1991) administered questionnaires which measure achievement-related beliefs to 194 3rd graders and 279 junior high school students. Girls were less likely than boys to attribute success to high ability and were more likely than boys to attribute success to luck and failure to low ability. Girls also tended to have less pride in their success and were less likely to believe that success could be achieved through effort.

A very recent study on causal attribution in mathematics performance examined gifted students. Cramer and Oshima (1992) assessed whether patterns of causal attribution differ between gifted males and females and between non-gifted males and females. The Survey of Achievement Responsibility Scale was given to 76 gifted males, 77 gifted females, and 150 non-gifted students in grades 3, 6, and 9. They reported that gifted females showed more self-defeating or maladaptive (Dweck, 1986) causal attributions (i.e.,attributing success to an unstable external variable such as luck or high efforts and attributing failure to a stable and internal factor such as lack of ability) relative to gifted male students in 9th grade. For the non-gifted students, the gender differences were not as clear as those for gifted students.

These studies indicate strong evidence of a gender difference in attributional patterns between male and female students, especially among those who are highly talented. One of the variables which might influence these gender difference in attributional patterns is one's stereotype about mathematics as a male domain.

2.3.5 Stereotyping Mathematics As A Male Domain

In the recent meta-analysis by Hyde et al. (1990), the largest effect size among various attitude variables was found in the stereotyping of mathematics as a male domain (d=-0.9). They also reported that males hold significantly stronger stereotypes regarding mathematics as a male domain than do females. Fennema & Sherman (1977) suggested that for females, perception of mathematics as a male domain is related to lower confidence in mathematics ability and to lower mathematical performances. Another study found a significant relation between stereotyping mathematics as a male domain and future plans for mathematics course taking, but only for males (Pedro et al. 1981). In the next section, evidence of differential course taking will be discussed.

2.3.6 Mathematics Course Taking

Many researchers argued that gender differences in mathematics performances were the result of differential course taking for males and for females. Fennema and Sherman (1978) tested 1320 students in the six through eighth grades. They controlled for the number of mathematics courses students have previously taken. The results of analysis suggested that when previous mathematics courses are controlled, the differences between males and females are very small. Therefore, they concluded that "the gender differences in mathematics achievement result primarily from the differential number and types of mathematics courses taken".

Pallas and Alexander (1983) examined the hypothesis that the gender difference in the mathematical part of SAT performance may be due to differential mathematics course- taking in high school. They found that the difference in the average score of the SAT-math between males and females was reduced dramatically when gender differences in mathematics course-work in high school were statistically controlled, though it was not eliminated. However, the question still remains as to why males and females decide to take or not take advanced mathematics courses.

In order to answer this question, it is necessary to have a theory or a model of achievement-related choice which includes all psychological and socio-cultural variables that might influence one's decision to take advanced mathematics courses. Among the theories of achievement motivation, the most comprehensive model of achievement related choices which may answer this question was espoused by Eccles and her colleagues (1983).

2.3.7 Eccles's Model Of Achievement Related Choice

Eccles and her colleagues (1983) constructed a model which tries to explain why female students often choose not to take advanced mathematics courses while male students who have similar achievement history choose to take advanced mathematics courses with confidence. Their model is based on an expectancy-value theory and is elaborated into a more concrete and complex structure which includes the cultural milieu and various psychological constructs that influence students' achievement choices. Their conceptual model is shown in in appendix B.

According to Eccles's model, the cultural environment such as gender role stereotypes and role models influence the way children perceive and interpret reality (past achievement or their own abilities in mathematics). The cultural milieu becomes an important reference as they interpret their experiences. For example, a girl who perceived mathematics as a male domain might interpret her experience in mathematics as more difficult, which might lead her to have a low self-concept in mathematics. Such elements directly influence aspects of students' motivation such as their goals, expectations, task values and so on. Ultimately, these factors determine one's performance and choice (e.g., whether one should take an advanced mathematics class or whether one should major in science or in English literature).

This model was assessed by a path analysis. Most paths that were indicated in Figure 4 were significant at 0.05 level except the path from expectancies to intention to take more math ($p<0.3$). The results of their analysis confirmed the importance of some psychological constructs - self-concept of ability, attribution for past performance, and perceptions of socializers' (parents and teachers) - as the critical variables to determine one's expectancies, values, and future choice of math course taking. Low enrollment of female students in advanced mathematics classes is likely to be the result of females' lack of self-confidence which leads them to perceive math as a more difficult course and less valuable (Eccles, 1983).

Ethington (1992) examined the validity of Eccles's model (1983) with data from the Second International Mathematics Study (SIMS). She found an interesting result. Males and females differed in terms of psychological variables which directly and indirectly influenced mathematics performance. She suggested that the model of mathematics achievement for females might be more complex than it is for males.

One important part of Eccles's model is its emphasis on the cultural milieu as the origin of psychological and motivational gender differences which ultimately produce the gender differences in mathematics performance. Baker and Jones (1993) explored the relation between gender stratification in nations and their mathematics performance using SIMS data. They examined mathematics performance of 77000 8th grade students from 19 countries and data on gender stratification of advanced educational and occupational opportunities in each country. The results of their analysis indicated that variation in the magnitude of gender differences in mathematics performance among nations was related to variation in the gender stratification in educational and occupational opportunities. Their longitudinal comparison (comparing data at 1964 and data at 1982) showed that when a society moved toward being more egalitarian in the access to higher education and occupation, the magnitude of gender differences in mathematics performance declined, in every country that participated. This study offers strong support for Eccles's model and the researchers who endorse the nurture view .

2.3.8 Summary Of The Nurture View

Various social and psychological variables are reviewed in this section. The brief summary of these variables are described as follows:

1) Parental influences: Although parents do not believe that there is a gender difference in mathematical ability, they believe that mathematics is more difficult for their daughters than sons. These parental beliefs about gender stereotypes on mathematics indirectly influence children's perception of their mathematical ability.

2) Teachers' treatment in math class: Mathematics teachers tend to interact with and encourage male students more than female students. They are also likely to wait longer when male students answer a question than when female students do.

3)Self-concept of math (confidence or efficacy): There is strong evidence that male students have more confidence in mathematics skills than female students even though males and females have similar achievement histories.

4) Attribution for success and failure: Males are more likely than females to attribute their success to ability and failure to lack of effort. This gender

difference in attributional pattern is more prominent among the intellectually talented students than average students.

5) Stereotype of mathematics as a male domain: Males hold stronger stereotypes of mathematics as a male domain than do females. Only for males, the stereotype of mathematics as a male domain correlates with future mathematics course-taking.

6) Mathematics course taking: When mathematics courses previously taken are statistically controlled, the gender differences in mathematics achievement are considerably reduced.

7) Eccles et al. model of achievement related choice: The variables previously examined individually are assessed altogether. Self-perception of ability, attribution of past performance, and perception of socializers' beliefs are important variables that determine one's expectancy, values, and future mathematics course taking. Females' model for achievement related choice was more complex than that for males.

8) Baker and Jones's study: Variations in size of gender differences in mathematics performance among the nations related to variation in gender stratification in educational and occupational opportunities. As nations move toward being more egalitarian in access to higher education and occupational opportunities, the gender difference in mathematics performance is reduced in every country.

These findings provide strong evidence for the nurture hypothesis. However, the following question has not addressed by these researchers: How do these social and psychological variables influence actual performance, which is a cognitive process? In the next section, some evidence of the differential cognitive processes used by male and female students in mathematics problem solving are explored.

2.4 Cognitive Approach

How individuals actually process mathematical problems or how individuals utilize strategies they have learned are the questions some researchers from the cognitive perspective have attempted to answer. Recent trends toward a cognitive approach in research on mathematical problem solving make it possible to understand underlying mechanisms in individuals' mathematical problem solving processes. There are three types of cognitive approaches; 1) error analysis, 2) problem solving processes and strategy analysis, and 3) learning style.

2.4.1 Error Analysis

Marshall (1983) analyzed errors that were made by 6th grade boys and girls in multiple choice problems. She found that girls were more likely than boys to make mistakes due to the misuse of spatial information, the use of irrelevant rules, or the choice of incorrect operation. She also found that girls make more errors on negative transfer and key word association, whereas boys were more likely than girls to make mistakes due to lack of perseverance and formula interference.

Marshall and Smith (1987) in a longitudinal study examined children's errors in mathematics performance on assessment tests for third and sixth graders. Their results of error analysis showed that boys and girls differed significantly in two error categories. Whereas boys tend to use incorrect rules, girls were more likely to make mistakes in associations. For example, when the question is 1/2 + 2/3 =, boys often answer 3/5. They add numerators and add denominators. In a word problem, girls often associate a word "altogether" to addition regardless of the content of the question. These differences were found in both third and six graders.

Whereas these researchers focussed on errors made by male and female students, other researchers have focused on differential strategy use or problem solving processes which bring correct answers between boys and girls. The work of these researchers shall be examined next.

2.4.2 Problem Solving Processes and Strategy Analysis

Among the few researchers who have focused on gender differences in cognitive processes, Kelly-Benjamin (1990) studied strategy differences using an interview method. She at first identified five SAT-math items that have the largest gender difference among high achieving students (at least a 12% difference favoring males). Using these five items, she observed problem-solving behavior individually. 20 male and 20 female students were selected as the subjects based on their average mathematics grade (A or B+). She gave students ample time to solve the five items. After the subject solved the items, she interviewed each subject about his or her solution methods for each item. She found that girls were more likely to use mathematics knowledge and procedures learned in math class, whereas boys were more likely than girls to use test-taking skills such as examining answers. Even when they started out using procedures learned in math class, they changed it quickly to intuitive or creative strategies when they found difficult to pursue the procedures learned in math class.

Byrnes and Takahira (1993) focused on the process of problem-solving and investigated the effectiveness of cognitive operations used by male and female students. They examined 49 male and 59 female high school students using five SAT-math items (Kelley-Benjamin, 1990), a strategy questionnaire, and prior knowledge tasks. The result of their analysis indicated that since there is no statistically significant gender difference in prior knowledge and strategy choice, other cognitive operations might be responsible for the observed gender difference in performance. The result also showed that 50 % of the variance of

SAT-Math score was explained by prior knowledge and strategy assembly and that gender explained no unique variance.

Another qualitative study of differential strategy was reported by Gallagher and De Lisi (1994). They examined SAT-math problem solving strategies among high school students who scored 670 or better in SAT-math. At first, they classified the SAT-M problems and the strategy used to solve the problems into two categories: conventional or unconventional problems and conventional or unconventional strategies. The conventional problems are those that can be solved by only one type of strategy taught in school, whereas the unconventional problems are those that can be solved either by a school-taught procedure or more quickly by using estimation or insight. They used a think-aloud method instead of interviewing after the problem solving. Twenty male and 20 female students were asked to think-aloud while they were solving SAT-math items. They found no gender difference in problem solving strategies on conventional problems. However, they found that for unconventional problems, female students relied more on conventional problem solving strategies (procedures learned in math class) whereas male students were more likely to use unconventional strategies (strategies that are not taught in math class and that require insight or creative thinking). At the same time, they also reported that although difference in strategy choice between two genders was found, there was a large overlap in problem solving strategy choice between males and females.

The way individuals solve a mathematics problem was often influenced by the way the individuals learned the mathematics problems. In the next section some of the evidence for a differential learning style between boys and girls is discussed.

2.4.3 Learning Pattern

Kimball (1989) examined the evidence for a hypothesis that males and females study mathematics differently. She found that girls are more likely to take the rote learning approach, whereas boys are more likely to take the autonomous learning approach in mathematics.

Ito (1989) examined 367 Japanese high school students concerning individual differences in mathematics learning patterns through a questionnaire which was developed by qualitative study. Factor analysis revealed three categories of learning patterns. Category 1 dealt with learning patterns of coping with mistakes, independence, advancement, and comprehension. Category 2 indicated precision. Category 3 was related to habits. Ito concluded that category 2 and 3 explained the gender differences in learning pattern. Girls try to be more precise and were often more habitual in their learning of mathematics than were boys.

Bohlin (1990) found similar results among high school students in the

United States. She explored the relationship among gender of subjects, learning style, performance in high school math class, and PSAT-math scores. She used a "Mathematics Learning Profile" as a measure of mathematics learning style. She reported a gender difference in mathematics learning style similar to that found by Ito (1989) in Japanese subjects. Girls were more precise and habitual than boys in mathematics learning.

Another interesting study was done by Ainley (1993). Although she did not include gender as a variable, she investigated ways in which student beliefs and goals distinguish different styles of engagement with learning. She also examined how such styles are associated with both the strategies students report using when they are preparing for exams and school achievement. The Learning Process Questionnaire (LPQ;Biggs,1987) was used to assess learning style. She identified six styles of engagement and concluded that these styles of engagement were significantly related to school achievement. Since she did not include gender as a variable, we can not draw any conclusions about gender differences in learning style. However, it is possible to infer that the gender differences in mathematics performance might be related to gender differences in engagement style or learning style.

2.4.4 Summary of Cognitive Approach

The summary of the cognitive approach is as following:

1) Error Analysis: Girls tended to make mistakes because of the misuse of spatial information, the use of irrelevant rules, or choice of incorrect operation, while boys tended to make mistakes due to lack of perseverance and formula interference.

2) Problem solving Processes and Strategy Analysis: Among the high ability students, girls were more likely than boys to use mathematics knowledge and procedures learned in mathematics class and conventional strategies, while boys were more likely than girls to use creative or unconventional strategies in mathematical problem solving tasks.

3) Learning Patterns: girls are more likely to use rote learning, while boys are more likely to use autonomous learning. Girls are also more precise and habitual than boys in mathematics learning.

These cognitive approaches reveal underlying mechanisms of mathematical performance. When difference in performance were found, males and females differ not only in the scores of a test but also in the processes or ways they solve a problem, which might be influenced by the differences in the ways boys and girls learn mathematics.

As it was mentioned before, the cognitive approach could be either a nature/interactionist view or nurture/environmentalist view. Interactionists argue that genetically predisposed traits might set the tendency for boys and girls to prefer certain problem solving strategies or learning styles and that the environment fosters the tendency. In contrast, a nurture theorist might argue that the differential patterns of learning mathematics and problem solving strategies between males and females are the result of differential attitudes and interest toward mathematics which are shaped by socio-cultural factors.

The cognitive approach could be described as a micro-approach toward the study of gender differences in mathematics performance, since cognition or mental activities in each item in each individual are the unit of interest.

In this chapter, empirical evidence of gender differences in mathematics performance and three different approaches to investigate causes of the gender differences were reviewed. The necessity of these different approaches and some of the inconsistent findings reflect the complexity and multi-dimensionality of the problem. In the next section, an overview of the problems and a discussion of what ought to be investigated in order to contribute in the literature of gender differences in mathematics performance are provided.

2.5 Problem Statement and Research Questions

2.5.1 Problem Statement

As is described in previous sections, researchers have been attempting to identify factors which explain gender differences in mathematics performance within each approach. However, only a few researchers have recognized the importance of the relationships among the variables from the different approaches. Especially, the cognitive approach is still in its infancy concerning the study of gender differences in mathematics performance. Very little is known about how variables among the cognitive approaches such as certain problem solving strategies relate to variables in learning pattern (the ways individuals study mathematics), or how variables from the cognitive approach (e.g., mathematics strategy choice) relate to variables in the motivational approach (e.g., perception of one's own math ability). The present study is primarily designed to fill this gap in the literature and provide a better understanding regarding gender differences in mathematics performance.

Another important element of the present study is its cross-cultural comparison between Japan and the USA. It provides us with variation in the cultural milieu such as gender-role stereotypes. It also provides us with stronger confirmation of a cognitive strategy difference between males and females, if any such difference is found across nations. The specific research questions are stated below.

2.5.2 Research Questions

1) Are there gender differences in problem solving performance (e.g. strategies and types of errors) among Japanese and American high school students?

2) Are there gender differences in learning patterns among Japanese and American students?

3) Are there gender differences in attitudes toward mathematics among Japanese and

American students?

4) Are there gender differences in sex-stereotyped beliefs about math among Japanese and American students?

5) How do mathematical problem solving strategies (and/or types of errors) relate to the ways students learn mathematics (learning pattern)?

6) How do the ways individuals learn mathematics (learning pattern) relate to motivational variables (attitudes toward mathematics).

In Chapter 4, the research methods used to answer these questions and the specific hypotheses associated with each research question will be stated. Chapter 3 presents Study 1, which includes the development of performance variables through a qualitative analysis. Chapter 5 presents the results of the preliminary factor analyses for attitude variables and learning variables for Study 2. In Chapter 6, the results of Study 2, which examined gender and national differences on the variables that are identified through study 1 and factor analysis, are described.

Chapter 3

STUDY 1

The purpose of this dissertation is to investigate gender differences in mathematics achievement cross-culturally, and look at how motivational factors, learning factors, and performance factors influence the gender difference. To carry out this investigation, students from Japan and the United States were studied to see whether there are gender differences in their attitudes toward mathematics, learning patterns, and problem solving strategies/causes of mistakes and whether there are relationships among these factors.

In Study 1, protocol analysis was used to identify the qualitative nature of mathematics problem-solving strategies and causes of mistakes.

If one focuses on the results of any mathematics test, one can only count the number of "right" or "wrong" answers. Such a focus would tell us nothing about qualitative differences in the processes which produced right answers or wrong answers. Some strategies are more efficient for reaching a correct answer than are other strategies, and also some mistakes are more serious than are other mistakes. The purpose of Study 1 is to identify (a) the different strategies which are used to get right answers, and (b) the various causes of mistakes in mathematics problem solving. The strategies and causes of the mistakes which were identified through this study serve as the basis for developing test instruments in Study 2.

The ambiguity in meaning of similar terms often creates confusion among researchers in cognitive sciences. In order to avoid such confusions, the definitions of the important constructs that were used in this study are stated as follows:

(1) Efficiency of solution strategy

One of the dimensions which distinguishes the quality of strategies used in mathematics problem-solving is the "efficiency" of the strategy. The efficiency of the strategy, in this study, is defined in terms of the speed of obtaining a correct answer. In most test situations, time is limited and students usually have to solve each mathematics item as quickly as possible. A more efficient strategy leads to a correct answer more quickly with fewer steps and less mental effort than less efficient strategies. More efficient strategies are often unconventional strategies which were not typically taught in mathematics classrooms. Instead, they involve some types of estimation or insight (Gallagher & De Lisi, 1994).

(2) Seriousness of cause of mistake

The "seriousness" of mistakes, in this study, is defined in terms of how close a given answer is to a correct answer. A mistake which reflects a fundamental misunderstanding of the question is a very serious mistake. In contrast, a computational mistake which occurs at the final step in the problem solving processes is a less serious mistake. Presumably, if the computation is executed correctly, one could get the right answer.

Results of previous protocol studies of mathematics problem solving in the U.S. (e.g., Kelly-Benjamin, 1989; Byrnes & Takahira, 1994) indicate that there are usually a limited number of possible strategies to reach correct answers. Similarly, there are a limited number of possible causes of mistakes in each item. Therefore, it is likely that the protocol analysis of American samples may have identified all possible strategies or all possible causes of mistakes in each item. However, due to the different educational systems and the different mathematics curriculums in Japan and in the United States, it is not clear whether Japanese students may use similar strategies or may make mistakes for similar reasons. Therefore, protocol data for a Japanese sample were collected in order to confirm or add additional information regarding the problem solving strategies and the causes of mistakes to that found in studies of American students.

3.1 Method

3.1.1 Instruments

Mathematics problem solving items

There were five mathematical problem solving items (Appendix C) that were taken from the mathematics section of the SAT. These items are those on which Kelley-Benjamin (1989) found a large gender difference in performance among relatively high ability students. In particular, they are items in which, on average, males performed twelve percent higher than females. For example, when 56% of males answered an item correctly, only 44% of females answered it correctly.

The items were translated from English to Japanese by the researcher. In order to avoid loss of meaning in text during the translation, an additional person who is fluent both in English and in Japanese assessed the accuracy of the translation (Appendix D).

3.1.2 American Sample And The Data Collection

The protocol data of the 5 mathematics items for the American sample is provided from the study done by Byrnes and Takahira (1994). In Study 1, these protocols were reanalyzed to identify the different problem solving strategies and the different causes of mistakes for each item. Since the number of strategies and causes of mistakes for each item are limited (at most three or four different strategies and causes of the mistakes), it seems reasonable to conclude that the protocols collected from the previous studies include information that is necessary and sufficient to represent the strategies and the causes of mistakes for each item for average American students.

In Byrnes and Takahira's study (1994), twenty male and twenty female students in the 10th and 11th grades from a parochial high school located in a suburban Maryland participated. These students were randomly selected and asked by their mathematics teacher to volunteer for the study.

The subjects were tested individually and each participant spent about 20 minutes with a researcher. Each student was asked to solve 5 mathematics items with a 5-minute time limitation. After the students solved the 5 items, they were interviewed by the researcher regarding their solution strategies in each item. Each session was tape-recorded.

3.1.3 Japanese Sample

Fourteen male and fourteen female students from the 10th grade were selected from a moderately sized public high school in a small town in the south west side of Japan. The population of the town is approximately 20,000 and the majority of people are working class and middle class families whose income levels range from $15,000 to $100,000 (comparable to the socioeconomic status of the American sample). The curriculum of any Japanese high school is highly centralized and set by the Japanese Ministry of Education. Therefore, any public high school in Japan has almost exactly the same mathematics curriculum, although the levels of a high school vary depending on the percentage of the students who usually go on to well-known universities. The high school which this study was conducted is a typical countryside high school in Japan, in which the achievement level of the students probably falls in the middle when it is compared to the national standard. Approximately 99% of the students successfully graduate from this high school and more than 85 % of the students go to some kind of post secondary educational institution such as universities, junior colleges, nursing schools, and so on.

The students were identified by the mathematics teachers based on their mathematics achievement levels. About half of the male and female students were above average and the other half were below average in mathematics achievement.

Male and female students were matched in their mathematics achievement levels.

3.1.4 Procedure

A researcher interviewed each participant individually. Each interview was recorded on an audio tape recorder by the researcher.

In the beginning, subjects were given two practice problems for think-aloud. The subjects were asked to solve these two items while they thought aloud. During this time the subjects were provided with feedback regarding their verbal expression.

Next, the subjects were asked to solve 5 items (Appendix D) while they were thinking aloud the same manner as in the practice session. Each subject was given a time constraint of 15 minutes to complete all 5 items. In an actual SAT, 60 minutes are given to solve 60 items. However, in the current study, 3 times more time was given in order to allow students time to verbalize their problem solving processes. Each session was tape-recorded.

3.1.5 Protocol Analysis

1) Identification of different strategies and different causes:

First, two researchers listened to audio-tapes either for American subjects or for Japanese subjects and identified strategies for the correct answers or causes for the incorrect answers for each item for each individual for each nation. A list of solution strategies and causes of mistakes for the 5 math problems for each individual for each nation was created in English. One researcher went through the lists and identified different types of solution strategies for correct answers and different types of mistakes for the incorrect answers in each item. An inter-rater reliability check was performed with the other researcher using a random sample of 20 subjects. The inter-rater agreement was 97%. Disagreement were resolved by discussion.

2) Categorization of solution strategies and causes of mistake:

The researchers classified different strategies which were identified in the first process into three categories, "efficient strategy," "intermediate strategy," and "inefficient strategy," and different causes of mistake into three categories, "serious cause of mistake," "intermediate cause of mistake," and "not serious cause of mistake" according to the definitions of strategy efficiency and seriousness of causes that were stated previously.

3) Discussion process:

Then, the researchers met together and discussed the classification of the different strategies. Any conflicts in the classification process between researchers were resolved through discussion. The inter-rater reliabilities are described in summary section. In the next section, the result of study 1, the different solution strategies and the different causes of mistakes were listed.

3.2 Results of Study 1

There were 5 solution strategies for item 1, 3 for item 2, 3 for item 3, 4 for item 4, and 5 for item 5. These solution strategies are described along with the description of each math problem. Then, they are categorized according to efficiency of the strategy.

3.2.1 Item 1 (Midpoint Problem)

On the number line above, which of the following is the coordinate of the midpoint of segment PQ?

(A) $\frac{x}{2}$

(B) $\frac{x+1}{2}$

(C) $x+\frac{1}{2}$

(D) $2(x+1)$

(E) $\frac{x(x+1)}{2}$

In this item, students have to find the coordinate of the midpoint of a given segment. The results of protocol analyses showed that both American and Japanese students in Study 1 used one of five following solution strategies.

Solution Strategies for Correct Answer

There were 5 different solution strategies for correct answers. These included:

Strategy 1

I used the midpoint formula, adding P and Q together and dividing the sum by 2. Thus { x + (x + 1)}/2, (2x + 1)/2, 2x/2 + 1/2, and x + 1/2.

Strategy 2

P=x and Q=x +1, I noticed that the distance between P and Q is 1. The midpoint between P and Q must be 0.5 from P, and thus, the answer is x + 1/2.

Strategy 3

I substituted x with a number. For example, when x=1, then P=1 and Q= 1+1 = 2. And the midpoint has to be in between 1 and 2. In reviewing the choices, I saw that substitution in choice (A) x/2 would put the sum before P. The choice (B) (x+1)/2 would bring the sum back to 1. Substitution in choice (c) makes 1 and 1/2.

Strategy 4

I substituted x with a number. When x=1, then p=1, and Q=x+1=1 +1=2. The midpoint between P and Q is the point which is halfway from P. Thus, if x =1, the midpoint is 1.5 which is (x + 0.5). Thus, x + 1/2 is the answer.

Strategy 5

I just guessed.

Strategy 2 was categorized as the most efficient strategy since this strategy has only three steps (distance between P and Q is 1, 2:midpoint means half way from P, 3:x +1/2)and no mental effort was required to compute a formula. Strategy 5 was categorized as an inefficient strategy (or no strategy) because of the uncertainty regarding the correct answer. Strategies 1, 3, and 4 which used the midpoint formula or substitution method to solve the problem were categorized as "intermediate" strategies, in between the previous two categories.

Cause of Mistake for Incorrect Answer

There were 8 different causes of mistakes for incorrect answers. These included:

Cause 1

I did not really understand the question.

Cause 2

I did not understand the phrase "the coordinate of the midpoint".

Cause 3

I tried to apply the midpoint formula but wasn't really sure of it. I thought it was x+1 divided by 2.

Cause 4

I tried to apply the midpoint formula but wasn't sure of it. I thought it was x multiply by (x+1), divided by 2.

Cause 5

I tried to apply the correct midpoint formula which is x+(x+1) divided by 2, but I could not find the result of my calculations in the answer choices - I circled the closest answer. I did not realize that I had to simplify the equation.

Cause 6

I tried to apply the correct midpoint formula and then simplify the equation but somehow I could not get the correct answer.

Cause 7

I understood the question but I couldn't really figure out how to do it.

Cause 8

I didn't have enough time to complete the calculations.

Causes 1, 2, and 7 were classified as "serious causes" of mistakes since the causes of the mistake were attributed to the fundamental understanding of the question and no strategy to begin with. On the other hand, a computational mistake (cause 6)) was classified as a "not serious cause" of mistake. Those students could get the correct answer if the computation was right. Causes 3,4, and 7 were caused by application of the incorrect midpoint formulas. They were classified as "intermediate causes" of mistake, in between the previous two categories, because they have an idea how to do it but they were not able to recall the right formula to solve the problem. Cause 8 (not having enough time) was also classified into the "intermediate cause" category. If the problem was only the matter of time, Cause 8 should be classified into "not serious cause"; however, if students were on the right track, they should have enough time to complete the problem.

3.2.2 Item 2 (Oatmeal Problem)

Oatmeal Recipe

Water	$\frac{3}{4}$	cup
salt	$\frac{1}{4}$	teaspoon
oats	$\frac{1}{3}$	cup

If the least possible multiple of the recipe above is prepared so that a whole number of cups of both water and oats are used, how many teaspoons of salt would be required?

(A) $\frac{1}{2}$ (B) $\frac{3}{4}$ (C) 1 (D) $2\frac{1}{4}$ (E) 3

Students were asked to find how many teaspoons of salt would be required if whole cups of both oats and water were used in order to make oatmeal . For this item three solution strategies which lead to the correct answer and nine causes of mistake were identified. The lists of the solution strategies and the causes of mistakes are following.

Solution Strategies for Correct Answer

There were three solution strategies. These included:

Strategy 1

I found a common denominator, 12, for both Oats (1/3) and water (3/4). I multiplied all three measurements by 12. Thus, 1/3 multiplied by 12 =4 cups, 3/4 multiplied by 12=9 cups, and 1/4 multiplied by 12=3 teaspoons.

Strategy 2

I didn't really understand the question so I just guessed. It was a lucky guess.

Strategy 3

I knew that I had to multiply all three ingredients by something. In order to get the right number to multiply, I tried from 3,4, 5....,and 12, finally worked out. I multiplied 1/4 by 12 to get 3 teaspoons.

Since there were only three solution strategies, Strategy 1 was the straightforward and "efficient" strategy to solve this problem among the three strategies. Finding the common denominator 12 is the key to solve this item. Strategy 2, guessing, was actually no strategy and classified into "inefficient strategy." The students who used Strategy 3 understood the question but did not realize the common denominator of (1/3) and (3/4). Then they used trial and error method to get the right number to multiply with. Thus, Strategy 3 was classified as an "intermediate strategy," in between "efficient" and "inefficient" strategies.

<u>Causes Of Mistake For Incorrect Answer</u>

There were 9 causes of mistakes for incorrect answers. These included:

<u>Cause 1</u>

I didn't really understand the question.

<u>Cause 2</u>

A "whole number" was needed so I figured that 1/4 + 3/4 =1. 1 is a whole number so 3/4 must be the answer.

<u>Cause 3</u>

I had to get a whole number so I multiplied each measure by something to get the whole number "1." 1/3 multiplied by 3 equals 1, 3/4 multiplied by 4/3 equals 1, and 1/4 multiplied by 4/1 equals 1.

Cause 4

I guessed incorrectly.

Cause 5

I understood the question - that I had to multiply each measure by something to get a whole number. I tried the numbers 2,3,4,....etc., but it took me too long so I gave up.

Cause 6

I multiplied each measure by 12. 12 multiplied by (1/4)=3.Then I multiplied 3 by 1/4 in order to convert to teaspoons.

Cause 7

I multiplied each measure by 3. 3/4 multiplied by 3=9/4. 1/4 multiplied by 3=3/4.

Cause 8

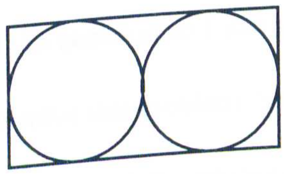
I could not really figure out how to do it.

Cause 9

I didn't have enough time to complete my calculation.

There were nine causes of mistake for this item. The serious causes that related to the fundamental understanding of the question were causes 1,2,3,4,7, and 8. Those students who made these mistakes did not really understand the question. Cause 6 was classified into the "not serious cause" category. The students who made this mistake had the correct strategy and the answer but misread the question to convert to teaspoon from cups. Some students tried to use a trial and error method to get the right number that would make both oats and water "whole number" and they ran out time. However, time should be enough if they understand how to do it clearly. Thus, these students whose major cause of mistake was likely attributed to the time factor were classified in the "intermediate cause" category in between the previous two categories (causes 5 and 9).

3.2.3 Item 3 (Circle Problem)



The rectangle above contains two circles, tangent to each other and each tangent to three sides of the rectangle. Which of the following pairs of numbers CANNOT be the length and width, respectively, of the rectangle?

(A) 2, 1 (B) 12, 6 (C) 16,10 (D) 22, 11 (E) 32, 16

Students were asked to find a pair of numbers which cannot be the length and width of a given rectangle. For this item, three solution strategies led to the correct answer and five causes of mistake were identified. The lists of solution strategies and the causes of mistake are as follows.

Solution Strategies For Correct Answer

There were three different strategies for the correct answers. These included:

Strategy 1

I didn't really understand the question. However, when I looked at the answer choices, I realized that all the choices were in 2-to-1 ratio except choice (c).

Strategy 2

The length of the rectangle is 2 diameters and width of the rectangle is 1 diameter. So any number which is in a 2-to-1 ratio could be a length and width of the rectangle. Only (c) isn't in a 2-to-1 ratio.

Strategy 3

I didn't really understand the question so I just guessed. It was a lucky guess.

There were not so many ways to solve this problem. Strategy 2 is based on a clear understanding of the question, which asked the relationship between a rectangle and two inscribed circles. Among the three strategies, therefore, Strategy 2 was classified into the "efficient" strategy. Strategy 3, guessing, was classified into "inefficient" or no strategy since the correct answer depended on a luck. Strategy 1, examining the answer choices, was classified in between the previous two categories, as an "intermediate strategy." If a student understood the question clearly when he/she read it, he/she would choose Strategy 1. However, if a student cannot understand the question clearly, he/she would use the third strategy.

Causes Of Mistake For Incorrect Answer

There were five different causes of mistake for incorrect answers. These included:

Cause 1

I didn't really understand the question.

Cause 2

I couldn't remember the meaning of the word "tangent" - so I couldn't understand the question.

Cause 3

I looked at the figure and looked at the answer choice. I incorrectly estimated the length and width of the rectangle based on looking at a picture.

Cause 4

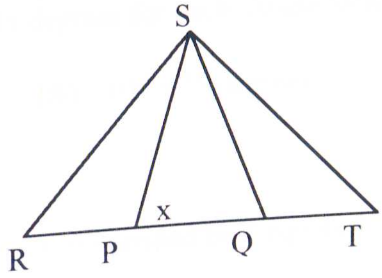
I was trying to get the actual length and width of the rectangle, but I couldn't figure it out.

Cause 5

I didn't have enough time to complete the calculations.

There were five causes of mistake for this item. Causes 1,2,3, and 4 related to a problem in fundamental understanding of the question. Thus, they were classified into "serious cause" of mistake. Cause 5, not having enough time, was classified into "less serious cause" of mistake. There was no cause that was classified into "not serious causes" categories.

3.2.4 Item 4 (Triangle Problem)



Note: Figure not drawn to scale.

In the figure above, ΔRST is a right triangle, RS=ST and right RST has been divided into three equal angles. What is the value of angle x?

(A)65 (B)70 (C)75 (D)80 (E)85

Students were asked to find a value for angle x that was indicated in a given figure of a triangle. There were several ways to get the correct value of x. Four solution strategies and four causes of mistake were identified.

Solution Strategies For Correct Answer

There were four different solution strategies for the correct answer. These included:

Strategy 1

The right angle RST is 90 degrees. It is divided into three equal angles so that each angle is 30 degrees. Each triangle has a total of 180 degrees. 180 minus 30 is 150 degrees remaining, equally divided between angles SPQ and SQP. 150 degrees divided by 2 equals 75 degrees.

Strategy 2

Right angle RST is 90 degrees. Each triangle has a total of 180 degrees. 180 minus 90 equals 90 degrees. angle SRT equals angle STR, therefore, 90 divided by 2 equals 45 degrees for each. Angle SPR = 180 - (30 + 45) = 105 degrees. The angle x = 180 - 105 =75 degrees.

Strategy 3

Angle RST is 90 degrees. 90 divided by 3 equals 30 degrees for each of the angles, RSP, PSQ, and QST. In triangle PST, angle PST = 30 + 30=60 degrees, and angle STP =45 degrees. 60 + 45 = 105 degrees. Each triangle has a total of 180 degrees so the solution is, x = 180 - 105 = 75 degrees.

Strategy 4

I couldn't really figure out how to do it so I just guessed. It was a lucky guess.

This is a geometry problem which requires knowledge about the characteristics of isosceles triangles. Strategy 1 requires the least steps (step1: each angle of three equally divided right angle was 30 degrees, step 2: triangle SPQ is an isosceles triangle, and step 3: angle SPQ and SQP are equal, step 4: (180-30)/2 =75 degrees) compared with Strategy 2 or 3. Thus, Strategy 1 was classified as an "efficient strategy." Strategy 4, guessing, was classified into the "inefficient" or no strategy category since the correct answer depended on luck. The other strategies (2 and 3) were classified as being in between the previous two categories.

Causes Of Mistake For The Incorrect Answer

There were four causes of mistakes for incorrect answers. These included:

Cause 1

I understand that I had to find the value of x but I did not know how to do it.

Cause 2

I couldn't understand the question.

Cause 3

I was trying to do the correct strategies, but somehow I made a computational mistake and could not get the right answer.

Cause 4

I did not have enough time to complete the calculations.

In this problem, some students expressed that they did not understand what the value x was. This indicates that they did not understand what they were asked to do. Thus, Cause 2 was classified into the "serious cause" category. Cause 3 was a computational mistake, which was classified as a "not serious" cause since the answer could be correct if students didn't make a mistake in computation. Other students mentioned that they had a clear understanding of the question regarding finding the value of x. However, they could not recall the theorems (e.g., isosceles triangles have two equal sides and inner angles) that were necessary to solve the problem. Cause 1 was classified as being an "intermediate" cause, in between the previous two categories. The time factor, Cause 4 was also classified as being in between previous two categories.

3.2.5 Item 5 (Cake Problem)

If a rectangle cake, 9 inches by 13 inches by 2 inches, is cut into x equal rectangle pieces. 3 inches by 3 ¼ inches by 2 inches, and no cake is left over, then x=

(A)9 (B)12 (C)13 (D)15 (E)22

This problem asked students to find how many rectangular pieces there would be if a whole cake was cut into equal size pieces and no cake was left over. There were four solution strategies for the correct answer and five causes of mistake. The lists of strategies and the causes of mistake were as follows.

Solution Strategies For The Correct Answer

There were four different solution strategies for correct answers. These included:

Strategy 1

I calculated the volume of the whole cake which is 9 x 13 x 2. Then, I calculated the volume of a small piece, which is 3 x 3(1/4) x 2. I divided the volume of the whole cake by the volume of the small piece which is 234 divided by 19.5. The subsequent answer is 12.

Strategy 2

I calculated the area of the whole cake, 9 x 13, and the area of the small piece, 3 x 3(1/4). Then I divided the area of the whole cake by the area of the small piece which is 117 divided by 9.75. The answer is 12.

Strategy 3

I didn't know how to do the problem so I just guessed. It was a lucky guess.

Strategy 4

I drew a picture. The width of the cake is 9, divided by the width of a piece, 3. This equals 3 slices. The length of the cake is 13, divided by the length of the piece, 3(1/4) which equals 4 slices. 3 pieces multiplied by 4 pieces yield 12 pieces total.

This problem was the last item of 5 math problems. Many students reported that they did not have enough time to solve this item. Strategy 4 used a picture to figure out the answer. This strategy did not involve a complex computation so that it was quicker to get the answer and less likely to promote computational mistakes during the problem solving process. Thus, Strategy 4 was classified into the "efficient" strategy category. Strategy 3, guessing, was classified into the "inefficient" or no strategy category. The use of the volume formula, Strategy 1, and the area formula, Strategy 2, were classified as "intermediate" strategies, in between the previous two categories. The computations of volume or area of the cake require dealing with larger numbers and, therefore, take more time.

Causes Of Mistake For Incorrect Answer

There were five different causes of mistakes. These included:

Cause 1

I tried to divide the area of the whole cake, 9 x 13, by the area of the small piece, 3 x 3(1/4), but somehow I made mistake in the computational process.

Cause 2

I misunderstood the question and couldn't get the right answer.

Cause 3

I just guessed because I couldn't understand the question and I didn't know how to do it.

Cause 4

I made a mistake when I computed the fraction 3(1/4) x 3.

Cause 5

I didn't have enough time to complete the calculations.

Time was the crucial factor in this item since this was the last item. However, for some students, the mistake was caused by the problem in fundamental understanding of the question. Cause 2 and 3 were classified as "serious" causes of mistake. The students who tried to use the volume or area formula to solve this item often made mistakes in the computational processes. Causes 1 and 4 were classified as "not serious" causes of mistake. The time factor, Cause 5, was classified as of "intermediate seriousness" in between the previous two categories.

3.3 Summary

The purpose of the Study 1 was, first, to identify as many solution strategies or causes of mistake as possible in each item, and second, to classify strategies into three categories according to the efficiency of solution strategy or seriousness of the cause of mistake. It should be noted that, in this study, neither gender nor national differences were analyzed.

Inter-rater reliability checks were performed two times. There was 94% agreement for the efficiency classifications and 84% agreement for the seriousness classification between the first and second raters. Disagreement was resolved through discussion. A second reliability check was performed with a third rater. Agreements was 92% for the efficiency classification, and 81% for the seriousness of cause classification. Through discussion, three raters reached 97% agreements for the efficiency classification and 100% agreements for the seriousness classification.

There were variations among the five mathematics items in terms of the number of solution strategies or number of causes of mistake identified in this study. Some items could be solved in multiple ways, while other items had only one way to solve them. Gallagher and De Lisi (1994) classified mathematics problems into two categories: conventional and unconventional problems. They defined the conventional problem as, "problems that could be answered only by primary algorithmic methods" and unconventional ones as, "problems that either required the use of an atypical solution strategy, such as an unusual use of a familiar algorithm, or could be solved more quickly using some type of estimation or insight." Items 1 and 5 might be said to fall into unconventional problem category since one of the solution strategies in these items require atypical solution methods such as estimation or insight. In contrast, Items 2, 3, and 4 might fall into conventional problem category. Although more than one solution strategy were identified, these strategies were likely to be taught in school using primary algorithmic methods.

In Study 2, these performance variables, solution strategies and causes of mistakes were quantitatively analyzed utilizing descriptive and inferential statistics in terms of subjects' gender and nationality. The next chapter presents the methods for Study 2.

Chapter 4

STUDY 2 METHOD

This dissertation was aimed to investigate cross-cultural aspects of gender differences in mathematics regarding motivational, learning, and performance factors. Particular questions were (1) whether there are gender differences in their attitudes toward mathematics, learning patterns, and problem solving strategies/causes of mistakes and (2) whether there are relationships among these factors.

In the first study, qualitative aspects of mathematics performance such as problem solving strategies and the reasons for mistakes were identified. In this second study, the role of the performance factors (problem-solving strategies and causes of mistakes), learning factors (learning patterns), and motivational factors (variables for mathematics attitudes) on gender differences in mathematics performance were examined. In this chapter, I describe: 1) the subjects, 2)the test instruments, 3) the testing procedures, 4) the specific hypotheses for each measurement, and 5) the methods of analysis.

4.1 Subjects

4.1.1 Japanese Sample

Ninety nine male and 108 female 10th grade Japanese students from a public high school participated in Study 2. This high school was the same high school as Study 1 and is in a relatively small town (population less than 20,000)(See chapter 3 for a detailed description). The average age for Japanese male subjects was 15.7 years old and for the Japanese female students was 15.8 year old. There were 280 10th grade students, who came from 7 classes. Each class consisted of 40 students and contained approximately 52% female and 48% male students. All students in the 10th grade were asked by a mathematics teacher to volunteer for this study. However, one class (40 students) was dropped from the data analyses because of mistakes in the procedure during the administration of the test instruments. Also, fourteen male and female students who had already participated in Study 1 were excluded from the data analyses for Study 2. Thus, 207 students participated in Study 2.

4.1.2 United States Sample

For the American sample, 67 male and 97 female students from 9th, 10th, 11th, and 12th grades participated. The average ages for male and female subjects in the United States were the same (16.1 years). The proportions of the students in each grade, 9th to 12th, were 13%, 9%, 40%, and 38% respectively. The proportion of male and female students did not differ significantly either by their grade level or by age (Chi-square(4)=2.23, $p<0.7$). All 9th graders were honors students who were enrolled in "Honors Geometry" class. All students who participated in this study had already taken Algebra I. Approximately 13% of the students were in Honors Geometry class, 52% were in the Algebra II/Trigonometry class, 26% were in Pre-Calculus class, and 9% were in Advanced Calculus class. Males and females did not differ regarding their course taking. These students were recruited from a parochial high school in suburban

Maryland which was the same high school which data for Study 1 were collected. They were asked by a mathematics teacher to volunteer the study.

4.2 Instruments

Mathematics Problem Solving Items (Appendix C)

The same five items used in Study 1 were used in Study 2.

Strategy And Mistake Questionnaire (Appendix E)

For each mathematics problem solving item, the different strategies and the different causes of mistakes identified through Study 1 were listed with the correct answer. Students who answered the item correctly were asked to answer part (A) which describes various strategies to reach the correct answer. Students who got an item wrong were asked to answer part (B), which describes various causes of mistakes of the item.

Learning Pattern Questionnaire (Appendix F)

The items in the Learning Pattern Questionnaire (Appendix F) developed by Ito (1989) were used in this study. The questionnaire consists of 26 items and had three scales. Scale 1 deals with learning patterns of coping with errors (e.g., I try to comprehend the cause of mistakes versus I just copy the correct answers). Scale 2 asks about student's learning patterns of precision (e.g., I write down answers along with my calculation processes versus I write down answers only). Scale 3 measures study habits (e.g., I study according to the schedule versus I study when I feel like it). Ito (1989) found the reliability of Scale 1 to be 0.77, Scale 2 to be 0.67, and Scale 3 to be 0.78. Although this questionnaire was originally developed in Japanese, the researcher obtained only an English version. Thus, the learning pattern questionnaire was translated in Japanese by the researcher and was assessed by another person who is fluent in both Japanese and English.

Mathematics Attitude Questionnaire (Appendix G)

The mathematics attitude questionnaire (Appendix G) developed by Eccles et al. (1983) was used. It consists of four constructs: an ability/expectancy, a perceived task value of mathematics, a perceived task difficulty and sex stereotyping constructs. The ability/expectancy construct includes 1) current expectancy for success in mathematics performance, 2) future expectancy for mathematics performance, 3) self-concept of mathematics ability, and 4) actual effort expended on mathematics. The perceived task value construct includes three aspects: 1) intrinsic interest value, 2) attainment value/importance, and 3) extrinsic utility value. The perceived task difficulty construct includes two scales, 1) task difficulty, and 2) required effort. The last construct, sex stereotyping scales, includes 1) cost of doing well in mathematics, 2) the utility of mathematics for women, 3) utility of mathematics for men, and 4) sex stereotyping of mathematics ability.

The attitude questionnaire was translated in Japanese by the researcher and was assessed by another person who is fluent in both Japanese and English.

4.3 Procedure

The mathematics problems and questionnaires were given in the following order. First, the students were asked to solve 5 mathematics problem solving items within 5 minutes. Second, after the answer sheet for the 5 mathematics items had been collected, they were given a questionnaire which included different types of strategies and causes of mistakes for each item. Finally, the learning pattern questionnaire and attitude questionnaire were given to the students. All these tasks were completed within one class period.

In Japan, the home-room teacher in each class administered the test and the questionnaires in his/her class. The procedure for the administration of the material was explained and written instruction was given to each teacher.

In the United States, the researcher visited each mathematics class and administered the test and the questionnaire with the cooperation of the mathematics teachers in each mathematics class.

4.4 Hypotheses

Given the literature review in Chapter 2, the following hypotheses are posed for the samples in each nation.

Hypotheses Related To Math Problem Solving Performance

1) Males will outperform females on total score of 5 problem solving items.

2) Males will use more efficient strategies than females.

3) Males will make less serious mistakes (e.g., computational mistakes) than females (e.g., mistakes in application of formula).

Hypotheses Related To Learning Patterns

1) Males will study math more regularly than females.

2) Males will study math more independently than females.

3) Females will have more positive study habits in math than males. (An example of positive study habits is,"I write down answers as well as my calculation process," and an example of less positive study habits is, "I write down answers only in my notes.")

Hypotheses Related To Attitudes Toward Mathematics

1) Males will have a higher confidence in their own math ability than females.

2) Males will value mathematics more highly than females.

3) Males will believe mathematics is less difficult than females.

4) Males will have stronger stereotyped beliefs than females about math as a male domain.

5) Males will have stronger stereotyped beliefs than females about the utility of math for men and for women.

In the present dissertation, the main interests were to find similarities and differences of gender differences in variables between nations. Thus, the hypotheses that delt with direct comparisons of variables between nations were not included in above hypotheses.

In the next section, the method of analysis for testing the above hypotheses will be presented.

4.5 Analyses

There are three different analyses in Study 2: a preliminary factor analysis, analyses of variances, and correlational analyses. The factor analyses were performed to identify and confirm the underlying meaningful structures among the items in each nation on the mathematics attitude questionnaire and on the learning patterns questionnaire. Then, analyses of variances and correlational analyses were performed on the attitude and learning variables that were identified through the factor analyses and the performance variables that were developed in Study 1. The method and results of the factor analyses are described in Chapter 5. The following sections describe the method of the main analyses of Study 2: analyses of variances and correlational analyses.

The variables from three factors (motivational, learning, and performance factor) are presented in Table 4.1. In each category, 2 (nation) x 2 (gender) ANOVAs were performed in order to find whether the main effect of nation or gender are significant in each category of variables.

Analysis of Performance Factor

Research question 1: Are there gender or country differences in math problem solving?

Three 2 (nation) x 2 (gender) ANOVAs were performed on (a) the total score on 5 items (Appendix C), (b) the average strategy efficiency score (Appendix E), and (c) the average seriousness of mistake score (Appendix E). The specific hypotheses concerning the performance variables were examined by separate univariate analyses.

Analysis of Learning Factor

Research Question 2: Are there gender or country differences in mathematics learning patterns?

Three 2 (nation) x 2 (gender) ANOVAs were performed on (a) study regularity, (b) study independence and (c) study habits (Appendix H). The specific hypotheses concerning the learning pattern variables were examined by separate univariate analyses.

Analysis of Motivational Factor

Research Question 3: Are there gender or country differences in attitude toward mathematics?

Three 2 (nation) x 2 (gender) ANOVAs was performed on (a) perception of math ability/expectancy, (b) perceived task value of math, and (c) perceived task difficulty (Appendix I). The sex-stereotyping factor (Appendix J) was also analyzed separately.

Table 4.1 Variables Used in Main Analyses of Study 2

Factor	Variables
Performance (Appendix C & E)	
	(1) Total score of 5 math items
	(2) Average strategy efficiency
	(3) Average seriousness of mistake
Learning Patterns (Appendix H)	
	(1) Study regularity
	(2) Study independence/task preference
	(3) Study habits
Motivational (Attitudes) (Appendix I)	
	(1) Perceived math ability/expectancy
	(2) Perceived task value of math
	(3) Perceived task difficulty
Sex-Stereotyping (one part of attitude variables) (Appendix J)	
	(1) Beliefs about math as a male domain
	(2) Beliefs about the utility of math
	(3) Beliefs about math related occupations

The specific hypotheses concerning the motivational variables were examined by separate univariate analyses.

Correlational Analyses

Correlations among all variables were computed (1) for American males, (2) for American females, (3) for Japanese males, and (4) for Japanese females. Of particular interest were: (a) the relation between mathematics problem solving (strategies and types of errors) and the ways individuals learn mathematics, (b) the relation between problem solving strategies and psychological motivational variables, (c) the relation between the ways students learn mathematics and their attitudes toward mathematics, and (d) the relation between attitudes toward mathematics and belief about math as a male domain.

In this chapter, the designs of Study 2 and the method of analyses were described. In the next chapter, the results of factor analyses for the motivation variables and learning variables are discussed.

Chapter 5

STUDY 2 RESULTS:

FACTOR ANALYSES AND RELIABILITY ANALYSES

In this chapter, the results of the factor analyses on the attitude variables and learning pattern variables for the Japanese sample and for the United States sample are reported. Along with the reliabilities of the scales developed from the factor analyses.

The purpose of the factor analyses and the reliability analyses were to identify and to confirm the underlying meaningful structures among the items in each nation. Although results of factor analyses on the mathematics attitude questionnaire were previously reported by Eccles and Wigfield (1995) with a sample from the United States, it was necessary to assess whether the factor structure of the Japanese sample is the same. Also, the results of a factor analysis on the mathematics learning patterns was reported by Ito (1988) and there are no data that validate this factor structure in a United States sample. Thus, factor analyses were done separately for the Japanese sample and American sample. When the structures of the factors were the same for both nations, scales were developed and the reliability of the scale was computed. When the structure of the factors turned out to be different in Japan and in the United States, the reasons for the differences are discussed, the scales consisting of the common items between the two nations were developed, and their reliabilities were assessed.

There are three sections in this chapter. The first section presents the results of the factor analyses and the reliability analyses of the mathematics attitude questionnaire. In the second section, the results of these analyses for the learning patterns questionnaire are reported. Finally, the common variables between the Japanese and American data for each construct are described.

For the factor analyses, it was assumed that some factors were correlated with each other. Thus, Oblimin rotation was used instead of Varimax rotation.

5.1 Mathematics Attitude Questionnaire

The Mathematics Attitude Questionnaire, developed by Eccles et.al. (1983, 1995), consisted of four main constructs: 1) sex-stereotyping items, 2) ability/ expectancy items, 3) perceived task value items, and 4) perceived task difficulty items. Each construct consisted of at least two or more items and some constructs were divided into smaller subconstructs. Because of limited computer memory, many of the factor analyses were performed within each construct.

5.1.1 Sex-Stereotyping Items

There were seven items that measure students' sex-stereotyping toward mathematics. The result of the factor analysis showed that there were two factors in both the Japanese and the American data. The seven items were classified into two factors, utility of math and stereotyping math as a male domain, as shown in Table 5.1. As can be seen in the table, the factors in the two countries are essentially identical.

The correlations between factors, utility of math and math as male domain were -0.05 for the Japanese sample and -0.03 for the United States sample.

Reliability

Table 5.2 presents the internal consistency reliability of scales based on the two factors. There was a low reliability among the three items that measure math as a male domain for the Japanese sample. These three items came from different questionnaires. Item 26 was originally included in the mathematics attitude questionnaire (Eccles et.al., 1983), and the other two items, item numbers 52 and 55, were taken from the questionnaire used in the Second International Mathematics Study (1986). Although the sample in the United States responded to these three items similarly, the Japanese sample responded quite differently. It is unlikely that there were translation mistakes since the questionnaire in Japanese and in English were confirmed by the author and one more person who is fluent in both languages. The exact causes of the differential reliability between Japanese and American samples are unknown at this point. Table 5.3 presents the correlation matrix among items measuring math as a male domain. Very low to no correlations were found between item 26 and both items 52 and 55 in the Japanese data and there were low correlations between these items in the American data. Thus, in order to create a more reliable instrument, item 26 was considered by itself. The other two items, 52 and 55, were treated as measuring a slightly different concept, stereotyping in math-related occupations. The internal consistency reliability for these two items was .59. Thus, there were three constructs to measure the

Table 5.1: Factor Loading For The Sex-Stereotyping Items

Item Number	Factor 1 Utility of math		Factor 2 Math as male domain	
	Japan	USA	Japan	USA
Item 10	.81	.78		
Item 11	.79	.78		
Item 14	.77	.78		
Item 34	.76	.73		
Item 26			.56	.64
Item 52			.65	.82
Item 55			.78	.86

Note: The factor loading is the result of the Oblimin Rotation.

Table 5.2: Internal Consistency Reliability For Sex-Stereotyping Items

	Reliability	
	Japan	USA
Utility of math	.99	.77
Math as a male domain	.45	.71

Note: Internal reliability was computed by Cronbach's Alpha

Table 5.3: Correlation Matrix Among Items Measuring Math As A Male Domain

Item Number	Item 26		Item 52	
	Japan	USA	Japan	USA
Item 26	1.00	1.00		
Item 52	.04	.26	1.00	1.00
Item 55	.23	.39	.35	.69

Note: N(Japan)=235 and N(USA)=162

beliefs about sex-stereotyping in mathematics; utility about math, math as a male domain, and stereotyping in math-related occupations.

5.1.2 Ability/Expectancy and Value Items

There were 5 items that measured students' belief about their own ability and expectations for their mathematics achievement, plus 7 task value items. The items for these two constructs first were analyzed together. As Eccles and Wigfield (1995) demonstrated in their American sample, it was expected that two factors would be identified, one an ability/expectancy factor and the other a perceived task value of mathematics. The results of the factor loadings are shown in Table 5.4.

For the American data, as expected from the previous report by Eccles and Wigfield (1995), an ability/expectancy factor (5 items) and a perceived task value factor (7 items) emerged. For the Japanese data, 6 items were clustered in the ability/expectancy factor. Among them, 5 are the ability/expectancy related items reported by Eccles & Wigfield (1995) and one is a perceived task value item. The item which factored into the ability/expectancy factor measured one of the three subconstructs within the construct of the perceived task value, intrinsic interest value. Thus, for the Japanese sample, intrinsic interest value might be more related to beliefs about their math ability and expectation about their math achievement than to perceived task value. Factor 2 represents the perceived task value, which includes three subconstructs. Perceived task value is described in the next section in detail.

Table 5.4: Factor loadings Of Ability/Expectancy And Value Items

	USA Sample		Japanese Sample		
	Factor 1	Factor 2	Factor 1	Factor 2	Factor 3
	Ability/Exp.	Task value	Ability/Exp.	Task Value	
Item 2	.65		.86		
Item 7	.87		.89		
Item 16	.88		.87		
Item 47	.74		.44	.60	
Item 51	.83		.85		
Item 1		.71	.65		
Item 9		.70		.73	
Item 20		.64		.76	
Item 23		.62		.42	.59
Item 30		.80		.74	
Item 33	.42	.48		.83	
Item 38		.65		.74	

Note: The factor loadings were the result of the Oblimin rotation.

Reliability

The five common items, item numbers 2,7,16,47, and 51, from the results of the factor analyses of the American data and Japanese data were used as the items that measure the perception of one's ability/expectation. Cronbach's alpha was computed for those 5 items on the Japanese and American data. The internal reliability for American sample was .89 and the Japanese sample was .87.

5.1.3 Perceived Task Value Item

According to Eccles and Wigfield (1995), the perceived task value scale is divided into three subconstructs: intrinsic interest value, attainment value/importance, and extrinsic utility value. Factor analyses were performed on those 7 items, to see if these factors emerged. Table 5.5 presents the results of the factor loadings for perceived task value.

In this study, the American data had only one factor and the Japanese data had two factors. According to Eccles and Wigfield (1995), item numbers 1 and 30 represent factor one, the intrinsic interest value; item numbers 23, 33, and 38 represent factor two, the attainment value/importance, and item numbers 9 and 20 represent factor three, extrinsic utility value. For the Japanese data, only the intrinsic interest value factor and the attainment value/importance factor were identified. Items 9 and 20 of the extrinsic utility value factor were spread across the previous two factors. The reason of the difference in factor structures between the present study and the study by Eccles and Wigfield (1995) might be the difference in statistical method used in those

Table 5.5: Factor Loadings of Perceived Task Value

Item Number	USA Factor 1	Japan Factor 1	Japan Factor 2
Item 30	.81	.88	
Item 1	.73	.86	
Item 38	.75		.74
Item 23	.59		.66
Item 33	.64		.83
Item 9	.69		.50
Item 20	.66	.56	

Note: Factor Matrix Oblimin Rotation

studies. Eccles and Wigfield (1995) got three factors using confirmatory factor analyses, which is more powerful than the exploratory factor analysis which the present study employed.

The purpose of the factor analyses is to identify the underlying factor structure for the Japanese data and to create common variables, in order to use the same items that measure the same constructs for the Japanese sample and for the American sample. Thus, there are two possibilities for creating variables for the Japanese data. The first possibility is to create a separate model which consists of 2 value scales for that construct for the Japanese data. The advantage of creating two variables is that each variable measures more accurately the underlying construct and has a higher internal reliability for each variable. However, the disadvantage is that it will not be a common variable, since the American data had only one factor. The other possibility is to create only one factor in which two factors would be collapsed into one factor. Although the Japanese data might not have high internal reliability for that factor, the two nations will have in common one factor, perceived task value.

Reliability

The internal consistency reliabilities among the items are shown in table 5.6 The results of the internal consistency reliability indicated that although two factors emerged in the Japanese data, the internal reliability of these two factors was lower (.70 and .66) than the reliability for the all items together (.74). Thus, perceived task value was treated as one variable which include 7 items for the Japanese and American data.

5.1.4 Perceived Task Difficulty Item

Five items measure perceived task difficulty. This construct consists of two subconstructs, task difficulty and required effort according to Eccles and Wigfield (1995). The factor analyses were performed on the five items. Both the Japanese and the American data had only one factor. Thus, the internal consistency reliability was computed for one factor for both nations and the two subconstructs were not considered in this study. The results of the factor loadings are shown in Table 5.7.

Reliability

The internal reliability of all 5 items was .86 for the Japanese data and .89 for the American data.

5.1.5 Summary of The Variables and The Reliability

The scales to be analyzed and their internal consistency reliability are presented in Table 5.8.

Table 5.6 The Internal Consistency Reliability for Perceived Task Value Items

Factor	USA	Japan
Perceived Task Value	.83	.74
Intrinsic Interest Value		.70
Importance/Attainment		.66

Note: Cronbach's Alpha

Table 5.7 Factor Loadings for the Perceived Task Difficulty Items

	Factor 1	
Item Number	USA	Japan
Item 4	.83	.82
Item 18	.84	.85
Item 39	.88	.88
Item 32	.80	.79
Item 27	.85	.61

Table 5.8 The Internal Consistency Reliability For Each Construct

Factor		USA	JAPAN
Sex-stereotyping			
1. Utility of math	(2)	.77	.99
2. math as male domain	(1)	---	---
3. math related occupation	(2)	.81	.51
Ability/expectation			
1. Ability/expectation	(5)	.89	.87
Perceived Task Value			
1. Perceived Task Value	(7)	.83	.74
Perceived Task Difficulty			
1. Perceived Task difficulty	(5)	.89	.86

Note: Cronbach's Alpha : Parentheses indicate the number of items for each variable.

5.2 Learning Patterns Questionnaire

The Learning Patterns Questionnaire, developed by Ito (1989), consists of 26 items and three main constructs: 1) learning patterns (12 items), 2) learning precision (7 items), and 3) study habits (7 items). Factor analysis was performed on the 26 items to investigate whether or not the samples from two nations have a similar factor structure.

5.2.1 Factor Analyses

At first, the factor structure of the all 26 items were analyzed for each sample. However, the Oblimin Rotation failed to converge for both Japanese and the American data. According to Ito (1989), the items were classified into three factors, learning patterns, learning precision, and study habits. Thus, a factor analysis was run specifying three factors. With the exception of few double loadings, for the most part, items were classified into three factors in both the Japanese and the American data. The factor loadings are shown in the Table 5.9.

Table 5.9 Factor Loadings of the Learning Patterns Variables

Item Number	Factor 1		Factor 2		Factor 3	
	USA	Japan	USA	Japan	USA	Japan
Item 1	-.79	.77				
Item 2		.73				
Item 3	-.74	.75				
Item 4	-.74	.67				
Item 5	-.43	.70			.43	
Item 6	-.45				.49	-.56
Item 7	-.73	.59				
Item 8		.50				
Item 9			.47	.46		
Item 10			.66	.60		
Item 11			.45	.54		
Item 12				.48		
Item 13			.62	.50		
Item 14					.72	-.51
Item 15					.70	-.48

continued

Item Number	Factor 1		Factor 2		Factor 3	
	USA	Japan	USA	Japan	USA	Japan
Item 16				.64	-.57	
Item 17						
Item 18			.63	.50		
Item 19			.48	.41		
Item 20					-.75	
Item 21			.49	.55		
Item 22						-.49
Item 23					.58	-.64
Item 24	-.42				.42	-.57
Item 25	-.46				.43	-.47
Item 26					.47	

Note: The factor loadings were the results of Oblimin Rotation.

5.2.2 Reliability

Internal consistency reliabilities were computed among the common items between Japan and the United States for each factor. There were 5 items in factor 1, 7 items in factor 2, and 5 items in factor 3. The results are shown in Table 5.9. These three scales did not necessarily reflect the three scales developed by Ito (1989). Thus, each scale was renamed: Scale 1 as "study regularity", Scale 2 as "study independence /task preference", and Scale 3 as "study habits". The results are shown in Table 5.10.

Table 5.10 The Internal Consistency Reliabilities For Learning Patterns

Factor	USA		Japan
Factor 1:Study Regularity	(5)	.64	.63
Factor 2:Study Independence	(7)	.66	.59
Factor 3:Study Habits	(5)	.78	.78

Note: Cronbach's Alpha

5.3 Summary

In preliminary analyses, common items and the common factors between the Japanese data and the data from the United States were identified through factor analyses; internal consistency reliabilities were computed for scales based on each factor. Three variables measuring a student's attitude toward mathematics (ability/expectancy beliefs, perceived task value, perceived task difficulty)(Appendix I), three variables measuring sex-stereotyped beliefs (beliefs about math as a male domain, beliefs about utility of math, beliefs about math related occupations)(Appendix J), and three variables measuring learning patterns in mathematics (study regularity, study independence, study habits)(Appendix H), were identified. In the next sections, these variables are examined according to the students' nationality and their sex.

Chapter 6

STUDY2 RESULTS :

MAIN ANALYSES

In the previous sections, 12 variables were identified through protocol analysis or factor analyses. Effects of nationality and gender on these variables were examined through anlyses of variances and the relationships between variables were examined through pearson's correlational analyses. There are two sections in this chapter, the results of analyses of variances and the results of correlational analyses.

6.1 Results of Analyses of Variance by Gender

This section presents the results of analyses of variance and follow up analyses on three sets of variables (attitude toward mathematics, learning patterns, and performance factors), and is divided into four subsections. In the first subsection, I examine gender differences regarding three aspects of sex-stereotyped beliefs about math. In the second, I examine gender differences in three aspects of attitude toward math (besides the sex-stereotyped attitudes). In the third, I examine gender differences in three aspects of learning patterns. In the fourth, I examine gender differences in three aspects of the performance factor. Hence there are four major subsections, each of which is divided into three subsections. Each analysis was organized around the hypotheses which guided this study.

6.1.1 Results of ANOVAs for Sex-Stereotyping Variables

There are three constructs that measure students' beliefs about sex-stereotyping in mathematics: (1) beliefs about math as a male domain, (2) beliefs about the utility of mathematics for men and for women, and (3) beliefs about mathematics-related occupations. The results of the ANOVA for each dependent variable are presented in three separate tables, 6.1 to 6.3.

6.1.1.1 Beliefs about Math as Male Domain

Hypothesis 1.1: Males will have more stereotyped beliefs about math as a male domain than females.

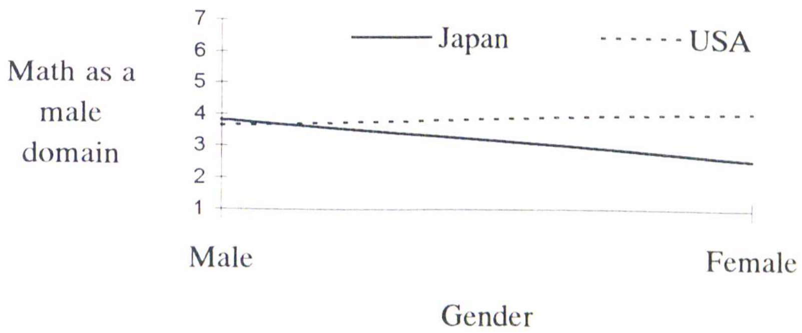
The results of the 2 (sex) x 2 (nation) ANOVA for the first dependent variable, beliefs about math as a male domain, are shown in Table 6.1. In this scale, a lower score indicates stronger stereotyped beliefs about math as a male domain (1=boys are better than girls in math, 4=boys and girls are the same in math, and 7=girls are better than boys in math).

There were significant main effects of sex and nation, and as well as a significant sex by nation interaction effect. Females (m=3.27) held stronger sex-stereotyped beliefs about math as a male domain than males (m=3.75),

Table 6.1 Results of ANOVA on Beliefs about Math as a Male Domain

Source of Variation	Sum of Squares	DF	Mean Square	F	P Value
Main Effects	73.48	2	36.74	29.72	.0001
Sex	25.89	1	25.89	20.95	.0001
Nation	52.36	1	52.36	42.36	.0001
2-Way Interactions	63.56	1	63.56	51.42	.0001
Explained	137.04	3	45.68	36.95	.0001
Residual	453.66	367	1.24		
Total	590.69	370	1.59		

Figure 6.1 Sex-Stereotyped Beliefs about Math as a Male Domain



$F(1,367)=20.95$, $p<.0001$. The Japanese students (m=3.17) held stronger sex-stereotyped beliefs about math as a male domain than the American students (m=3.89), $F(1,367)=42.36$, $p< .0001$. To follow up the interaction, the results of separate univariate analyses within nation were done. They revealed that in the United States, male students held stronger stereotyped beliefs than female students about math as a male domain ($F(1,162)=8.15$, $p<.005$). However, for the Japanese sample, female students held stronger stereotyped beliefs than male students about math as a male domain ($F(1,205)=53.73$, $p<.0001$). Thus, the hypothesis was supported only for the American sample. The mean score for the beliefs about math as a male domain was 3.82 (SD=1.31) for Japanese males, 2.56 (SD=1.17) for Japanese females, 3.64 (SD=1.19) for American males, and 4.06 (SD= .69) for American females. Among the four groups, Japanese females held the strongest stereotyped beliefs about math as a male domain and the American females held the most egalitarian view. Male students in both nations held similar beliefs about math as male domain.

6.1.1.2 Beliefs about the Utility of Math for Men and for Women

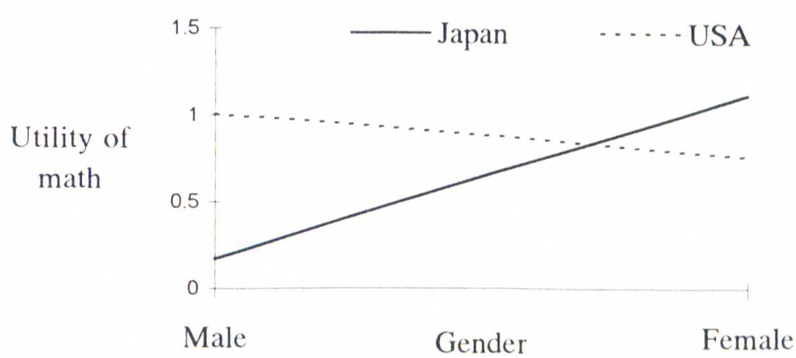
Hypothesis 1.2: Males will have stronger stereotyped beliefs about utility of math than females.

The results of the 2 (sex) x 2 (nation) ANOVA for the second dependent

Table 6.2 Results Of ANOVA For Beliefs About Utility Of Math

Source of Variation	Sum of Square	DF	Mean Square	F	P Value
Main Effects	20.100	2	10.05	5.84	.003
Sex	16.32	1	16.32	9.48	.002
Nation	2.75	1	2.75	1.60	.207
2-way Interaction	31.19	1	31.19	18.13	.0001
Explained	51.29	3	17.10	9.94	.0001
Residual	631.40	367	1.72		
Total	682.69	370	1.85		

Figure 6.2 Sex-stereotyped Beliefs about Utility of Math for Men and for Women



variable, utility of math for men and for women, are shown in Table 6.2. The score for this scale was computed by subtracting the score on beliefs about utility of math for women from the score on beliefs about utility of math for men. Thus, a bigger positive score indicates a stronger sex-stereotype favoring males in utility of math. Only the main effect of sex ($F(1,367)=9.48$, $p<.002$) and interaction effect ($F(1,367)=18.13$, $p<.0001$) were significant, but not the main effect of nation, $F(1,367)=1.60$, $p<.207$. Females (m=.86) held stronger sex-stereotyped beliefs about the utility of math than males (m=.66). The result of separate univariate tests within nation revealed that there was a significant gender difference in beliefs about the utility of math for the Japanese students ($F(1,205)=28.95$, $p<.0001$), but not for the American students ($F(1,162)=1.23$, $p< .27$). But, since it was the female students who held stronger stereotyped beliefs that math is more useful for men than for women in Japan, together these results show that Hypothesis 1.2 was not supported.

The mean score for this scale was .17 (SD=1.13) for Japanese males, 1.11 (SD=1.35) for Japanese females, 1.01 (SD=1.44) for American males, and .76 (SD=1.35) for American females. Among the four groups, The Japanese males held the most egalitarian view and the Japanese females and the American males held similar but strong sex-stereotyped beliefs that math is more useful for men than it was for women.

6.1.1.3 Beliefs about Math-Related Occupations

Hypothesis 1.3: Males will have stronger stereotyped beliefs than females that math-related occupations are more appropriate for males.

For this scale, students were asked to mark their degree of agreement with the given statements such as "men are better at being engineers and scientists than women" with 1 being strongly disagree and 7 being strongly agree.

The results of the 2(sex) x 2(nation) ANOVA for the third dependent variable, beliefs about math-related occupations, are shown in Table 6.3. There were significant main effects of sex ($F(1,367)=22.5$, $p< .0001$) and nation ($F(1,367)=115.1$, $p< .0001$) as well as a significant sex by nation interaction ($F(1,367)=40.1$, $p< .0001$). Hypothesis 1.3 was partially supported, but only for the American sample. Males ($m=3.77$) held stronger stereotyped beliefs about math-related occupations than females ($m=3.04$). Japanese students ($m=4.01$) held stronger stereotyped beliefs than U.S. students ($m=2.55$).

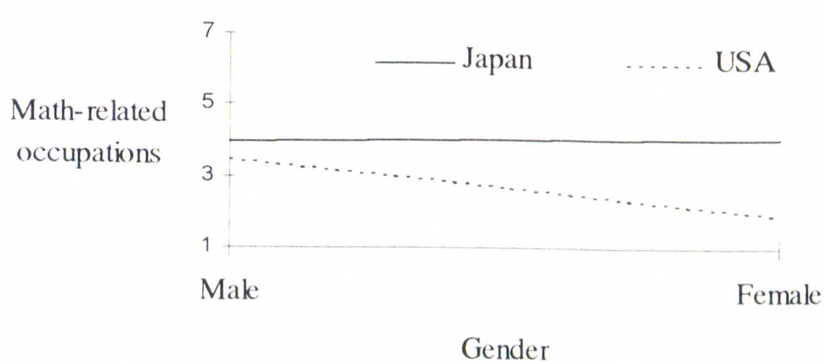
Separate univariate tests within nation revealed that whereas for the American sample the gender difference in stereotyped beliefs about math-related occupations was significant, $F(1,162)=47.97$, $p<.0001$, for the Japanese sample, it was not, $F(1,205)= .48$, $p< .49$.

The mean score for this scale was 3.95 ($SD=1.05$) for the Japanese males, 4.06 ($SD=1.15$) for the Japanese females, 3.49 ($SD=1.74$) for the American males, and 1.91 ($SD=1.17$) for the American females. Among the four groups, the

Table 6.3 Results Of ANOVA For Beliefs About Math-Related Occupations

Source of Variation	Sum of Square	DF	Mean Square	F	P Value
Main Effects	229.09	2	114.54	72.68	.0001
Sex	35.43	1	35.43	22.48	.0001
Nation	181.38	1	181.38	115.09	.0001
2-way Interaction	63.17	1	63.17	40.08	.0001
Explained	292.25	3	97.42	61.81	.0001
Residual	578.39	367	1.58		
Total	870.65	370	2.35		

Figure 6.3 Beliefs About Math-Related Occupations



American females held the most egalitarian view about math-related occupations and both Japanese male and female students held strong stereotypes.

6.1.1.4 Summary

Based on the ANOVAs for the sex-stereotyping factor, four cross-cultural gender differences in sex-stereotyped beliefs about mathematics become apparent:

(1) Japanese females had the strongest sex-stereotyped beliefs regarding mathematics among the four groups.

(2) American females held the most egalitarian view (on two variables out of three) regarding mathematics.

(3) Within the American sample, males held more sex-stereotyped beliefs about math than females.

(4) Within the Japanese sample, females held more sex-stereotyped beliefs about math than males.

6.1.2 Results of ANOVAs for Attitude Toward Mathematics Variables

There are three constructs related to students' attitudes toward mathematics: (1) ability/expectancy beliefs, (2) perceived task value, and (3) perceived task difficulty. The results of the ANOVA for each dependent variable are presented in three separate tables, 6.4 to 6.6.

6.1.2.1 Perception of Ability/Expectancy

Hypothesis 1.4: Males will have higher confidence in their own math ability than females.

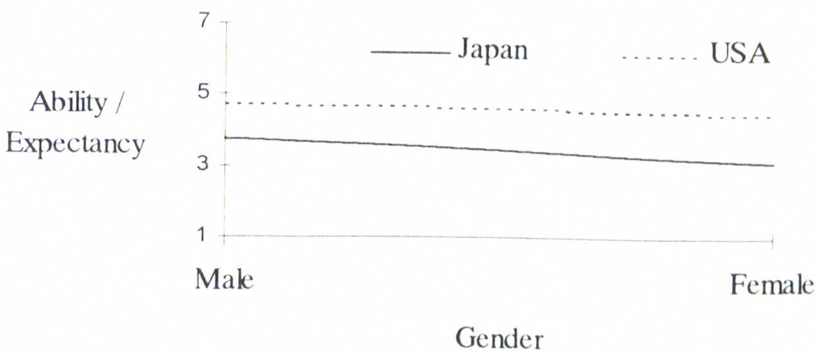
The results of the 2 (sex) x 2 (nation) ANOVA for the first dependent variable, ability/expectancy beliefs, are shown in Table 6.4. For this scale, students were asked to rate their perception of own ability or expectancy, for example; compared to other students in your class, how well do you expect to do in mathematics this year? (1=much worse than other students and 7=much better than other students).

There were significant main effects, for both sex and nation. Males (m=4.17) had higher confidence in their own math ability than females (m=3.78), $F(1,367)=13.94$, $p< .0001$. The U.S. students (m=4.16) had higher confidence in their own math ability than the Japanese students (m=4.30). There was no significant sex by nation interaction, $F(1,367)=2.72$, $p<.10$. The results of separate univariate analyses within nation revealed that Hypothesis 1.3 was supported only for the Japanese sample. Whereas Japanese males had higher confidence in their own math ability than Japanese females, $F(1,205)=14.99$, $p<.0001$, American males and females did not differ in perception of their own math ability, $F(1,162)=1.51$, $p< .221$. The significant main effect of nation indicates that the American students have significantly higher confidence than the Japanese students in their own math ability, $F(1,367) =15.60$, $p< .0001$.

Table 6.4 Results Of ANOVA For Perception Of Ability/Expectancy

Source of Variation	sum of Square	DF	Mean Square	F	P Value
Main Effects	149.45	2	74.72	51.11	.0001
Sex	20.39	1	20.39	13.94	.0001
Nation	135.66	1	135.66	92.78	.0001
2-Way Interaction	3.97	1	3.97	2.72	.10
Explained	153.42	3	51.14	34.98	.001
Residual	563.61	367	1.46		
Total	690.03	370	1.87		

Figure 6.4 Perception Of Own Math Ability/Expectancy



The mean score for this scale was 3.77 (SD=1.31) for the Japanese males, 3.12 (SD=1.12) for the Japanese females, 4.76 (SD=1.24) for the American males, and 4.52 (SD=1.18) for the American females.

6.1.2.2 Perception of Task Value/Importance

Hypotheses 1.5: Males will tend to value mathematics more than females.

The results of the 2 (sex) x 2 (nation) ANOVA for the second dependent variable, perception of task value/importance, are shown in Table 6.5. An example of a question for this scale is; I feel that, to me, being good at solving problems which involves math or reasoning mathematically is....(1=not at all important and 7=very important). The mean score for this scale was 4.24 (SD=.91) for the Japanese males, 4.08 (SD= .96) for the Japanese females, 4.30 (SD=1.17) for the American males, and 4.25 (SD=1.04) for the American females. None of the effects were significant, and so Hypothesis 1.5 was not supported.

6.1.2.3 Perceived Task Difficulty

Hypothesis 1.6 : Females will feel that mathematics is more difficult than males feel it is.

The results of the 2 (sex) x 2 (nation) ANOVA for the third dependent variable,

Table 6.5 Results Of ANOVA For Perception Of Task Value/Importance

Source of Variation	Sum of Square	DF	Mean Square	F	P Value
Main Effects	3.85	2	1.93	1.89	.15
Sex	1.98	1	1.98	1.94	.17
Nation	2.14	1	2.14	2.10	.15
2-Way Interaction	.03	1	.03	.03	.86
Explained	3.88	3	1.29	1.27	.29
Residual	374.69	367	1.02		
Total	378.57	370	1.02		

Figure 6.5 Perception Of Task Value/Importance

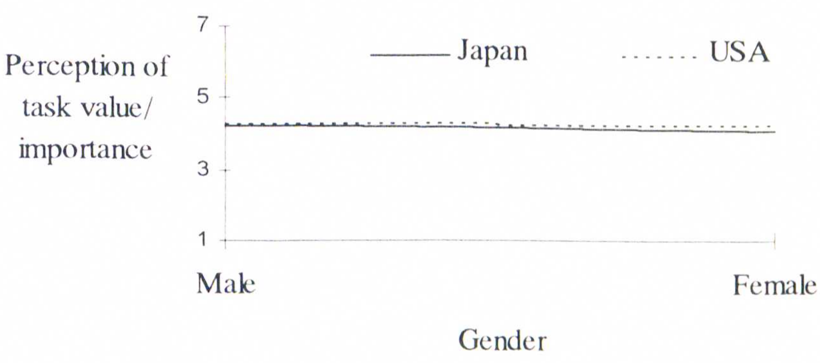
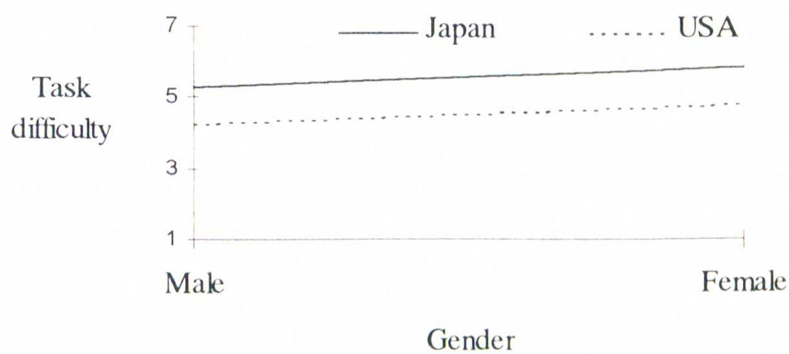


Table 6.6 Results Of ANOVA For Task Difficulty

Source of Variation	Sum of Square	DF	Mean Square	F	P Value
Main Effects	124.99	2	62.49	47.25	.0001
Sex	28.80	1	28.80	21.77	.0001
Nation	103.17	1	103.17	78.00	.0001
2-Way Interactions	.001	1	.001	.001	.976
Explained	124.99	3	41.66	31.50	.0001
Residual	485.42	367	1.32		
Total	610.41	370	1.65		

Figure 6.6 Task Difficulty



perceived task difficulty, are shown in Table 6.6. Sample question for this scale is: "Compared to most others in your class, how hard is math for you?" (1=much easier and 7= much harder).

Both the main effects for sex and nation were significant. Hence Hypothesis 1.6 was supported. Females (m=5.38) scored significantly higher than males (m=4.89) in their perception of the difficulty of mathematics, $F(1,367)=21.77$, $p<.0001$. The Japanese students (m=5.61) also perceived mathematics to be more difficult than the American students (m=4.59), $F(1,367)=78.00$, $p<.0001$.

The results of separate univariate tests within nation revealed that there are significant gender differences in perception of the difficulty of mathematics both among the Japanese sample ($F(1,205)=18.40$, $p<.0001$) and among the United States sample ($F(1,162)=6.46$, $p<.012$).

The mean scores for this scale were 5.31 (SD=1.14) for the Japanese males, 5.87 (SD= .87) for the Japanese females, 4.25 (SD=1.28) for the American males, and 4.81 (SD=1.33) for the American females.

6.1.2.4 Summary

The following three points describe the characteristics of gender differences in attitudes toward mathematics based on the results of the ANOVAs.

(1) The Japanese male sample had a higher confidence in their own math ability than the Japanese female sample did. The American male and female sample did not

differ in their perception of own math ability.

(2)No gender differences in the perception of task value were found for either the Japanese sample or the United States sample.

(3) In both nations, the females perceived math to be more difficult than the males.

6.1.3 Results of ANOVAs for Learning Pattern Variables

In this section, there are three constructs related to students' learning patterns in mathematics: (a) study regularity, (b) study independence and task preference, and (c) study habits. The results of the ANOVA for each dependent variable are presented in three separate tables, 6.7 to 6.9.

6.1.3.1 Study Regularity

Hypothesis 1.7: Females will study mathematics more regularly than males.

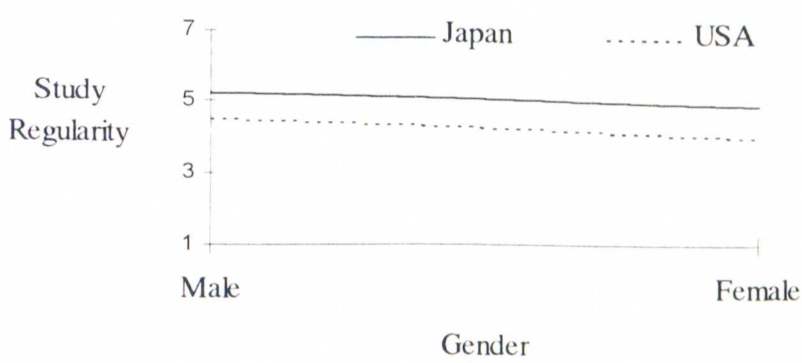
The results of the 2 (sex) x 2 (nation) ANOVA for the first dependent variable in this group, study regularity, are shown in Table 6.7. In this scale, students were asked to rate their perception of study regularity in mathematics (e.g., 1=I study math for regular hours every day and 7=I study math with no regularity).

Both the main effects of sex and nation were significant, but the sex x nation interaction was not significant, $F(1,367)=.47$, $p< .50$. Females ($m=4.51$) reported that they studied math with more regularity than males ($m=4.95$) did,

Table 6.7 Results Of ANOVA For Study Regularity

Source of Variation	Sum of Square	DF	Mean Square	F	P Value
Main Effects	73.91	2	36.96	23.62	.0001
Sex	13.72	1	13.73	8.77	.003
Nation	55.98	1	55.98	35.77	.0001
2-Way Interaction	.73	1	.73	.47	.496
Explained	74.65	3	24.88	15.90	.0001
Residual	574.33	367	1.57		
Total	648.98	370	1.75		

Figure 6.7 Study Regularity



$F(1,367)=8.77$, $p< .003$. The American sample's rating (m=4.25) of their study regularity in mathematics was higher than that of the Japanese sample (m=5.06), $F(1,367)=35.77$, $p< .0001$. The results of separate univariate analysis within nation revealed that the gender difference in study regularity among the Japanese students did not reach significance, $F(1,205)=3.70$, $p< .06$). Among the American students, the gender difference in study regularity was significant, with females reporting they studied math with more regularity than males, $F(1,162)=5.13$, $p< .03$.

The mean score was 5.23 (SD=1.19)for Japanese males, 4.92 (SD=1.12) for Japanese females, 4.54 (SD=1.40) for the American males, and 4.05 (SD=1.33) for the American females. Among the four groups, the Japanese males reported studying math with the least regularity.

6.1.3.2 Study Independence/Task Preference

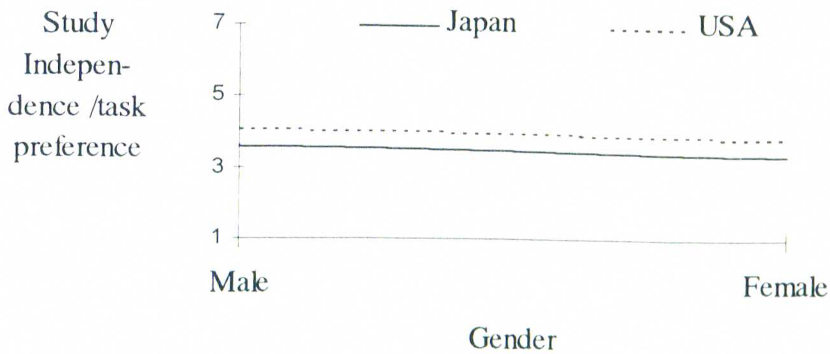
Hypothesis 1.8: Males will study more independently and prefer working at more advanced problems than females.

The results of the 2 (sex) x 2 (nation) ANOVA for the next dependent variable, study independence, are shown in Table 6.8. For this scale, students were asked to rate their study preference. An example of such question is to rate on a 1 to 7 scale, where 1="when I can't solve a problem, I rely on someone to help me" and

Table 6.8 Results Of ANOVA For Study Independence/Task Preference

Source of Variation	Sum of Square	DF	Mean Square	F	P Value
Main Effects	28.63	2	14.32	15.52	.0001
Sex	5.68	1	5.68	6.16	.014
Nation	24.45	1	24.45	26.50	.0001
2-Way Interaction	.04	1	.04	.045	.832
Explained	28.67	3	9.56	10.36	.0001
Residual	338.62	367	.92		
Total	367.29	370	.99		

Figure 6.8 Study Independence/Task Preference



7 ="Even when I have difficulty in solving a problem, I work at it myself."

Both main effects , sex and nation, were significant, but no interaction effect emerged, $F(1,367)=.05$, $p<.83$. Females (m=3.60) reported that they tend to rely on others more than males (m=3.81) do when they study mathematics, $F(1,367)=6.16$, $p<.014$. The Japanese students (m=3.47) also reported that they tend to rely on others and to prefer working on basic problems when they study mathematics, while the American students (m=3.98) reported that they tend to be independent and to prefer working on advanced problems, $F(1,367)=26.50$, $p<.0001$. The results of separate univariate tests within nation showed that the gender difference was significant only for the Japanese sample ($F(1,205)=4.43$, $p<.037$, for Japanese; $F(1,162)=1.95$, $p<.16$, for American).

The mean score was 3.61 (SD=.91) for the Japanese males, 3.35 (SD=.92) for the Japanese females, 4.11 (SD=.97) for the American males and 3.88 (SD=1.04) for the American females.

6.1.3.3 Study Habits

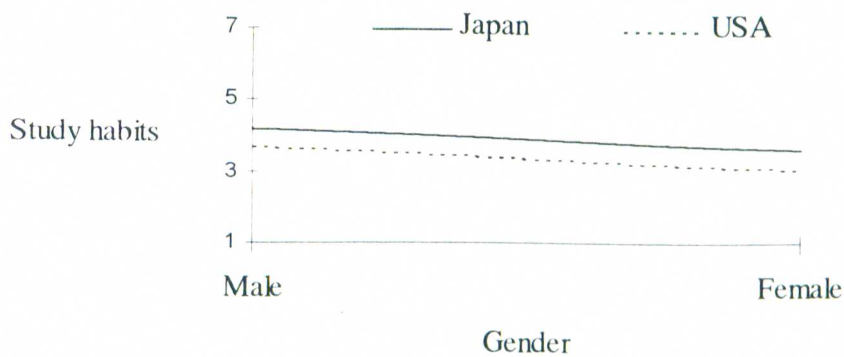
Hypothesis 1.9: Females will have more positive study habits than males.

The results of 2 (sex) x 2 (nation) ANOVA for the third dependent variable in this group, study habits, are shown in Table 6.9. For example, students described their behavior on the following scale; 1="I write down answers as well as with my

Table 6.9 Results Of ANOVA For Study Habits

Source of Variation	Sum of Square	DF	Mean Square	F	P Value
Main Effects	63.27	2	31.64	30.63	.0001
Sex	31.48	1	31.48	30.48	.0001
Nation	27.39	1	27.39	26.52	.0001
2-Way Interaction	.09	1	.092	.09	.765
Explained	63.36	3	21.12	20.45	.0001
Residual	379.08	367	1.03		
Total	442.45	370	1.20		

Figure 6.9 Study Habits



calculation process" and 7="I write down answers only in my notes." For this study, having a lower score indicates "positive study habits" and having higher score indicates "less positive study habits".

There were significant main effects but no significant interaction, $F(1,367) = .09$, $p < .77$. Females (m=4.51) reported having more positive study habits than males (m=4.95) did, $F(1,367)=8.77$, $p < .003$. The students in the United States sample (m=4.25) reported having more positive study habits than the Japanese students (m=5.06) did, $F(1,367)=35.77$, $p<.0001$. The results of separate univariate tests within nation indicates that gender differences in study habits were significant in both nations, $F(1,205)=17.83$, $p < .0001$, for the Japanese sample, $F(1,162)=12.92$, $p < .0004$, for the American sample. The mean score was 4.20 (SD=.91) for the Japanese males, 3.64 (SD=.99) for the Japanese females, 3.69 (SD=1.17) for the American males, and 3.07 (SD=1.04) for the American females.

6.1.3.4 Summary of the Results of ANOVAs on the Learning Variables

There are three major findings from the ANOVA on the learning variables:

(1) Regardless of the nationality of the students, males tend to study math with less regularity than females do.

(2) Among the Japanese sample, females tend to rely on others more than males do when they study math. Among the sample in the United States, no gender differences in study independence were found.

(3) Regardless of the nationality of the sample, females tend to have more positive study habits than males do.

6.1.4 Results of ANOVAs for Performance Variables

There are three performance variables: (a) the total score of 5 math items, (b) the average score of the efficiency in solution strategy, and (c) the average score of the seriousness of cause of mistake. Three 2 (sex) x 2 (nation) ANOVAs for each dependent variable were performed. The results of ANOVAs for each dependent variable are presented in three tables, 6.10 to 6.12.

6.1.4.1 Total Score of 5 Math Items:

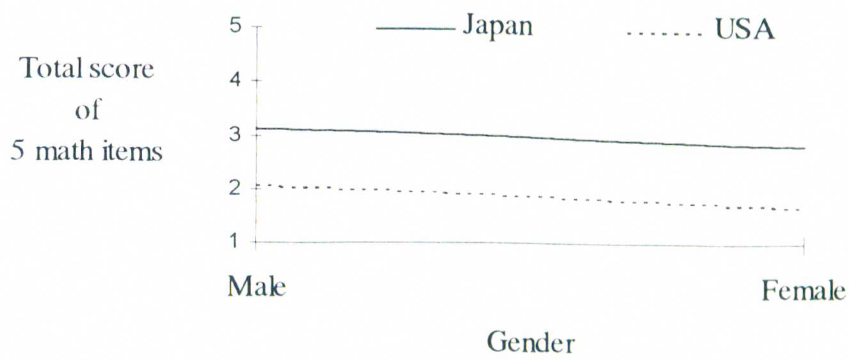
Hypothesis 1.10: Males will outperform females in the total score of 5 math items.

The results of the 2 (sex) x 2 (nation) ANOVA are shown in Table 6.10. There were significant main effects of sex and nation, but a sex x nation interaction was not significant, $F(1,367)=.11$, $p< .74$. Males ($m=2.69$) outperformed females ($m=2.29$) in the total score of 5 math items, $F(1,367)=6.91$, $P< .009$. The Japanese students ($m=2.97$) performed better than the American students ($m=1.84$), $F(1,367)=80.94$, $p< .0001$. The results of separate univariate analyses within nation revealed that the gender difference in total score of 5 math items was significant only among the American students, $F(1,162)=4.08$, $p< .05$, but not

Table 6.10 Results Of ANOVA For The Total Score Of 5 Math Items

Source of Variation	Sum of Squares	DF	Mean Square	F	P Value
Main Effects	126.27	2	63.14	45.79	.0001
Sex	9.53	1	9.53	6.91	.009
Nation	111.60	1	111.60	80.94	.0001
2-Way Interactions	.15	1	.15	.11	.744
Explained	126.43	3	42.14	30.56	.0001
Residual	506.03	367	1.38		
Total	632.45	370	1.71		

Figure 6.10 Total Score Of 5 Math Items



among the Japanese students, $F(1,205)=3.01$, $p<.08$.

The mean score of the total score of 5 math items was 3.12 (SD=1.21) for the Japanese male students, 2.83 (SD=1.18) for the Japanese female students, 2.06 (SD=1.21) for the American male students, and the 1.69 (SD=1.11) for the American female students.

6.1.4.2 Efficiency of Solution Strategy

Hypothesis 1.11: Males will use more efficient solution strategies than females when they solve the 5 math problems.

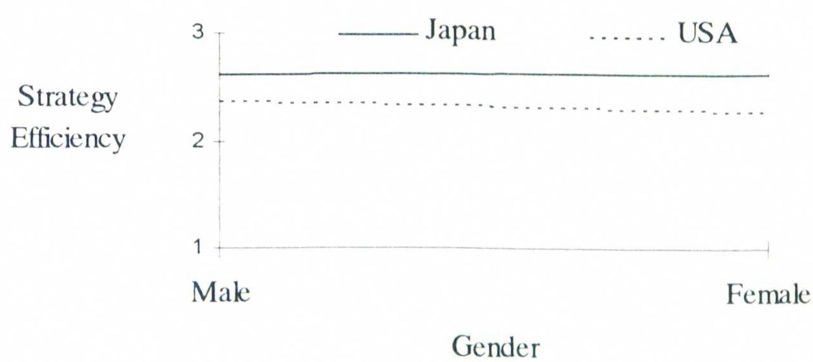
The results of a 2 (sex) x 2 (nation) ANOVA are shown in Table 6.11. The average score of efficiency in strategy was computed by adding up all efficiency scores and dividing the total by the number of correct responses for each person. Thus, if a student answered three items correctly, the efficiency scores for those three items were added up and divided by three. If a student had no correct item, the student was not included in the analysis. The range of the average score of strategy efficiency is 1 (when a student used the least efficient strategies for each item he/she got correct) to 3 (when a student used the most efficient strategies for each item he/she got correct).

Only the main effect of nation was significant, $F(1,349)=32.92$, $p< .0001$. Thus, the hypothesis 1.11 was not supported. The mean score for the strategy efficiency for American students was 2.32 and the Japanese students was 2.52. The

Table 6.11 Results Of ANOVA For The Strategy Efficiency

Source of Variation	Sum of Square	DF	Mean Square	F	P Value
Main Effects	6.19	2	3.10	11.97	.0001
Sex	.001	1	.001	.002	.96
Nation	6.18	1	6.18	23.90	.0001
2-way Interaction	.20	1	.20	.78	.377
Explained	6.40	3	2.13	8.24	.0001
Residual	80.99	313	.26		
Total	87.39	316	.28		

Figure 6.11 Strategy Efficiency



mean of the strategy efficiency score was 2.61 (SD=.43) for the Japanese males, 2.64 (SD=.33) for the Japanese females, 2.37 (SD=.66) for the American males, and 2.29 (SD=.58) for the American females.

6.1.4.3 Seriousness of Cause Of Mistake

Hypothesis 1.12: Females will make more serious mistakes than males.

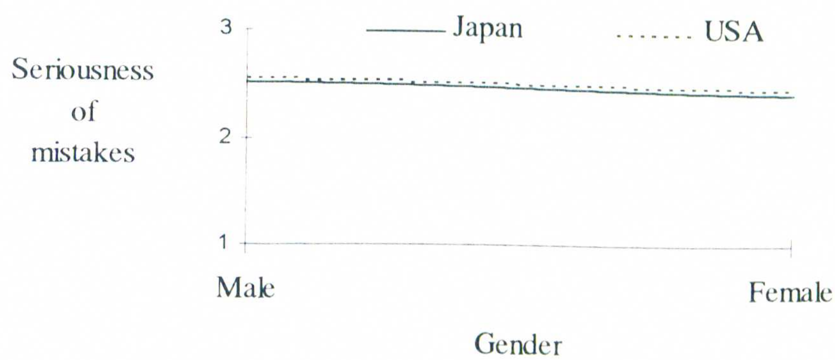
The results of the 2 (sex) x 2 (nation) ANOVA are shown in Table 6.12. The average score for seriousness of mistake was computed by adding up all the seriousness scores for the incorrect answers and divided this number by the number of incorrect answers. For example, if a student had two incorrect answers, the seriousness scores for these two items were added up and divided by two. Thus, students who answered at least one item incorrectly were included in this analysis. Higher scores (maximum of 3) indicate more serious mistakes.

The main effect of sex was significant but the nation effect and the interaction effect were not. However, Hypothesis 1.12 was not supported. Among the students who had at least one incorrect answer, males (m=2.54) made more serious mistakes than did the females (m=2.44), $F(1,330)=4.25$, $p< .04$. However, the results of separate univariate analyses within nation showed no significant gender difference either in the Japanese sample ($F(1,177)=2.32$, $p< .13$) or in the American sample ($F(1,155)=1.93$, $p<.17$)(see Chapter 3 for the

Table 6.12 Results Of ANOVA For Seriousness Of Cause Of Mistake

Source of Variation	Sum of Square	DF	Mean Square	F	P Value
Mail Effects	1.11	2	.55	2.49	.085
Sex	1.06	1	1.06	4.77	.030
Nation	.07	1	.07	.30	.582
2-way Interactions	.03	1	.03	.15	.701
Explained	1.14	3	.38	1.71	.165
Residual	69.55	313	.22		
Total	90.69	316	.22		

Figure 6.12 Seriousness of Mistakes



definition of and the example of serious and less serious mistakes). Apparently, the increased N of the overall gender effect (disregarding nation) was the reason why the overall effect was significant while the gender effect with each nation was not.

The mean for the average score of seriousness of cause of mistake was 2.52 (SD=.46) for the Japanese males, 2.42 (SD=.49) for the Japanese females, 2.56 (SD=.43) for the American males, and 2.46 (SD=.47) for the American females.

6.1.4.4 Summary of ANOVAs for Performance Variables

Based on the results of three ANOVAs for the three performance variables (total score of 5 math items, average score for strategy efficiency, and average score for seriousness of mistake), the following three points emerged.

(1) For the total score of 5 math items, a gender difference emerged only among the American sample (favoring males).

(2) Regardless of nation, among the students who had at least one correct answer, there was no gender difference in strategy efficiency.

(3) Regardless of nation, among the students who had at least one wrong answer, males tended to make more serious mistakes than females.

In the next section, the results of the ANOVAs (sex-stereotyping, attitude, learning and performance variables) are summarized.

6.1.5 Summary of ANOVAs

The results of effect sizes for each variable in the four factors, sex-stereotyping, attitude, learning, and performance factors, are described in Table 6.13. In this paper, "small" effect sizes are those smaller than .3, "moderate" effect sizes are in the range of .30 to .69, and "large" effect sizes are those larger than .70. Based on the table 6.13, the summary of the effect sizes of gender differences in each area are as follows:

Gender Differences in Sex-stereotyping Variables

(1) The direction of the gender differences were opposite for the Japanese sample and for the American sample. Among the American sample, females hold more egalitarian views toward mathematics than males. In contrast, in the Japanese sample, it is the females who hold stronger sex-stereotyping in mathematics than males.

(2) Across the three variables in the sex-stereotyping factor, the largest effect size in the Japanese sample was for beliefs about math as a male domain (females held stronger stereotyped beliefs than males), whereas in the American sample,the largest effect size was for beliefs about math-related occupations (males held stronger stereotyped beliefs than females).

Gender Differences in Attitude Variables

(1)A moderate effect size (male > females) was found in perception of ability only

Table 6.13 Effect Sizes for the Japanese and American Samples

Factor	Variables	Japan	USA
Sex -Stereotyping	Male domain	-1.08 *** (F>M)	.61 ** (M>F)
	Utility	- .70 *** (F>M)	.18
	Occupation	.092	1.35 *** (M>F)
Attitude	Ability	.58 *** (M>F)	.20
	Task value	.17	.12
	Task difficulty	-.64 *** (F>M)	-.43 ** (F>M)
Learning	Regularity	-.28	-.37 ** (F>M)
	Independence	.29 * (M>F)	.22
	Habits	-.57 *** (F>M)	-.60 * (F>M)
Performance	Total of 5	.25	.33 * (M>F)
	Efficiency	- .09	.13
	Seriousness	.22	.22

Note: Effect Size = $\frac{\text{(Males' mean score - Females' mean score)}}{\text{SD for females}}$

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

for the Japanese sample.

(2) The effect sizes in the perception of the task difficulty are moderate (females > males) for both Japanese and the American samples.

Gender Differences in Learning Pattern Variables

(1) A moderate effect size (females > males) was found for the American sample in study regularity. (2) For both nations, moderate effect sizes were found in study habits (females have more positive study habits than males do).

Performance Variables

(1) The effect size (males > females) for the total score of 5 math items was bigger for the American sample than for the Japanese sample.

(2) Among the four groups of variables that were examined, the effect sizes of the performance variables were the smallest.

For the Japanese sample, moderate to large gender differences were found in the sex-stereotyping variables and the attitude variables. For the U.S. samples, gender differences were found in the sex-stereotyping variables and the learning pattern variables. In the next section, the results of the analyses which examine relationships among the variables for each sample are presented.

6.2 Results of Correlational Analyses

This section presents the results of the correlational analyses and is divided into two parts. The first part presents the tables for correlational analyses and the second part present the summary of the analyses.

The correlational analyses are organized into seven tables according to the variables analyzed. Tables 6.14 to 6.16 present the correlations between performance variables and (1) sex-stereotyping variables, (2) attitude variables, and (3) learning variables. Tables 6.17 to 6.19 present correlations between sex-stereotyping variables and (1) attitude variables and (2) learning variables. Then, Table 6.20 presents the correlations among attitude variables and learning variables. Each table includes correlations for four groups: the Japanese male students, the Japanese female students, the male students in the United States, and the female students in the United States. The second part of this section includes three summary tables 6.21 to 6.22 as well as a textual interpretation of these summary tables. The textual summary is organized according to the groups of subjects: (1) relations found in all groups, (2) relations found only for female subjects, (3) relations found only for male subjects, (4) relations found only Japanese subjects, (5) relations found only for the United States' subjects, (6) relations found only for the Japanese female subjects, (7) relations found only for the Japanese male subjects, (8) relations found only for the American female students, (9) relations found only for the American male students, and (10) other correlations.

Table 6.14 Correlation Between Total Score Of 5 Math Items And Other Variables

Variables	Total scores of 5 math items			
	JAPAN		USA	
	Male	Female	Male	Female
Math as male domain	-.01	-.01	.09	-.02
Utility of math	-.02	-.20 *	.30 *	-.01
Math related occupation	-.03	-.21 *	-.02	.02
Ability/Expectancy	.20 *	.20 *	.44 **	.22 *
Perceived task value	.23 *	.14	.35 **	.01
Task difficulty	-.22 *	-.21 *	-.37 **	-.28 **
Study Regularity	.12	-.03	.13	-.07
Study independence	.19	.06	.25 *	.02
Study habits	.02	-.06	-.19	.12

* $p < .05$,

** $p < .01$,

*** $p < .001$

Table 6.15 Correlations Between Strategy Efficiency And Other Variables

Variables	Average score for strategy efficiency: JAPAN Male	JAPAN Female	USA Male	USA Female
Math as a male domain	.09	.16	.16	-.04
Utility of math	-.06	-.11	.11	.02
Math related occupation	-.16	-.07	-.21	.06
Ability/Expectancy	.24 *	.21 *	.17	.20
Perceived task value	.23 *	.04	.35 ** .	37 ***
Task difficulty	-.08	-.26 **	-.04	-.09
Study regularity	-.01	.11	-.12	-.08
Study independence	-.12	-.02	.18	.24 *
Study habits	-.06	-.07	-.29 *	-.24 *

*$p < .05$,

** $p < .01$,

*** $p < .001$

Table 6.16 Correlations Between Seriousness Of Mistakes And Other Variables

	Average Score for Seriousness of Cause of Mistake			
	JAPAN		USA	
Variables	Male	Female	Male	Female
Math as a male domain	.33 **	.07	.12	-.07
Utility of math	-.20	-.01	-.15	-.17
Math related occupation	-.16	-.10	.15	.11
Ability/Expectancy	.07	-.05	-.22	-.18
Perceived task value	.16	-.14	-.23	-.27 **
Task difficulty	-.04	-.04	.40 ***	.14
Study regularity	-.06	.23 *	-.05	.04
Study independence	-.11	-.17	-.33 **	-.22 *
Study habits	-.12	.25	.17	.34 ***

*p < .05,

** p < .01,

*** p < .001

Table 6.17 Correlation Between Beliefs About Math As A Male Domain And Other Variables

	Score on beliefs about math as male domain			
	JAPAN		USA	
Variables	Male	Female	Male	Female
Ability/Expectancy	-.18	.06	.01	.12
Perceived task value	-.16	-.12	-.04	.07
Task difficulty	-.08	-.12	.23	-.08
Study regularity	.02	.23 *	-.04	.00
Study independence	-.16	-.12	.04	.14
Study habits	.07	.02	.04	.01

*p < .05,

** p < .01,

*** p < .001

Table 6.18 Correlation Between Score For Utility Of Math And Other Variables

	Score for utility of math for men and for women			
	JAPAN		USA	
Variables	Male	Female	Male	Female
Ability/Expectancy	.19	-.11	.13	.09
Perceived task value	.31 **	-.26 **	.16	-.02
Task difficulty	-.23 *	.12	-.09	-.06
Study regularity	-.15	-.05	.32 **	.01
Study independence	.28 **	-.00	.10	.01
Study habits	-.08	-.02	-.07	-.10

*p < .05,

** p < .01,

*** p < .001

Table 6.19 Correlations Between Beliefs About Math Related Occupation And Other Variables

	Score for beliefs about math related occupation			
	JAPAN		USA	
Variables	Male	Female	Male	Female
Ability/Expectancy	.20 *	.18	-.02	.09
Perceived task value	.08	-.05	-.08	.02
Task difficulty	-.15	-.11	-.07	-.06
Study Regularity	-.02	.11	.21	-.13
Study independence	.10	.06	-.07	.07
Study habits	-.11	-.06	.05	-.05

*$p < .05$,

** $p < .01$,

*** $p < .001$

Table 6.20 Correlations Between Learning Variables And Attitude Variables

Variables	JAPAN Male	JAPAN Female	USA Male	USA Female
	Score for study regularity			
Ability/Expectancy	-.26 **	.03	.29 *	-.13
Perceived task value	-.23 *	-.21 *	-.06	-.29 **
Task difficulty	.01	-.15	-.29 *	-.14
	Score of study independence			
Ability/Expectancy	.44 ***	.38 ***	.52 ***	.54 ***
Perceived task value	.38 ***	.47 ***	.40 ***	.52 ***
Task difficulty	-.25 *	-.25 **	-.49 ***	-.49 ***
	Score for study habits			
Ability/Expectancy	-.19	-.19 *	-.16	-.21 *
Perceived task value	-.25 *	-.29 **	-.47 ***	-.43 ***
Task difficulty	.22 *	.11	.02	-.02

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

6.2.1 Summary of Correlational Analyses

In this section, the correlations between variables from four different factors were examined separately for four groups: Japanese males, Japanese females, American males, and American females. Figures 6.13 to 6.16 shows all correlations found (a) for the Japanese males, (b) for the Japanese females, (c) for the American males, and (d) for the American females.

These results are organized in the following tables and summarized according to the groups of subjects. The results of correlations between (1) performance variables and sex-stereotyping variables, (2) performance variables and attitude variables, and (3) performance variables and learning variables are organized in Table 6.21. Table 6.22 presents the results of correlations between (1) the sex-stereotyping variables and the attitude variables and (2) the sex-stereotyping variables and the learning variables. Finally, Table 6.23 summarizes the results of the correlation between attitude variables and learning variables.

The significant correlations (at least $p < .05$) between variables for the particular sample are indicated in the tables by the name of subjects such as the Japanese male subjects (Jm), the Japanese female subjects (Jf), the American male subjects (USm), and the American female subjects (USf).

Figure 6.13 Correlations found for the Japanese Male Students

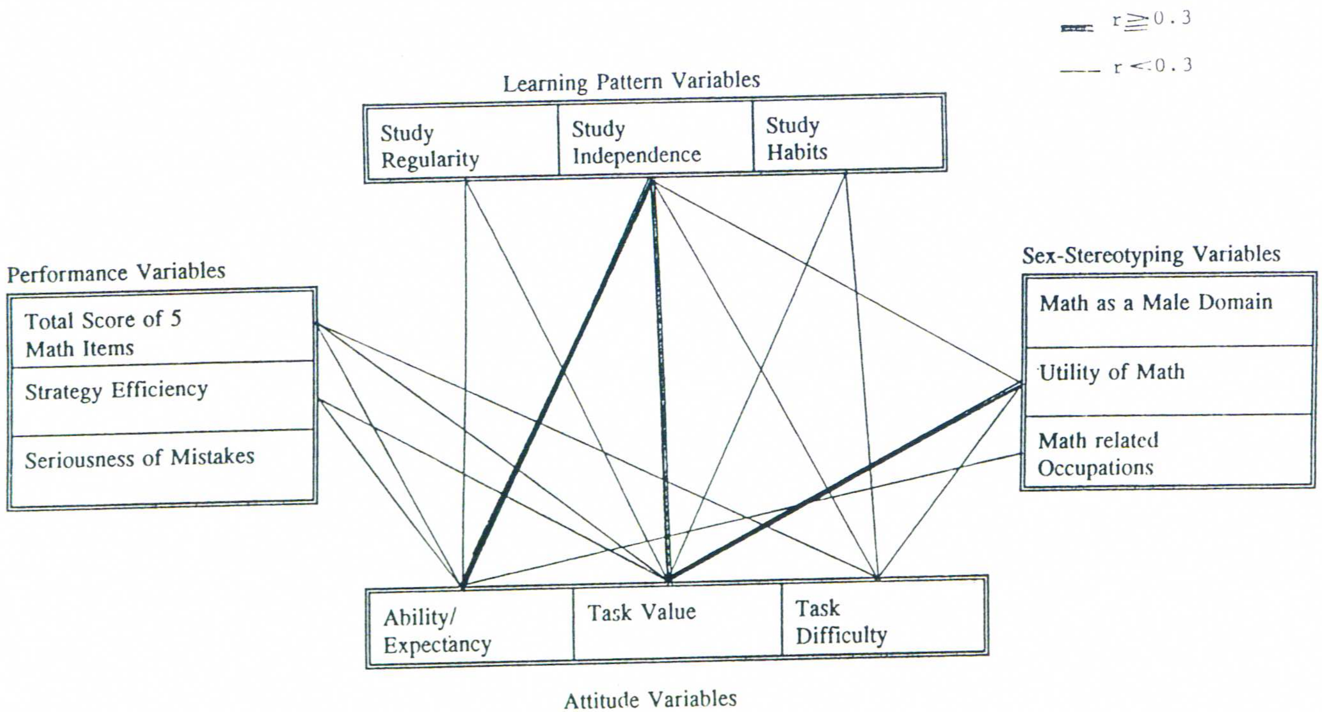


Figure 6.14 Correlations Found for the Japanese Female Students

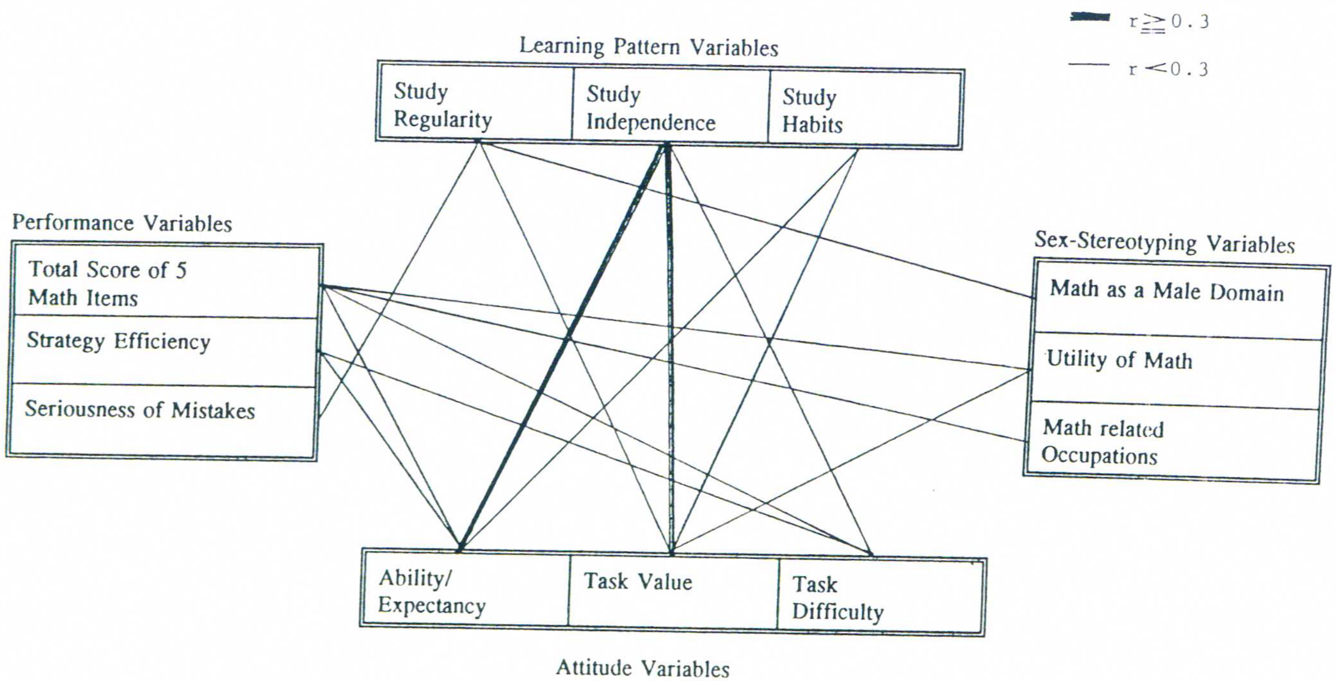


Figure 6.15 Correlations Found for the American Male Students

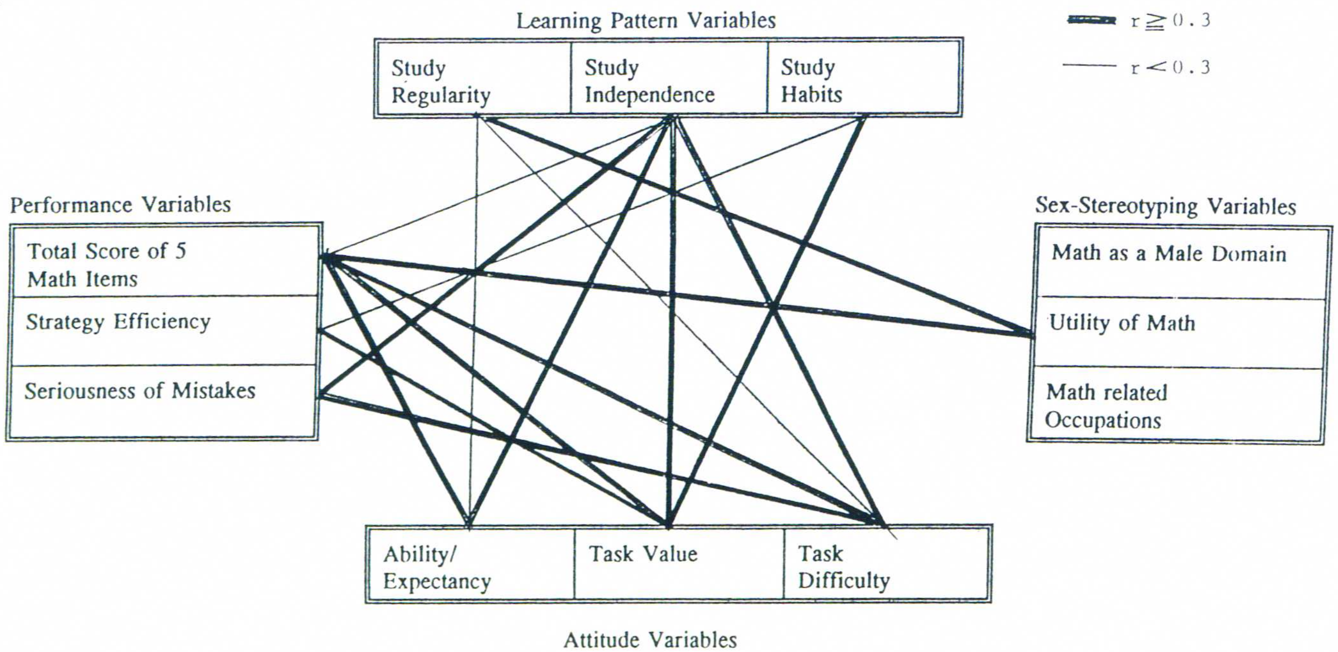


Figure 6.16 Correlations Found for the American Female Students

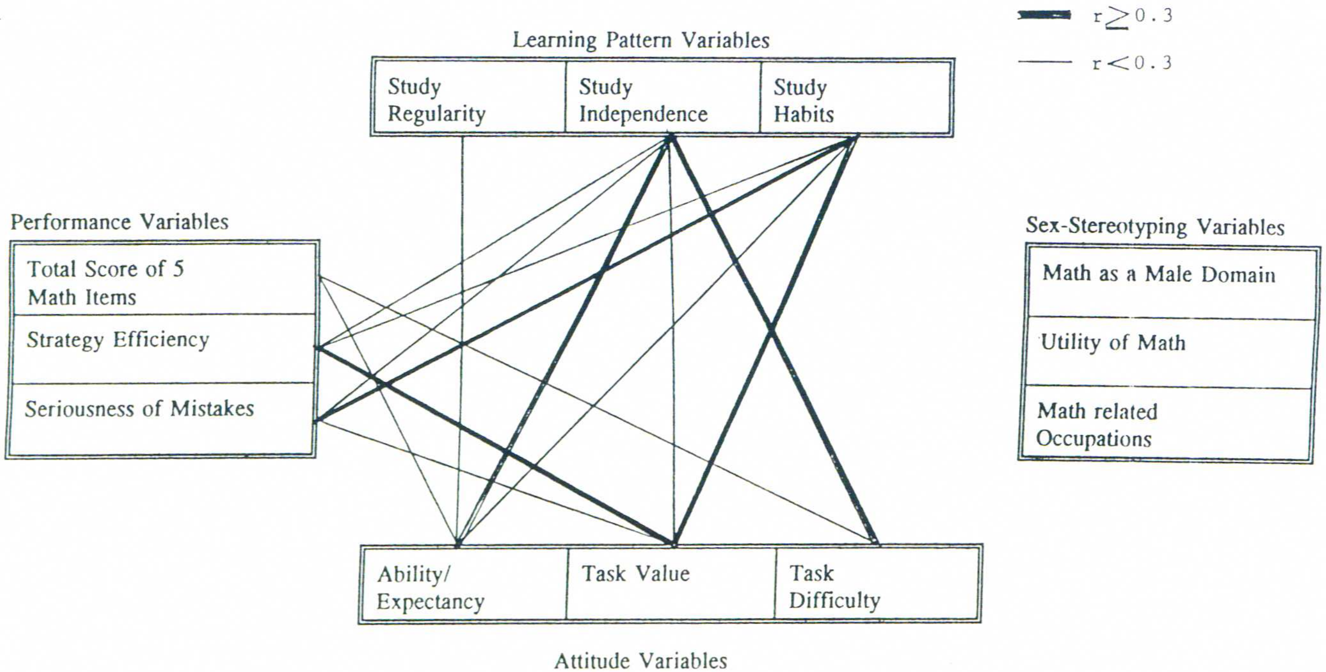


Table 6.21

Summary Of The Correlations Between Performance Variables And Other Variables

	Performance Variables		
	Total 5 items	Efficiency	Seriousness
Sex-Stereotyping Variables			
Male domain			Jm
Utility	Jf, USm		
Occupation	Jf		
Attitude Variables			
Ability	Jm,Jf,USm,USf	Jm,Jf	
Task V	Jm,USm	Jm,USm,USf	USf
Task D	Jm,Jf,USm,USf	Jf	USm
Leaning Variables			
Regularity			Jf
Independence	USm	USf	USm,USf
Habits		USm,USf	Jf,USf

Table 6.22 Summary of Correlations between Sex-stereotyping Variables and Attitude and Learning Variables

	Sex-Stereotyping Variables		
	Male domain	Utility	Occupation
Attitude Variables			
Ability			Jm
Task Value		Jm,-Jf	
Task Diff.		Jm	
Learning Variables			
Regularity	Jf	USm	
Independence		Jm	
Habits			

Table 6.23

Summary of Correlations between Attitude Variables and Learning Variables

	Learning Variables		
	Regularity	Independence	Habits
Ability	Jm,USm	Jm,Jf,USm,USf	Jf,USf
Task Value	Jm,Jf	Jm,Jf,USm,USf	Jm,Jf,USm,USf
Task Difficulty	USm	Jm,Jf,USm,USf	Jm

Relations Found For All Subjects

(1) Students who solved more of the 5 math problems tended to perceive themselves as having high math ability and considered math to be less difficult; students who solved fewer math problems tended to perceive themselves as having less math ability and viewed math as being more difficult;

(2) Students who perceived themselves as having more math ability and who valued math more tended to study independently; students who perceived themselves as having less math ability, valued math less, and studied math less independently;

(3) Students who rated math as being difficult tended to rely on others when they study; independent studiers rated math as being less difficult;

(4) Students who valued math more tended to have more positive study habits;

students who valued math less had less positive study habits.

Relations Found Only For Female Subjects

(1) Females who had less positive study habits tended to make more serious mistakes and rated their math ability lower; Females who had more positive study habits made less serious mistakes and rated their math ability higher.

Relations found only for male subjects

(1) Students who rated math as less difficult solved more of the 5 math problems; students who rated math as being difficult tended to solve fewer problems;

(2) For Japanese males, there was a positive correlation between ability ratings and study regularity (higher self-perceptions, more regularity); For American males, the opposite was found (high self-ratings of ability correlated with less regularity).

Relations Found Only For The U.S. Subjects

(1)Students who reported more positive study habits tended to use more efficient strategies; students who reported less positive study habits tended to use less efficient strategies;

(2) Students who studied independently tended to make less serious mistakes; students who rely on others when they study math tended to make more serious mistakes.

Relations Found Only For The Japanese Subjects

(1) Higher self-perceptions of math ability correlated with more efficient strategies;

(2) Higher valuing of math correlated with more regularity in studying math;

(3) For Japanese males, students who valued math more tended to believe that math was more useful for men than for women; males who valued math less tended to believe that math is useful both for men and for women; In contrast, Japanese females who valued math more tended to believe that math was useful both for men and for women; females who valued math less tended to believe that math was more useful for men than for women.

Relations Found Only For The Japanese Male Subjects

(1) Students who had more sex-stereotyped beliefs about the utility of math tended to (a) rate the value of math higher, (b) rate math to be easier, and (c) prefer studying independently;

(2) Students who had more sex-stereotyped beliefs about math as a male domain tended to make less serious mistakes;

(3) Students who had more sex-stereotyped beliefs about math related occupations tended to rate themselves higher in math ability;

(4) Students who perceived math to be easier tended to have more positive study habits.

Relations Found Only For The Japanese Female Subjects

(1) Students who solved more of the 5 math problems tended to have less sex-stereotyped beliefs about (a) utility of math and (b) math related occupations;

(2) Students who studied more regularly tended to (a) have less sex-stereotyped beliefs about math as a male domain, and (b) make less serious mistakes;

(3) Students who rated math to be easier tended to use more efficient strategies.

Relations Found Only For The U.S. Male Subjects

(1) Students who had stronger sex-stereotyped beliefs about utility of math tended to (a) solve more of the 5 math problems and (b) study math less regularly;

(2) Students who studied math less regularly tended to perceive math to be easier;

(3) Students who studied math more independently solved more of the 5 math problems;

(4) Students who rated math easier tended to make less serious mistakes.

Relations Found Only For The U.S. Female Students

(1) Students who placed a high value on math tended to make less serious mistakes;

(2) Students who studied math more independently tended to use more efficient strategies.

Other Correlations

(1) With the exceptions of the Japanese females, all subjects who rated math as more difficult tended to use less efficient strategies;

In the next chapter, these results are discussed in terms of (1) explanations for gender differences and non-differences, (2) explanations for the cultural differences, (3) limitations of the study, and (4) implications for future research.

Chapter 7

DISCUSSION

The purpose of this dissertation is to investigate gender differences in mathematics cross culturally, and to look at motivational, learning, and performance variables influencing the gender differences. To carry out this investigation, students from Japan and the United States were studied to see whether there are gender differences in their sex-stereotyped beliefs in math, attitudes toward mathematics, learning patterns, and problem solving strategies/causes of mistakes and whether there are relationships among these variables.

This chapter is organized into three sections: (1) discussion of the results, (2) limitations of the study, and (3) implications for future research.

7.1 Discussion of the Results

The present study examined four sets of variables: (a) sex-stereotyped beliefs about math, (b) other attitudes toward math, (c) learning patterns, and (d) performance. At issue were gender differences in the Japanese sample and the U.S. sample regarding these variables. Results pertaining to each set of variables are discussed next along with hypotheses in relation to these variables.

7.1.1 Gender Differences In Sex-Stereotyping Variables

There were three sex-stereotyping variables: sex-stereotyped beliefs about (1) math as a male domain, (2) utility of math for men and women, and (3) math-related occupations. The hypotheses related to these variables were as follows:

Hypothesis 1.1: Males will have more stereotyped beliefs about math as a male domain than females.

Hypothesis 1.2: Males will have stronger stereotyped beliefs about the utility of math than females.

Hypothesis 1.3: Males will have stronger stereotyped beliefs than females that math -related occupations are more appropriate for males.

Hypotheses 1.1, 1.2, and 1.3 were not supported for the Japanese sample. For the U.S. sample, only Hypotheses 1.1 and 1.3 were confirmed. It was rather unexpected that among the Japanese sample, females held stronger sex-stereotyped beliefs than males about math as a male domain and utility of math. Japanese males and females did not differ in their sex-stereotyped beliefs about math related occupations. This does not mean that Japanese males and females held less stereotyped beliefs about math related occupations. For this variable, Japanese males held as strong sex-stereotyped beliefs as Japanese females. A previous study (NIER,1982) with a nationally representative sample reported that 12th grade Japanese male students tend to hold more sex-stereotyped beliefs than females about math-related occupations. The reasons for the inconsistent results with the present study are not clear at this point. One possible reason might be a cohort effect. The study was carried out in 1980 as a part of the second international mathematics study. A fifteen-year time lag might have an influence on students' sex-stereotyped beliefs about math. Today's Japanese male or female students might hold less sex-stereotyped beliefs than the Japanese males or females held 15 years ago. There is no study available which directly examined gender differences in the other two sex-stereotyping variables in Japan.

It was expected that among the U.S. sample, males would hold stronger sex-stereotyped beliefs than females about math (Eccles, 1983). These gender differences in sex-stereotyped beliefs about math between Japan and the United States might be, in part, explained by cultural differences such as availability of role models in the society (Eccles, 1983) and parental beliefs about sex-stereotyping about math (Evans,1993). Almost 60 % of Japanese mothers compared to 25% of American mothers believe that math is more useful for males and only 38% of Japanese mothers compared to 73% of American mothers think that math is useful for both male and females. According to the report from the second International mathematics study conducted in 1980, almost half of the high school mathematics teachers in the United States were female teachers, whereas less than 10% of the high school mathematics teachers were females in Japan (NIER, 1992). Moreover, a significant correlation was found between the achievement levels of classes that teachers taught and the teacher's sex-stereotyped beliefs about math. High school teachers who taught classes with high math achievers tended to have stronger sex-stereotyped beliefs that men are better at being scientists and engineers than women than teachers who taught classes which contained low math achievers (NIER,1987). These cultural differences might influence the strong sex-stereotyped beliefs about math in Japanese male and female students.

7.1.2 Gender Differences In Attitudes Toward Math Variables

There are three attitude variables; (1) ability/expectancy beliefs, (2) perceived task value, (3) perceived task difficulty. The hypotheses relating to these variable were:

Hypothesis 1.4: Males will have higher confidence in their own math ability than females.

Hypothesis 1.5: Males will tend to value mathematics more than females.

Hypothesis 1.6: Females will feel that mathematics is more difficult than males feel it is.

For the Japanese sample, Hypotheses 1.4 and 1.6 were confirmed. For the U.S. sample, only Hypothesis 1.6 was supported. Japanese males had higher confidence in their own math ability and felt math was easier than females. Among the U.S. sample, males and females had a similar perception of their own math ability and value about math but females felt math was more difficult than males.

Many previous studies have reported significant gender differences in perceptions of math ability favoring males (e.g., Fennema & Sherman, 1978;

Marsh et.al., 1985; Parsons et.al., 1982; Wigfield et al., 1991). Although American male students were slightly higher than female students in the perception of their own math ability in this study, the difference did not reach the .05 significance level. The lack of significance might be explained by the selection of the American sample in this study. The American sample consisted of 9th to 12th graders who had been taking the same mathematics classes (Honors' Geometry class to Advanced pre-calculus) at the time this study was conducted. Thus, male and female students in this study were almost matched in terms of their math courses. Since most math classes are not required for the U.S. students, students who had chosen to take a math class might have more confidence in their math ability regardless of gender. In contrast, although Japanese students had been taking the same math classes, the math classes were required classes so that they did not have a choice.

With the exception of Wigfield et al. (1991), most prior studies also revealed gender differences in perceived task value (e.g., Eccles et al.1983). The lack of no gender difference in task value among the American sample in this study could also be explained by the sample's selectivity. But this explanation does not account for why there was still a gender differences in the perception of the difficulty of math.

Unlike the other two attitude variables, Japanese males and females did not differ in their value of math. This might be explained by the following reason. Japanese society as a whole places a high value on mathematics (Ito, 1989). Because many Japanese universities require a high math score on entrance examinations in most academic areas, high mathematics achievement is one measure of success in Japanese society. Approximately 85% of the Japanese students in this study planned to go to some kind of post-secondary institution. Males and females might differ in their perception of their own math ability or perception of math difficulty, but it is not surprising that males and females placed a similar high value on math.

7.1.3 Gender Differences In Learning Pattern Variables

There are three learning pattern variables; (1) study regularity, (2) study independence, and (3) study habits. Hypotheses related to these three variables were:

Hypothesis 1.7: Females will study mathematics more regularly than males.

Hypothesis 1.8: Males will study more independently and will show a stronger preference for working at advanced problems than females.

Hypothesis 1.9: Females will have more positive study habits than males.

Among the U.S. sample, Hypotheses 1.7 and 1.9 were supported. For the Japanese males, Hypotheses 1.8 and 1.9 were supported. Japanese males reported that they studied math more independently (and to prefer working on advanced problems) but with less positive study habits than females. American males reported that they tended to study math with less regularity and less positive study habits (e.g., preserving calculation processes as well as the final answer or listening and following along carefully when a classmate is orally responding to a question) than females.

For the Japanese sample, the results are consistent with Ito's findings (1989). The results for study regularity approached significance ($p < .06$). For the U.S. sample, although few studies that directly support gender differences in learning patterns in U.S. students (Kimball,1989), the results are similar with those of Ito (1989). U.S. males and females did not differ in their study independence. This might relate to the sample selection in the U.S.. As was mentioned before, the U.S. sample in this study were 9th to 12th grade students who had been taking math classes at the time the study was conducted. Thus, both male and female students could be more math-oriented than the students who were not taking the math courses. Ito (1989) reported that items for task preference (I like to work on basic problems versus I like to work at advanced problems) distinguished students' preference of major in university between a science major and arts major among Japanese high school students. Regardless of their gender, math and science-oriented students tended to prefer working at more advanced problems than arts-oriented students. The scale in the present study include items from both constructs: study independence and task preference. This might be the reason that the variable did not differ by gender among the U.S. sample.

7.1.4 Gender Differences In Performance Variables

There are three performance variables; (1) total score of 5 math items, (2) strategy efficiency score, (3) seriousness of mistake score. The hypotheses related to these variables were as follows:

Hypothesis 1.10: Males will outperform females in the total score of 5 math items.

Hypothesis 1.11: Males will use more efficient solution strategies than females when they solve math problems.

Hypotheses 1.12: Females will make more serious mistakes than males.

For the Japanese sample, none of the hypotheses were confirmed. For the U.S. sample, Hypothesis 1.10 was supported. Among the performance variables, a significant gender differences were found only in the total score of 5 math items among the subjects in the United States.

It was expected that among the American students, males would outperform females in the total score of 5 math items, since these 5 items were the ones that were found to have the largest gender differences among SAT takers (Kelly-Benjamin, 1989; Byrnes & Takahira, 1993). Although the significance level ($p < .08$) for the total score of 5 math items did not reach the .05 level among the Japanese students, the mean score for male students (3.12) was higher than the mean score for female students (2.83). Since other math items were not examined except those 5 math items, we can not determine whether these 5 math items produce similarly large gender differences between Japanese males and females as was the case for U.S. students. The effect size for the Japanese sample was $d = .25$ with sample size of 207, whereas the effect size for U.S. sample was $d = .33$ with sample size of 167. The smaller effect size with larger sample size for the Japanese sample give us clues that these 5 math items may not produce the largest gender difference among Japanese students. The lack of significance in the total of 5 math items for the Japanese sample might be partially explained by homogeneity of math background. The Japanese sample is very homogeneous regarding mathematics background. This homogeneity might minimize the gender difference in the total score of these 5 math items.

Another possible reason is that since the Japanese curriculum is more demanding, these 5 math items might be too easy to produce a gender difference among Japanese students. The content of these 5 math items is most likely to be taught in junior high school which includes grades 7 to 9. At the 10th grade, they have already studied (a) quadratic functions, (b) probability, and (c) trigonometry which is usually taught at the 11th grade in the United States. Thus, homogeneous high level mathematical experience might narrow the performance gap between Japanese males and females. Some items might have significant gender differences among the Japanese students as large as that found for the American students. Careful item by item investigations will be required in the future to find the gender differences in each item in each nation.

There were no gender differences either on the average strategy efficiency score or on the average seriousness of mistake score among the Japanese students or the students in the United States. However, average strategy efficiency had significant correlations with perceptions of math ability for the Japanese students, and with perception of task value for the American students. Thus, the results indicate that among the Japanese students, regardless of gender, students who perceived themselves as having high math ability tended to use more efficient solution strategies than the students who perceived themselves to have low math ability. Among the American students, regardless of gender, students who valued math more highly tended to use more efficient strategies than the students who valued math less.

A previous study by Gallagher and De Lisi (1994) suggested possible gender effect in the use of different types of solution strategies. Although the categories of the types of strategy used in their study do not exactly correspond to the categories used in this study, the use of different types of solution strategies might relate to some attitude factors more strongly than gender. Future research should investigate these relations between different types of solution strategies and attitude factors.

7.1.5 Gender Differences In Relationships Among Variables

Research question 2.1: How do mathematics performance (performance variables) relate to the ways that students study mathematics (learning pattern variables)?

There were some relationships between performance variables and learning variables for some samples. But no correlations were significant for Japanese males. Regardless of gender, for U.S. students, there were significant relationships between

(1) study habits and strategy efficiency and (2) study independence and seriousness of mistake. There were significant relationships between study habits and seriousness of mistake only for females, regardless of nationality.

<u>Research question 2.2:</u> How do the ways individuals learn mathematics (learning pattern variables) relate to individuals' motivation (attitude toward math variables)?

There were significant relationships between attitude variables and learning variables. Especially, significant correlations were found for all four groups (Japanese males, Japanese females, U.S. males, and U.S. females) (a) between study independence/task preference and all three attitude variables, ability/expectancy, task value, and task difficulty and (b) between study habits and task value. Regardless of gender or nationality, students who study math more independently and prefer working with more advanced math problems tended (1) to have higher beliefs about their own math ability, (2) to place more value on math, and (3) to feel that math is less difficult than students who rely on others and prefer working with basic problems. Regardless of gender and nationality, students who placed more value on math tended to have positive study habits than students who placed less value on math.

Many relationships between learning and attitude variables existed in all four groups, but the relationship between learning variables and performance variables existed mostly for the U.S. sample. There were not many significant relationships between sex-stereotyping variables and either attitude variables or learning variables and they were mostly for the Japanese male sample. These results might indicate differential influence of different variables for different groups. Since only a few studies have, in the past, examined relationships between variables from different approaches (Kimball,1989; Pintrich & De Groot, 1990), there is not enough evidence to compare the results of the present study. This study should promote more investigation regarding the relationships between those variables.

7.2 Limitations of the Study

This study has certain limitations. First, the subjects were taken from only one high school in each nation. Although the Japanese subjects represent typical middle level students, gifted students or low ability students were not included in this study. Also, the American subjects were taken from a Parochial high school and most students were from white middle class families. Thus, the generalizability of the results to other groups might be limited.

Second, the homogeneity of subjects was greater in Japan than in the United States. The Japanese students were all 10th graders and had almost exactly the same mathematics curriculum from the time they were in the first grade up to the semester this study was conducted. In contrast, the American consisted of students in the 9th grade honors class to the 12th grade advanced-calculus class. Although male and female students were almost matched regarding their math courses previously taken in each grade level, they were in the different stages of mathematics curriculum. This difference in homogeneity in subjects might affect some of the results regarding national difference in performance factors.

Third, in the present study, we used only 5 math items that were previously found to have large gender differences in the U.S.. However, similar gender effects may or may not be found in other items as well. Thus, the discriminant validity of the gender difference items were not confirmed in this study among the Japanese subjects. More items should be included in future studies.

Difficulties of Making Cross-Cultural Comparisons

A critical limitation having important implications in the results of present study lies its difficulties in making cross-cultural comparison. Some of the main effects of nation which were found to be significant might not reflect the reality of national differences in these variables and should be interpreted with careful consideration for the following reasons.

The first reason is that the meaning of the variables/constructs might not be the same in both nations. For example, the meaning of "math ability" in the United States is usually closely related to predisposed innate ability, and so is not changeable. Many Americans believe that mathematics achievement reflect one's innate math ability. However, in Japan, the meaning of "math ability" is more closely related to the results of mathematics achievement which reflect the amount of efforts one put into. Thus, meanings of the some of the constructs might not be the same for the Japanese and U.S. subjects.

The second reason is that even if the meaning of the constructs were the same, there are cultural differences in tendency to see oneself. For example, in the United States, because of the cultural value in individualism, being different from others, especially, smarter than other, is highly valued. People tend to see themselves according to cultural norms and it is natural to express their feeling about how smart they are. On the other hand, in Japan, social pressure toward conformity is very important aspect of the Japanese life at any age levels. People value not being deviant in either good or bad ways and tend to be modest and humble when they evaluate themselves. Even though some people perceive themselves as being smart, they never express their feeling about themselves in public. Thus, this cultural differences in tendency to perceive themselves might affect the results of the main effect of the nation in some variables such as perception of own math ability.

The third reason is related to the cultural differences in the reference groups. Many of the variables did not specify the reference group in the questionnaire. For example, regarding "study regularity", the subjects rate their perception of their study regularity compared to what they think of the standard in terms of study regularity. Japanese students who study math (beside the assignment) 2 hours every other day may feel that they do not study regularly since their peers study math almost every day. In contrast, American students who work on math assignment 30 minutes every day may feel that they study math quite regularly compared to their peers. Thus, the national difference in some of the variables do not necessarily reflect absolute differences in value between nations. Although U.S. students rated themselves significantly higher than did the Japanese students in their math ability and self-perception of study regularity, for the above reasons, we must be careful in making cross-cultural comparisons in these and other variables.

If the cultural differences in above aspects affect each variable, then, we must also consider how the cultural differences might have produced the differences in relations among the variables. However, the correlation among variables are within nation analyses. Therefore, even though we compare the correlations between two nations, we are not comparing the absolute value of the variables between nations but the relative relationship among variables between nations. The comparisons of the patterns of relationships among the variables between nations are more meaningful.

7.3 Practical Applications and Implications for Future Research

The present study might indicate some of the important variables that influence gender difference in mathematics performance in Japan and in the United States and the relationships among the variables. Although the present study was not designed to answer directly to the question how we can improve females' math achievement, we may be able to infer the answer based on the results of this study.

The results of this study may indicate some possibility for practical intervention to improve females' performance in mathematics. For example, the following relations were found only in female students regardless of nationality: females who have positive study habits tended to make less serious mistakes and to perceive themselves as having higher math ability than the females who have less positive study habits. Teachers should discuss the importance of positive study habits for math in class, and teach low achieving female students to have more positive study habits. Such activities might be the first step to change females' attitude toward math and to obtain ultimate goal of improving their math performance.

Particularly for the Japanese female students, providing role models such as female math teachers and female professionals in math and science related fields may be important since females held stronger sex-stereotyped beliefs about math than males. School authorities put more effort on hiring female math teachers over males teachers especially, at high school level. Also, Japanese math teachers should be aware of females' low confidence in math and try to encourage females to have more confidence in math by introducing better study habits or by teaching to persist little bit more on problems even if they have some difficulties solving them.

For the American students, although females in the sample showed the most egalitarian view regarding math among the four groups, American males still held sex-stereotyped beliefs about math as a male domain. This might indicate that there may be a tendency by males to see high achieving females as unfeminine or masculine. This tendency by males might create great psychological conflict among the high achieving females. It is important to educate both male and female students not to associate mathematics with masculinity. Teachers should introduce male and female students that some of the historically important mathematical theorems were discovered by female mathematicians such as theorems of Kowarefscaya.

For both Japanese and American females, school counselors should also introduce high achieving female students possibilities and alternatives of the selecting math and science related fields as their major in universities in the early periods of their high school life.

Nature may play a role in creating certain gender differences. However, the present study suggests that the gender difference in mathematics is a within-culture phenomenon, so that gender differences may occur for different reasons in different societies or similar reasons in similar societies. For example, sex-stereotyped beliefs about math are common both for Japanese society and for the United States. However, the degree of stereotyping is, in fact, different. The Japanese society seems to have implanted a pessimistic view in females in terms of sex-stereotyped beliefs about math in spite of their achievement level. However, the relations found among the sex-stereotyping variables, learning variables, attitude variables and performance factor may indicate the possibilities of interventions in order to improve female students' learning patterns, attitude toward math, and therefore ultimately, performance in math. The next tasks for researchers are: (1) establish relationships between variables with a larger sample size, (2) develop a theory of gender differences, and (3) test the theory of gender difference in mathematics. Finally, practical intervention strategies should be developed based on the theory and findings about gender difference in mathematics. Among the research in gender difference in mathematics, this study is the first to reveal a cross-national aspect to gender differences and the relationships among math performance, learning, and attitude variables. In order to reduce the gap between male and female students in mathematics performance and attain gender equality in science fields, researchers must put more effort in the investigations of gender differences and be aware of the importance of the role of culture.

Appendix A

Three Trends in Gender Differences in Mathematics

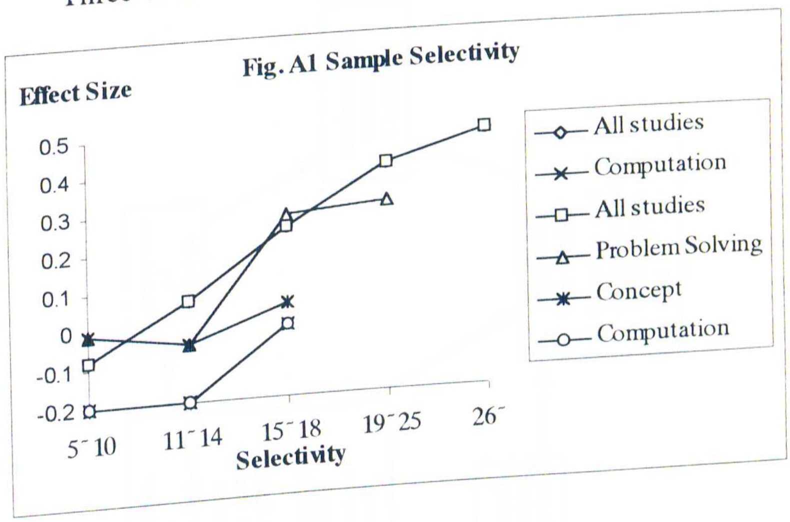


Fig. A1 Sample Selectivity

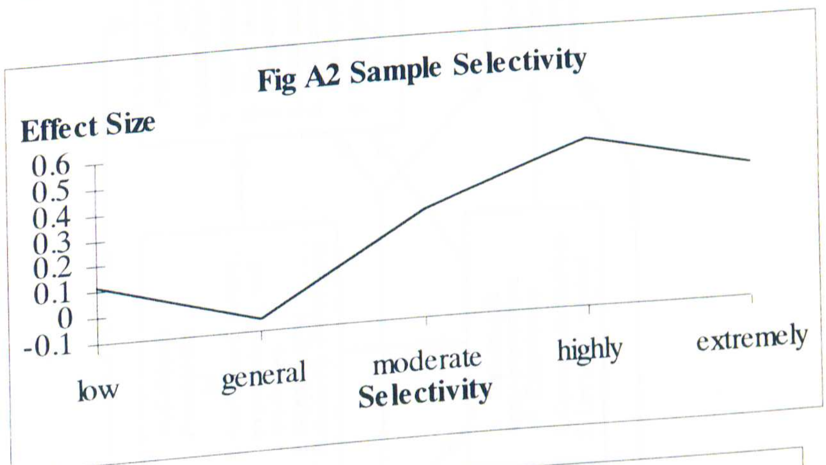


Fig A2 Sample Selectivity

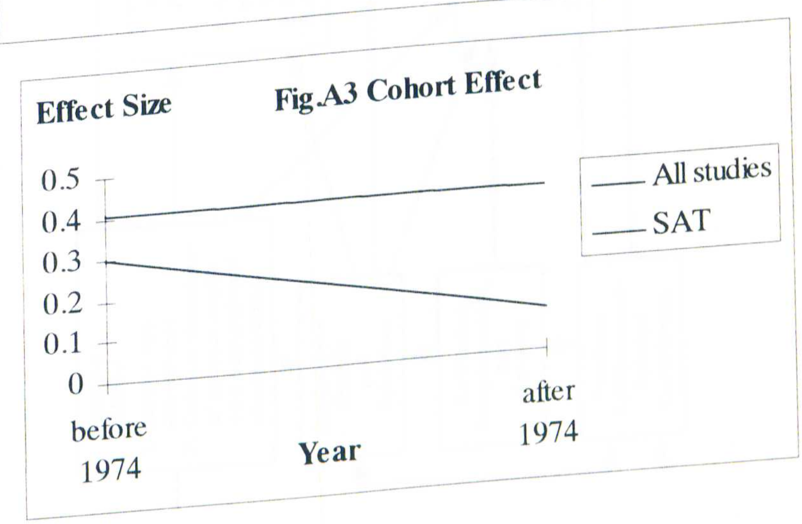
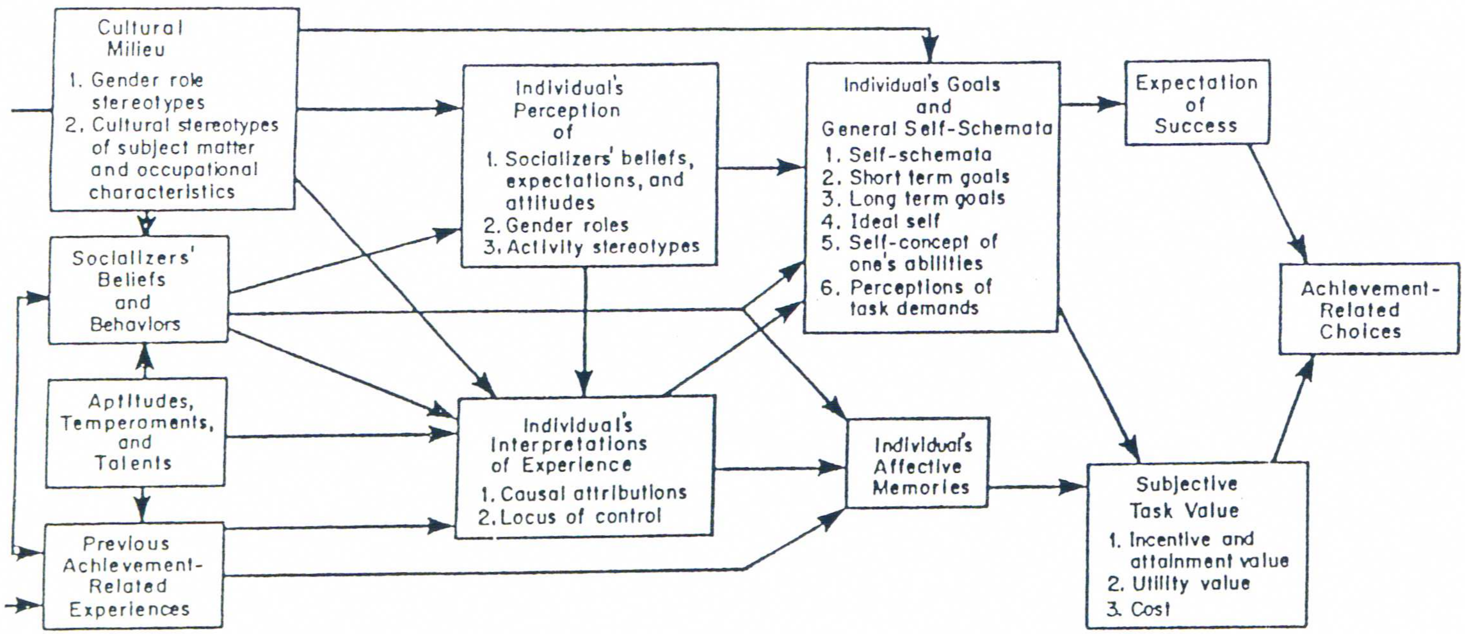


Fig.A3 Cohort Effect

Appendix B

Eccles's Model of Achievement Related Choice



Appendix C

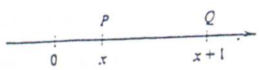
Math Problem (I)

Last 6 digit of social security number ___ ___ -- ___ ___ ___ ___, Age __________

Gender (Male or Female), Grade (9th, 10th, 11th, or 12th) Please circle one

Time limit : 5 minutes

Problem (1)



On the number line above, which of the following is the coordinate of the midpoint of segment PQ ?

(A) $\frac{x}{2}$

(B) $\frac{x+1}{2}$

(C) $x + \frac{1}{2}$

(D) $2(x + 1)$

(E) $\frac{x(x+1)}{2}$

Problem (2)

Oatmeal Recipe

Water: $\frac{3}{4}$ cup

Salt: $\frac{1}{4}$ teaspoon

Oats: $\frac{1}{3}$ cup

If the least possible multiple of the recipe above is prepared so that a whole number of cups of both water and oats are used, how many teaspoons of salt would be required?

(A) $\frac{1}{2}$

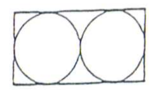
(B) $\frac{3}{4}$

(C) 1

(D) $2\frac{1}{4}$

(E) 3

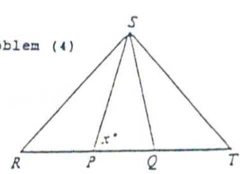
Problem (3)



The rectangle above contains two circles, tangent to each other and each tangent to three sides of the rectangle. Which of the following pairs of numbers CANNOT be the length and width, respectively, of the rectangle?

(A) 2, 1
(B) 12, 6
(C) 16, 10
(D) 22, 11
(E) 32, 16

Problem (4)



Note: Figure not drawn to scale.

In the figure above, $\triangle RST$ is a right triangle. $RS = ST$ and right angle RST has been divided into three equal angles. What is the value of x ?

(A) 65
(B) 70
(C) 75
(D) 80
(E) 85

Problem (5)

If a rectangular cake, 9 inches by 13 inches by 2 inches, is cut into x equal rectangular pieces, 3 inches by $3\frac{1}{4}$ inches by 2 inches, and no cake is left over, then $x =$

(A) 9
(B) 12
(C) 13
(D) 15
(E) 22

Appendix D

数学問題（A）

1年＿＿＿組＿＿＿＿番、　年齢＿＿＿才、　（男・女）（いずれかに○を）

1）下の数直線上で、線分PQの中点の座標を、下から一つ選べ

(A) $\frac{x}{2}$

(B) $\frac{x+1}{2}$

(C) $x+\frac{1}{2}$

(D) $2(x+1)$

(E) $\frac{x(x+1)}{2}$

2）下のようなお粥の材料表がある。水とお米が両方とも整数のカップとなるような最小の分量を作る時、塩はどれだけ必要か？

(A) $\frac{1}{2}$

(B) $\frac{3}{4}$

(C) 1

(D) $2\frac{1}{4}$

(E) 3

お粥の材料

水	$\frac{3}{4}$	カップ
塩	$\frac{1}{4}$	さじ
米	$\frac{1}{3}$	カップ

3）下の長方形に含まれる２つの円は、互いに正接しており、また長方形の３辺とも正接している。

下のペアの中で、長方形の横とたてになりえないのはどれか？

(A) ２，１

(B) １２，６

(C) １６，１０

(D) ２２，１１

(E) ３２，１６

4）下の図で△ＲＳＴは、直角三角形である。ＲＳ＝ＳＴであり、∠ＲＳＴは直角であり、３等分されている。∠ｘの値を求めよ。

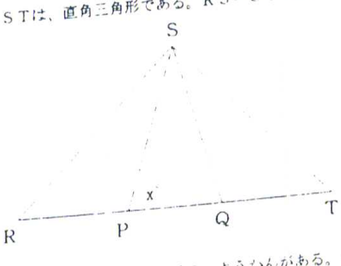
(A) 65

(B) 70

(C) 75

(D) 80

(E) 85



5）各辺が９センチ、１３センチ、２センチの、ようかんがある。このようかんを各辺が３センチ、３(1/4)センチ、２センチの小さいようかん、Ｘ個に等分する。Ｘを求めよ。

(A) ９

(B) １２

(C) １３

(D) １５

(E) ２２

Appendix E

Questionnaire (I)

Last 6 digit of social security number ____ - ____________

Age __________,   Gender (Male   or Female),   Grade ____10th

____11th

____12th

Please mark all the math courses that you have taken previously and that you are taking this year.

_______ Algebra I

_______Geometry

_______Algebra II/Trigonometry

_______Pre-calculus

_______A.P. Calculus

Average math GPA ___________

The following 5 pages correspond to the 5 problems you just solved and poll your problem solving strategies. On the top of each page, the correct answer is shown. If your answer was correct, please select the strategy that you used for solving the problem from section (A). If your answer was incorrect, please select your reason(s) of mistake from section (B) .

Problem 1

On the number line above, which of the following is the coordinate of the midpoint of segment PQ?

(A) $\frac{x}{2}$ (B) $\frac{x+1}{2}$ (C) $x+\frac{1}{2}$ (D) $2(x+1)$ (E) $\frac{x(x+1)}{2}$

(A) Correct Answer - Choice "C"

1) I used the midpoint formula, adding P and Q together and dividing the sum by 2. Thus {x + (x+1)}/2; (2x + 1)/2; 2x/2 + 1/2, and x + 1/2.

2) P = x and Q = x + 1. I noticed that the distance between P and Q is 1. The midpoint between P and Q must be 0.5 from P, and thus the answer is x + 1/2.

3) I substituted x with a number. For example, when x = 1, then p = 1 and Q = 1 + 1 = 2. And the midpoint has to be in between 1 and 2. In reviewing the choices, I saw that substitution in choice (A) x/2 would put the sum before P. The choice (B), (x+1)/2, would bring the sum back to 1. Substitution in choice (C) makes 1(1/2), a value between P (1) and Q (2).

4) I substituted x with a number. When x = 1, then P = 1, and Q = x + 1 = 1 + 1 = 2. The midpoint between P and Q is the point which is halfway from P. Thus, if x = 1, the midpoint is 1.5 which is (X + 0.5). Thus, x + 1/2 is the answer.

5) I just guessed.

6) Other (Please specify in detail ______________________________

(B) Incorrect Answer - Choices other than "C" (Please circle all that apply)

1) I didn't really understand the question.

2) I didn't understand the phrase "the coordinate of the midpoint".

3) I tried to apply the midpoint formula but wasn't really sure of it. I thought it was x + 1 divided by 2.

4) I tried to apply the midpoint formula but wasn't really sure of it. I thought it was x multiplied by (x + 1), divided by 2.

5) I tried to apply the correct midpoint formula which is x + (x + 1) divided by 2, but I could not find the result of my calculations in the answer choices - so I circled the closest answer. I did not realize that I had to simplify the equation.

6) I tried to apply the correct midpoint formula and then simplify the equation but somehow I could not get the correct answer.

7) I understood the question but I couldn't really figure out how to do it.

8) I didn't have enough time to complete the calculations (Please describe how far you got and the strategy you used). ______________________________

9) Other (Please specify in detail) ______________________________

Problem 2

Oatmeal Recipe

Water	$\frac{3}{4}$	cup
salt	$\frac{1}{4}$	teaspoon
oats	$\frac{1}{3}$	cup

If the least possible multiple of the recipe above is prepared so that a whole number of cups of both water and oats are used, how many teaspoons of salt would be required?

(A) $\frac{1}{2}$ (B) $\frac{3}{4}$ (C) 1 (D) $2\frac{1}{4}$ (E) 3

(A) Correct Answer - Choice " E "

1) I found a common denominator, 12, for both Oats (1/3) and Water (3/4). I multiplied all three measurements by 12. Thus, 1/3 multiplied by 12 = 4 cups, 3/4 multiplied by 12 = 9 cups, and 1/4 multiplied by 12 = 3 teaspoons.

2) I didn't really understand the question so I just guessed. It was a lucky guess.

3) I knew that I had to multiply all three ingredients by something. In order to get the right number to multiply, I tried from 3, 4, etc,..., and 12 finally worked out. I multiplied 1/4 by 12 to get 3 teaspoons.

4) Other (Please specify in detail) ____________________

(B) Incorrect Answer - Choices other than " E " (Please circle all that apply)

1) I couldn't really understand the question.

2) A "whole number" was needed so I figured that 1/4 + 3/4 = 1. 1 is a whole number so 3/4 must be the answer.

3) I had to get a whole number so I multiplied each measure by something to get the whole number "1". 1/3 multiplied by 3 = 1, 3/4 multiplied by 4/3 = 1 and 1/4 multiplied by 4/1 = 1.

4) I guessed incorrectly.

5) I understood the question - that I had to multiply each measure by something to get a whole number. I tried the numbers 4, 5, 6, etc,...but it took me too long so I gave up.

6) I multiplied each measure by 12. Then I multiplied 3 by 1/4 in order to convert to teaspoons.

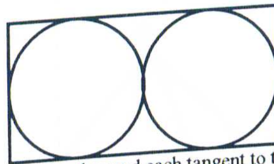
7) I multiplied each measure by 3. 3/4 multiplied by 3 = 9/4.

8) I could not really figure out how to do it.

9) I didn't have enough time to complete my calculations (Please describe how far you got and the strategy you used). ____________________

10) Other (Please specify in detail) ____________________

Problem 3



The rectangle above contains two circles, tangent to each other and each tangent to three sides of the rectangle. Which of the following pairs of numbers CANNOT be the length and width, respectively, of the rectangle?

(A) 2, 1 (B) 12, 6 (C) 16,10 (D) 22, 11 (E) 32, 16

(A) Correct Answer - Choice "C"

1) I didn't really understand the question. However, when I looked at the answer choices, I realized that all the choices were in a 2-to-1 ratio except choice (C).

2) The length of the rectangle is 2 diameters and the width of the rectangle is 1 diameter. So any number which is in a 2-to-1 ratio could be a length and width of the rectangle. Only (C) isn't in a 2-to-1 ratio.

3) I didn't really understand the question so I just guessed. It was a lucky guess.

4) Other (Please specify in detail)______________________________

(B) Incorrect Answer - Choices other than "C" (Please circle all that apply)

1) I didn't understand the question.

2) I couldn't remember the meaning of the word "tangent" - so I couldn't understand the question.

3) I looked at the figure and looked at the answer choices. I incorrectly estimated the length and width of the rectangle based on looking at a picture .

4) I was trying to get actual length and width of the rectangle, but I couldn't figure it out.

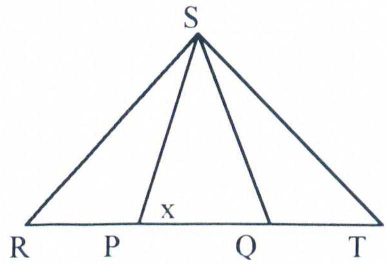
5) I didn't have enough time to complete the calculations (Please specify how far you got and the strategy you used).

____

6) Other (Please specify in detail)

____

Problem 4



Note: Figure not drawn to scale.

In the figure above, ΔRST is a right triangle, RS=ST and right RST has been divided into three equal angles. What is the value of angle x?

(A)65 (B)70 (C)75 (D)80 (E)85

(A) Correct Answer - Choice " C "

1) The right angle RST is 90 degrees. It is divided into three equal angles so that each angle is 30 degrees. Each triangle has a total of 180 degrees. 180 minus 30 = 150 degrees remaining, equally divided between angles SPQ and SQP. 150 divided by 2 = 75 degrees.

2) Right angle RST is 90 degrees. Each triangle has a total of 180 degrees. 180 minus 90 degrees = 90 degrees. SRT = STR, therefore, 90 divided by 2 = 45 degrees for each. SPR = 180 - (30 + 45) = 105 degrees. The angle x = (180 - 105) = 75 degrees.

3) RST is 90 degrees. 90 divided by 3 = 30 degrees for each of the angles, RSP, PSQ, and QST. In triangle PST, angle PST = 30 + 30 = 60 degrees, and STP= 45 degrees. 60 + 45 = 105. Each triangle has a total of 180 degrees so the solution is, x = (180 - 105) = 75 degrees.

4) I couldn't really figure out how to do it so I just guessed. It was a lucky guess.

5) Other (Please specify in detail) ______________________________

(B) Incorrect Answer - Choices other than " C " (Please specify all that apply)

1) I understood that I had to find the value of x but I did not know how to do it.

2) I couldn't understand the question.

3) I was trying to do one of the above strategies {1, 2, or 3} (Please circle one), but somehow I made a computational mistake and could not get the right answer.

4) I did not have enough time to complete the calculations (Please describe how far you got and the strategy you used)

____

5) Other (Please specify in detail)

____

Problem 5
If a rectangle cake, 9 inches by 13 inches by 2 inches, is cut into x equal rectangle pieces. 3 inches by 3 ¼ inches by 2 inches, and no cake is left over, then x=

(A)9 (B)12 (C)13 (D)15 (E)22

(A) Correct Answer - Choice "B "

1) I calculated the volume of the whole cake which is 9 X 12 X 2. Then, I calculated the volume of small piece, which is 3 x 3(1/4) x 2. I divided the volume of the whole cake by the volume of the small piece which is 234 divided by 19.5. The subsequent answer is 12.

2) I calculated the area of the whole cake, 9 x 13, and the area of the small piece, 3 x 3(1/4). Then I divided the area of the whole cake by the area of the small piece which is 117 divided by 9.75. The answer is 12.

3) I drew a picture and figured out the answer without any computing. The 9 inch side has 3 blocks and the 13 inch side has 4 blocks. Drawing this in yielded a total of 12 pieces.

4) I didn't know how to do the problem so I just guessed. It was a lucky guess.

5) I drew a picture. The width of the cake is 9, divided by the width of a piece, 3. This equals 3 slices. The length of the cake is 13, divided by the length of the piece, 3(1/4) which equals 4 slices. 3 pieces multiplied by 4 pieces yield 12 pieces total.

6) Other (Please specify in detail) ____________________

(B) Incorrect Answer - Choices other than " B " (Please circle all that apply)

1) I tried to divide the area of the whole cake, 9 x 13, by the area of the small piece, 3 x 3(1/4), but somehow I made mistakes in the computational process.

2) I misunderstood the question and couldn't get the right answer.

3) I just guessed because I couldn't understand the question and I didn't know how to do it

4) I made a mistake when I computed the fraction 3(1/4) x 3. (Please describe the strategy you used) ____________________

____

5) I didn't have enough time to complete the calculations (Please describe how far you got and the strategy you used). ____________________

____

6) Other (Please specify in detail)____________________

Appendix F

The following questions (items 1 to 26) ask about your study strategies for mathematics. Please circle the number that is closest to your idea from 1, 2, 3, 4(neither one), 5, 6, or 7.

1. I study for regular hours every day.	1 2 3 4 5 6 7	I study with no regularity.
2. I study little by little every day.	1 2 3 4 5 6 7	I study in one lengthy session.
3. I always review class lessens.	1 2 3 4 5 6 7	I never review class lessons.
4. I study at home every day.	1 2 3 4 5 6 7	I study lessons only in school.
5. I always prepare for class.	1 2 3 4 5 6 7	I never prepare for class.
6. I always prepare for exams.	1 2 3 4 5 6 7	I never prepare for exams.
7. I study according to a schedule.	1 2 3 4 5 6 7	I study when I feel like it.
8. I prepare for exams intensively at one time.	1 2 3 4 5 6 7	I prepare for exams gradually every day.
9. I learn only the fundamentals.	1 2 3 4 5 6 7	I learn by solving many problems.
10. I like to work at basic problems.	1 2 3 4 5 6 7	I like to work at advanced problems.
11. I try to memorize formulas.	1 2 3 4 5 6 7	I try to comprehend formulas.
12. I correct my errors in problems.	1 2 3 4 5 6 7	I try problems again to understand causes of errors.
13. When I can't solve a problem I rely on someone to help me.	1 2 3 4 5 6 7	Even when I have difficulty in solving a problem, I work at it myself.
14. I throw away the papers (class notes or exams) which demonstrates the solution processes.	1 2 3 4 5 6 7	I preserve the papers (class notes or exams) which demonstrates the solution processes.
15. While a classmate is orally responding to a question, I think of something else.	1 2 3 4 5 6 7	While a classmate is orally responding to a question, I follow along carefully.
16. When I get my graded test paper back, I just write down the correct answer.	1 2 3 4 5 6 7	When I get my graded test paper back, I try to understand the causes of my errors.
17. I like to work at basic problems.	1 2 3 4 5 6 7	I like to work at advanced problems.
18. I rely on answers solved by peers on the blackboard.	1 2 3 4 5 6 7	I try to solve problems myself, independent of my peers' answers.
19. I review my school textbooks or my notebooks.	1 2 3 4 5 6 7	I review using a reference book or by doing extra problems.
20. I don't care about errors in a graded paper.	1 2 3 4 5 6 7	I correct errors in a graded paper.
21. I try to take notes during lessons.	1 2 3 4 5 6 7	I try to listen during lessons.
22. I copy everything my teacher writes on the blackboard.	1 2 3 4 5 6 7	I write down certain points of that my teacher says or writes in class.

23. I write down answers as well as with my calculation process.	1 2 3 4 5 6 7	I write down answers only in my notes.
24. I always solve problems with the same effort as I do on exams.	1 2 3 4 5 6 7	When I solve problems, I do not put the same effort as I do on exams.
25. I give precedence to homework.	1 2 3 4 5 6 7	My own interests take precedence over the homework.
26. I spend much time writing out problems in preparation for exams.	1 2 3 4 5 6 7	I spend much time looking over materials in preparation for exams.
27. I usually study in quiet surroundings.	1 2 3 4 5 6 7	I usually study in noisy environments.

Appendix G

Questionnaire (II)

Student's ID Number ______________________, Age ________,

Gender (Male or Female), Grade (10th, 11th, 12th) Please circle one

1. How much education do you want to pursue ?
   1) I do not plan to go college or university.
   2) Technical school, community college, or junior college
   3) Four year University
   4) Graduate school (master program), business school, medical school, or law school
   5) Graduate school (Doctoral program)

2. What is your area of interest (major) in education beyond high school??
   1) Non-mathematics related area (such as Arts, Literature, Journalism, Education, History, etc)
   2) mathematics and science related area (Physics, Computer science, Engineering, etc)
   3) undecided

3. How many hours per week do you study mathematics beyond your regular mathematics class lessons and homeworks (such as with math tutor)?
   Last week ________hours In average, ________hour(s) per week

4. Does your mother (or step mother) who lives with you have a job outside the home?
   1) She does not have a job outside home.
   2) She has a part-time job.
   3) She has a full-time job.

5. If you circle choices 2) or 3) in question 4, what kind of job does she have? Is she a ......
   1) company or government employee
   2) company president, executive, or manager
   3) agricultural or other farm worker
   4) store or other business owner
   5) teacher, engineer, artist, doctor, lawyer, or other occupation requiring special skills
   6) part-time worker (such as store clerk, child care, etc)
   7) other (please describe the occupation)________________________________

The following questions or statements ask attitudes toward mathematics and study strategies toward mathematics. Please circle the number which is closest to your idea from 1, 2, 3, 4(neither), 5, 6, or 7.

1. In general, I find working on math assignments
   very boring 1 2 3 4 5 6 7 very interesting

2. How good at math are you? not at all good 1 2 3 4 5 6 7 very good

3. How hard do you try to get good grades in math?
   a little 1 2 3 4 5 6 7 a lot

4. In general, how hard is math for you? very easy 1 2 3 4 5 6 7 very hard

5. What is the lowest grade or evaluation mark you would be satisfied with in your present math course? ________

6. How smart does one have to be to do well in advanced high school math (like Algebra II, Trigonometry, or Calculus)?
   average in brightness 1 2 3 4 5 6 7 extremely bright

7. Compared to other students in your class, how well do you expect to do in mathematics this year?
   much worse than other students 1 2 3 4 5 6 7 much better than other students

8. How successful do you think you'd be in a career which required mathematics ability?
   not very successful 1 2 3 4 5 6 7 very successful

9. How useful is what you would learn in high school math (like Algebra II, Trigonometry, or Calculus) for what you want to do when you finish school and go to work?

not very useful 1 2 3 4 5 6 7 very useful

10. How useful do you think women find advanced high school math (like Algebra II, Trigonometry, or Calculus) in their jobs?

not at all useful 1 2 3 4 5 6 7 very useful

11. How useful do you think women find advanced high school math for their everyday lives?

not at all useful 1 2 3 4 5 6 7 very useful

12. In general, I find working on number puzzles and games

very boring 1 2 3 4 5 6 7 very interesting

13. How good at math does your mother think you are?

not at all good 1 2 3 4 5 6 7 very good

14. How useful do you think men find advanced high school math (like Algebra II, Trigonometry, or Calculus) for their everyday lives?

not at all useful 1 2 3 4 5 6 7 very useful

15. How upset do you think your mother would be if you got a low mark in math?

not very much 1 2 3 4 5 6 7 very much

16. If you were to order all the students in your math class from the worst to the best in math, where would you put yourself?

the worst 1 2 3 4 5 6 7 the best

17. How hard do you try in math? a little 1 2 3 4 5 6 7 a lot

18. Compared to most others in your class, how hard is math for you?

much easier 1 2 3 4 5 6 7 much harder

19. How good at math does your teacher think you are?

not at all good 1 2 3 4 5 6 7 very good

20. How useful is what you would learn in advanced high school math (like Algebra II, Trigonometry, or Calculus) for your daily life outside of school?

not at all useful 1 2 3 4 5 6 7 very useful

21. How smart does one have to be to do well in basic high school math?

average in smartness 1 2 3 4 5 6 7 very smart

22. How good at math does your father think you are?

not at all good 1 2 3 4 5 6 7 very good

23. I feel that, to me, being good at solving problems which involve math or reasoning mathematically is:

not at all important 1 2 3 4 5 6 7 very important

24. How upset do you think your father would be if you got a low mark in math?

not very much 1 2 3 4 5 6 7 very much

25. How much time do you spend on your math homework? In average, ______hour(s) a day, and ________ hours a week

Before an exam, how much time do you spend for preparation of math exam? In average, ______ hour(s) a day, _______ hour(s) a week

26. In general, I think boys are.......
1)___ much better than girls at math
2)___ somewhat better than girls at math
3)___ a little better than girls at math
4)___ the same as girls at math
5)___ a little worse than girls at math
6)___ somewhat worse than girls at math
7)___ much worse than girls at math

27. To do well in math, I have to work ....
1) ___ much harder in math than I do in other subjects
2) ___ somewhat harder in math than I do in other subjects
3) ___ a little harder in math than I do in other subjects
4) ___ the same as in other subjects
5) ___ a little harder in other subjects than I do in math
6) ___ somewhat harder in other subjects than I do in math
7) ___ much harder in other subjects than I do in math

28. Compared to most other students you know, how much time do you have to spend working on your math assignment?
much less time than other students 1 2 3 4 5 6 7 a lot more time than other students

29. Compared to most other school subjects that you have taken or are taking, how hard is math for you?
my easiest course 1 2 3 4 5 6 7 my hardest time

30. How much do you like doing math?
not very much 1 2 3 4 5 6 7 very much

31. In math, most of the time, how well do you do in each of the following things?

a) When the teacher calls on you for an answer in class
very poorly 1 2 3 4 5 6 7 very well

b) When taking a test you have studied for
very poorly 1 2 3 4 5 6 7 very well

c) When doing math homework problems
very poorly 1 2 3 4 5 6 7 very well

32. How hard do you have to study for math test to get a good grade?
a little 1 2 3 4 5 6 7 a lot

33. How important is it to you to get a good grade in math?
not at all important 1 2 3 4 5 6 7 very important

34. How useful do you think men in advanced high school math (like Algebra II, Trigonometry, or Calculus) in their jobs?
not at all useful 1 2 3 4 5 6 7 very useful

35. In comparison to most of your other academic subjects, how good are you at math?
much worse 1 2 3 4 5 6 7 much better

36. How upset would you be if you got a low mark in math?
not at all upset 1 2 3 4 5 6 7 very much upset

37. How much does your mother like math?
not very much 1 2 3 4 5 6 7 very much

38. Is the amount of effort it will take to do well in your math course this year worthwhile to you?
not very worthwhile 1 2 3 4 5 6 7 very worthwhile

39. In comparison to your other academic subjects, how hard is math for you?
my easiest course 1 2 3 4 5 6 7 my hardest course

40. How hard does your mother think math is for you?
very easy 1 2 3 4 5 6 7 very hard

41. How well do you think your teacher expects you to do in math this year?
not very well 1 2 3 4 5 6 7 very well

42. How much do you think your teacher enjoys teaching math?
not very much 1 2 3 4 5 6 7 very much

43. How hard does your father think math is for you?
very easy 1 2 3 4 5 6 7 very well

44. How well do you think your father expects you to do in math this year?
not very well 1 2 3 4 5 6 7 very well

45. How well are you doing in school in general?
not so well 1 2 3 4 5 6 7 very well

46. How hard does your teacher think math is for you?
very easy 1 2 3 4 5 6 7 very hard

47. How well do you expect to do on your next math test?
not at all well 1 2 3 4 5 6 7 very well

48. How much do you like your math teacher?
not very much 1 2 3 4 5 6 7 very much

49. How much does your mother use math?
not very much 1 2 3 4 5 6 7 very much

50. How much does the amount of time you spend on math keep you from doing other things you would like to do?
takes away no time 1 2 3 4 5 6 7 takes away lot of time

51. How have you been doing in math this year?
very poorly 1 2 3 4 5 6 7 very well

52. Men need to have more math knowledge than women.
strongly disagree 1 2 3 4 5 6 7 strongly agree

53. Both men and women should have careers which require special skills.
strongly disagree 1 2 3 4 5 6 7 strongly agree

54. In order to get a high salary job, one needs to know mathematics.
strongly disagree 1 2 3 4 5 6 7 strongly agree

55. Men are better as scientists or engineers than women.
strongly disagree 1 2 3 4 5 6 7 strongly agree

56. If you tried as much as you could, how well do you think you could do in an advanced high school math course?
not very well 1 2 3 4 5 6 7 very well

Appendix H

LEARNING FACTOR ITEMS

(1) Study Regularity : 5 Items

1. I study for regular hours every day. 1 2 3 4 5 6 7 I study with no regularity.

3. I always review class lessens. 1 2 3 4 5 6 7 I never review class lessons.

4. I study at home every day. 1 2 3 4 5 6 7 I study lessons only in school.

5. I always prepare for class. 1 2 3 4 5 6 7 I never prepare for class.

7. I study according to a schedule. 1 2 3 4 5 6 7 I study when I feel like it.

(2) Study Independence/Task Preference: 7 Items

9. I learn only the fundamentals. 1 2 3 4 5 6 7 I learn by solving many problems.

10. I like to work at basic problems. 1 2 3 4 5 6 7 I like to work at advanced problems.

11. I try to memorize formulas. 1 2 3 4 5 6 7 I try to comprehend formulas.

13. When I can't solve a problem I rely on someone to help me. 1 2 3 4 5 6 7 Even when I have difficulty in solving a problem, I work at it myself.

18. I rely on answers solved by peers on the blackboard. 1 2 3 4 5 6 7 I try to solve problems myself, independent of my peers' answers.

19. I review my school textbooks or my notebooks. 1 2 3 4 5 6 7 I review using a reference book or by doing extra problems.

21. I try to take notes during lessons. 1 2 3 4 5 6 7 I try to listen during lessons.

(3) Study Habits: 5 Items

14. I throw away the papers (class notes or exams) which demonstrates the solution processes. 1 2 3 4 5 6 7 (Reverse coding item) I preserve the papers (class notes or exams) which demonstrates the solution processes.

15. While a classmate is orally responding to a question, I think of something else. 1 2 3 4 5 6 7 (Reverse coding item) While a classmate is orally responding to a question, I follow along carefully.

23. I write down answers as well as with my calculation process. 1 2 3 4 5 6 7 I write down answers only in my notes.

24. I always solve problems with the same effort as I do on exams. 1 2 3 4 5 6 7 When I solve problems do not put the same effort as I do on exams.

25. I give precedence to homework. 1 2 3 4 5 6 7 My own interests take precedence over the homework.

Appendix I

ATTITUDE TOWARD MATH FACTORS

(1) Perceived Ability / Expectancy : 5 Items

2. How good at math are you? not at all good 1 2 3 4 5 6 7 very good

7. Compared to other students in your class, how well do you expect to do in mathematics this year?
much worse than other students 1 2 3 4 5 6 7 much better than other students

16. If you were to order all the students in your math class from the worst to the best in math, where would you put yourself?
the worst 1 2 3 4 5 6 7 the best

47. How well do you expect to do on your next math test? not at all well 1 2 3 4 5 6 7 very well

51. How have you been doing in math this year? very poorly 1 2 3 4 5 6 7 vary well

(2) Perceived Task Value Items: 7 Items

Intrinsic/Interest value

1. In general, I find working on math assignments... very boring 1 2 3 4 5 6 7 very interesting

30. How much do you like doing math? not very much 1 2 3 4 5 6 7 very much

Attainment/Importance Value

23. I feel that, to me, being good at solving problems which involve math or reasoning mathematically is:
not at all important 1 2 3 4 5 6 7 very important

33. How important is it to you to get a good grade in math?
not at all important 1 2 3 4 5 6 7 very important

38. Is the amount of effort it will take to do well in your math course this year worthwhile to you?
not very worthwhile 1 2 3 4 5 6 7 very worthwhile

Extrinsic value

9. How useful is what you would learn in high school math (like Algebra II, Trigonometry, or Calculus) for what you want to do when you finish school and go to work?
not very useful 1 2 3 4 5 6 7 very useful

20. How useful is what you would learn in advanced high school math (like Algebra II, Trigonometry, or Calculus) for your daily life outside of school?
not at all useful 1 2 3 4 5 6 7 very useful

(3) Perceived Task Difficulty : 5 Items

Task Difficulty

4. In general, how hard is math for you? very easy 1 2 3 4 5 6 7 very hard

18. Compared to most others in your class, how hard is math for you?
much easier 1 2 3 4 5 6 7 much harder

39. In comparison to your other academic subjects, how hard is math for you?

my easiest course 1 2 3 4 5 6 7 my hardest course

Required Effort

27. To do well in math, I have to work .... (Reverse coding)
   1) ___ much harder in math than I do in other subjects
   2) ___ somewhat harder in math than I do in other subjects
   3) ___ a little harder in math than I do in other subjects
   4) ___ the same as in other subjects
   5) ___ a little harder in other subjects than I do in math
   6) ___ somewhat harder in other subjects than I do in math
   7) ___ much harder in other subjects than I do in math

32. How hard do you have to study for math test to get a good grade?

a little 1 2 3 4 5 6 7 a lot

Appendix J

SEX-STEREOTYPING FACTORS

(1) Beliefs about Math as a Male Domain :1 Item

26. In general, I think boys are.......
 1)___ much better than girls at math
 2)___ somewhat better than girls at math
 3)___ a little better than girls at math
 4)___ the same as girls at math
 5)___ a little worse than girls at math
 6)___ somewhat worse than girls at math
 7)___ much worse than girls at math

(2) Beliefs about Utility of Math for Men and for Women: 4 Items original
2 Items (item 14- item 11) & (item 34 - item 10)

10. How useful do you think women find advanced high school math (like Algebra II, Trigonometry, or Calculus) in their jobs?
not at all useful 1 2 3 4 5 6 7 very useful

11. How useful do you think women find advanced high school math for their everyday lives?

not at all useful 1 2 3 4 5 6 7 very useful

14. How useful do you think men find advanced high school math (like Algebra II, Trigonometry, or Calculus) for their everyday lives?
not at all useful 1 2 3 4 5 6 7 very useful

34. How useful do you think men in advanced high school math (like Algebra II, Trigonometry, or Calculus) in their jobs?
not at all useful 1 2 3 4 5 6 7 very useful

(3) Beliefs about Math Related Occupation : 2 Items

52. Men need to have more math knowledge than women.

strongly disagree 1 2 3 4 5 6 7 strongly agree

55. Men are better as scientists or engineers than women.

strongly disagree 1 2 3 4 5 6 7 strongly agree

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