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ABSTRACT

The Third International Mathematics and Science Study (TIMSS) offers a unique opportunity to examine some of the issues related to gender differences in mathematics achievement in an international context. TIMSS report of 8th grade mathematics achievement revealed few significant differences in mean achievement by gender; differences that did exist, however, tended to favor males. The TIMSS report of students in their final year of secondary school found significant gender differences favoring males in mathematics literacy (i.e., application of mathematics to everyday problems), and even greater differences favoring males in advanced mathematics. Previous cross-national studies, including TIMSS, have examined gender differences in secondary school mathematics achievement overall and by content area, but few have looked at gender differences in mathematics achievement by levels of achievement or according to the processes for problem solving involved in different mathematical tasks. In Part I of the study, TIMSS performance data were analyzed by gender for low-, middle-, and high-performers to determine if differences are related to overall achievement levels. Part 2 examined TIMSS performance data by gender and by cognitive demand to see if the processes for solving problems in mathematical tasks differ for males and females. Part 3 of the study examined TIMSS achievement data by gender and by item format to decide if performance differs for males and females by the type of item (i.e., multiple choice, short answer, or extended response). The study observed few differences in mathematics performance between 8th grade males and females by ability level. Larger gender differences developed in the 12th grade mathematics literacy assessment and even larger gender differences were observed in advanced mathematics. In the 12th grade, high-performing males (i.e., top 25%) tended to outperform females in a majority of the countries. In general, 12th grade males outperformed females on problem solving and multiple-choice items in both the mathematics literacy and advanced mathematics assessments. An examination of gender differences in mathematics performance by item format found few differences at the 8th grade level but larger differences in all three item formats in the 12th grade mathematics literacy and advanced mathematics assessments. Contains 62 references and 20 tables. (Author/WRM)

EXAMINING GENDER DIFFERENCES IN MATHEMATICS ACHIEVEMENT ON THE THIRD INTERNATIONAL MATHEMATICS AND SCIENCE STUDY (TIMSS)

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ABSTRACT

The Third International Mathematics and Science Study (TIMSS) offers a unique opportunity to examine some of the issues related to gender differences in mathematics achievement in an international context. TIMSS report of 8th grade mathematics achievement revealed few significant differences in mean achievement by gender; differences that did exist, however, tended to favor males. The TIMSS report of students in their final year of secondary school found significant gender differences favoring males in mathematics literacy (i.e., application of mathematics to everyday problems), and even greater differences favoring males in advanced mathematics. Previous cross-national studies, including TIMSS, have examined gender differences in secondary school mathematics achievement overall and by content area, but few have looked at gender differences in mathematics achievement by levels of achievement or according to the processes for problem solving involved in different mathematical tasks. In Part 1 of the study, TIMSS performance data was analyzed by gender for low-, middle-, and high-performers to determine if differences are related to overall achievement levels. Part 2 examined TIMSS performance data by gender and by cognitive demand to see if the processes for solving problems in mathematical tasks differ for males and females. Part 3 of the study examined TIMSS achievement data by gender and by item format to decide if performance differs for males and females by the type of item (i.e., multiple choice, short answer, or extended response). The study observed few differences in mathematics performance between 8th grade males and females by ability level. Larger gender differences developed in the 12th grade mathematics literacy assessment and even larger gender differences were observed in advanced mathematics. In the 12th grade, high-performing males (i.e., top 25%) tended to outperform females in a majority of the countries. In general, 12th grade males outperformed females on problem solving and multiple-choice items in both the mathematics literacy and advanced mathematics assessments. An examination of gender differences in mathematics performance by item format found few differences at the 8th grade but larger differences in all three item formats in the 12th grade mathematics literacy and advanced mathematics assessments.

Examining Gender Differences In Mathematics Achievement on the Third International Mathematics and Science Study (TIMSS)

INTRODUCTION

Students with a strong grasp of mathematics have an advantage in academics and in the job market (Riley, 1997). The United States Bureau of Labor Statistics (BLS) Occupational Outlook Handbook projects that in the next ten years jobs requiring the most mathematics education and training will be the fastest growing and the highest paying (U.S. BLS, 1997). As Stanic and Hart (1995) have noted, "knowledge of mathematics is essential for all members of society. In order to participate fully in democratic processes and to be unrestricted in career choice and advancement, individuals must be able to understand and apply mathematical ideas" (p. 258). Because males continue to outperform females in mathematics achievement, especially at the higher grades, there has been an increasing international concern about the gender gap. In order to achieve true equity, it is important to continue a line of inquiry into the nature of gender differences in mathematics achievement.

BACKGROUND AND PERSPECTIVES

The male advantage in mathematics achievement has resulted in numerous studies attempting to report and/or explain the gender differential in mathematics (Willingham & Cole, 1997; Secada, Fennema, & Adajian, 1995; Fennema & Leder, 1990; Chipman, Brush, and Wilson, 1985). Topics investigated include the role of gender in mathematics achievement for students from elementary school (Fennema, Carpenter, Jacobs, Franke, & Levi, 1998) to high school (Willingham & Cole, 1997; Chipman, Brush, and Wilson 1985), biological differences (Lynn & Petersen, 1986), developmental differences (Brush, 1986), examination of gender differences by mathematical subject area (Robitaille & Garden, 1989; Hanna, Kündiger, & Larouche, 1990), and student mathematical process strategies (Fennema & Carpenter, 1998). Many of the studies investigating gender differences in mathematics achievement have examined student performance in mathematics within the United States (NAGB, 1996; Reese, Miller, Mazzeo, and Dossey, 1997; Rock and Pollock, 1995) or within other countries (Robitaille and Garden, 1989; Beaton, Mullis, Martin, Gonzalez, Kelly, and Smith, 1996; Mullis, Martin, Beaton, Gonzalez, Kelly, and Smith, 1997; Mullis, Martin, Beaton, Gonzalez, Kelly, and Smith, 1998).

The backdrop of this paper on gender differences in mathematics achievement is the concern expressed by policy makers and educators about equitable mathematics achievement in the U.S. and internationally for males and females. In the U.S., the National Assessment of Educational Progress (NAEP) has reported gender differences favoring males on average mathematics scale scores and in mathematics subject content areas in the 12th grade (NAGB, 1996; Reese, et al., 1997). Despite recent NAEP reports that state gender differences in mathematics achievement are decreasing for 8th graders, a gap favoring males continues to exist for 12th graders (NAGB, 1997; Campbell, Voelkl, and Donahue, 1997).

In today's rapidly advancing technological world, knowledge of mathematics is imperative. Moreover, mathematics plays an important role in enabling students in the U.S. and around the world to address current

challenges in science, technology, and health. Thus, a strong educational system has substantial economic importance. To assist in improving education globally, the International Association for the Evaluation of Educational Achievement (IEA), an independent international cooperative of over 50 international research institutions and governmental research agencies, reports on the condition of education on a cross-national basis. The IEA's primary purpose is to conduct large-scale comparative studies of educational achievement, with the aim of gaining more of an understanding of policies and practices within and across systems of education (IEA Brochure, 1995). The IEA conducted the Third International Mathematics and Science Study (TIMSS) in 1994-95.

The Third International Mathematics and Science Study (TIMSS) that collected data in 1994-95 and is the largest and most ambitious IEA study to date (Mullis, Beaton, Martin, Gonzalez, Kelly, and Smith, 1998). TIMSS assessed more than half a million students in mathematics and science at five different grade levels in more than 40 countries (Martin and Kelly, 1997).

Purpose of Examining Gender Differences in Mathematics Achievement

The IEA's TIMSS offers a unique opportunity to examine some of the issues related to gender differences in mathematics achievement in an international context. An IEA report of gender differences in reading literacy in 32 countries, Are girls better readers?, provides valuable data and explanations for gender differences in reading literacy for two age levels (9-year-olds and 14-year olds) (Wagemaker, 1996). Paralleling the 1996 IEA Reading Literacy study, this study will use the TIMSS data to conduct an in-depth examination of gender differences. Since gender differences seem to increase during high school, analysis will be conducted for 8th graders and for students in their final year of secondary school in both mathematics literacy and advanced mathematics. The study will examine gender differences in mathematics achievement by students' achievement levels, by the cognitive processes involved in solving the mathematics items and by item format. Specifically for the United States and internationally, this study will focus on the following research questions:

1. Are females underrepresented among higher levels of achievement in mathematics?
2. Do females outperform males on rote learning mathematics items, and conversely do males outperform females on problem solving items?
3. Are differences in mathematics achievement between males and females related to the format of the items (i.e., multiple choice, short answer, or extended response)?

Significance of the Study

The existing literature examining the nature of secondary students' performance by gender on large-scale international assessment is limited. Studies examining gender differences in mathematics performance rarely go beyond reporting overall mean differences and differences by subject content area. Large-scale international surveys are a relatively recent development in the field of educational research, due in part to the increasing importance of education for global economies (Robitaille, et al., 1993).

In addition to the goal of shedding light on a previously unexplored area, a closer look at gender differences in secondary student's mathematics achievement using the rich TIMSS database could be of potential use to several audiences. First, contributions to the research on gender differences could useful to mathematics education reformers (e.g., NCTM) interested in understanding student's processes of inquiry. Investigating the nature of the

performance of individuals on TIMSS should provide educators with useful insights into how to improve mathematics curriculum to develop all students' procedural knowledge, conceptual understanding, and problem solving abilities in a more equitable manner. Moreover, international comparative studies provide an opportunity for countries to examine their own curriculum in broader context (Robitaille, et al., 1993).

Examining Gender Differences in the Eighth and Twelfth Grade – Data Source

In this paper, the examination of gender differences in mathematics achievement, in the United States and internationally, used the following three mathematics assessments (described below):

> **8th Grade Mathematics** Test: The 8th-grade mathematics test covered six content areas: fractions and number sense; measurement; proportionality, data representation, analysis, and probability; geometry; and algebra (Beaton, et al., 1996).
>
> **Final Year of Secondary School (12th Grade) Mathematics Literacy Test**: The mathematics literacy test was designed to measure the mathematics learning of all final-year students who are at the point of leaving school and entering the workforce or post-secondary education, regardless of their school curriculum. The purpose of this test was to measure the application of mathematics to everyday life (Mullis, et al., 1998).
>
> **Final Year of Secondary School (12th Grade) Advanced Mathematics Test**: The advanced mathematics test was developed to measure learning of advanced mathematics concepts among final-year students who have studied advanced mathematics. This test covered five content areas: numbers and equations, calculus, and geometry, probability and statistics, and validation and structure[1] (Mullis, et al., 1998).

The TIMSS mathematics assessments included mostly multiple-choice items, with a smaller number of short-answer, and extended response items (Martin & Kelly, 1997). Because some of constructed-response items were worth up to three points, and some items had two parts, the number of score points exceeds the number of items on the assessments (Beaton, et al., 1996; Mullis, et al., 1998). For the purpose of analysis, each level of partial credit is considered as a separate item; in terms of score points the number of score points exceeds the number of items by 12 in eighth grade mathematics, by 9 mathematics literacy items, and by 14 advanced mathematics items in the final year of secondary school.

TIMSS reported student achievement in mathematics overall and by content area for all three grade levels. When reporting overall results in the 4th, 8th, and 12th grade, TIMSS used item response theory (IRT) scaling procedures (Adams, Wu, and Macaskill, 1997). IRT scaling allows student performance to be reported on a common scale even when students have been administered different sets of items (Adams, Wu, and Macaskill, 1997). TIMSS overall achievement scores were transformed onto an international achievement scale with a mean of 500 and a standard deviation of 100 (Gonzalez, 1997). The common scale also makes it possible to make cross-national comparisons and to help show relationships between overall mathematics performance and background variables (Adams, Wu, and Macaskill, 1997).

[1] The advanced mathematics test included probability and statistics, and validation and structure items that were not scaled separately (i.e., by subject content area). The overall advanced mathematics scale did include these items.

Average proportion-correct technology was used for reporting mathematics achievement subject content area results by gender in 4th and 8th grade (Beaton and Gonzalez, 1997). The average proportion-correct approach allowed the averaging across items and made it possible to obtain standard errors which are necessary in statistical comparisons (Beaton and Gonzalez, 1997). Due to time and cost considerations, TIMSS decided to use average proportion-correct technology instead of IRT scaling (Beaton and Gonzalez, 1997). The IRT scaling procedure was used for reporting mathematics subject content area by gender for 12th graders (Mullis, et al., 1998). Like NAEP, when reporting gender differences, TIMSS reported mean mathematics achievement and subject content area results.

TIMSS reported differences between males and females for mathematics achievement overall and by content area (Beaton, et al., 1996; Mullis, et al., 1998). The rich TIMSS database includes much information that can be analyzed by gender. Few cross-national studies have examined gender differences in secondary school student mathematics achievement and even fewer have looked at mathematics according to the processes for problem solving involved in different mathematical tasks.

The Third International Mathematics and Science Study (TIMSS) report of 8th grade mathematics achievement revealed few significant differences in mean achievement by gender; differences that did exist, however, tended to favor males (Beaton, et al., 1996). The TIMSS report of students in their final year of secondary school found significant gender differences favoring males in mathematics literacy (i.e., application of mathematics to everyday problems), and even greater differences favoring males in advanced mathematics (Mullis, et al., 1998). Previous cross-national studies, including TIMSS, have examined gender differences in secondary school mathematics achievement overall and by content area, but few have looked at gender differences in mathematics achievement by levels of achievement or according to the processes for problem solving involved in different mathematical tasks.

Countries Included in the Study

This analysis will include only countries with approved sampling procedures and adequate participation rates in the testing of 8th graders. As a result of the approach taken, the number of countries included in this study are a subset of the number of countries listed in previous TIMSS reports.[2] The countries included in this study are shown in Table 1.

Insert Table 1 about here

Statistically Significant Differences

In order to determine if statistically significant differences exist between males' and females' average mathematics achievement scores on TIMSS, an estimate of the degree of uncertainty associated with the difference between the averages of males and females must be calculated. TIMSS reported estimates of males and females mathematics achievement are based on samples of students, therefore it is important to have measures of uncertainty of the estimates (Martin and Kelly, 1997). The standard error of the difference between males and females will be

[2] A listing of participating countries is available in *Mathematics Achievement in the Middle School Years* (Beaton, et al, 1998) and in *TIMSS Mathematics and Science in the Final Year of Secondary School* (Mullis, et al, 1998).

obtained by taking the square root of each group's jackknifed standard error, summing the squared standard errors, and taking the square root of that sum, where M represents males and F represents females (Johnson and Rust, 1992; Beaton and Gonzalez, 1997).

$$\textit{Standard Error of the Differences} = SE_{M-F} = \sqrt{SE_{M^2} + SE_{F^2}}$$

In order to compare males and females from many different countries multiple sets of confidence intervals must be analyzed. To identify differences between males and females mathematics achievement scores, across several countries, a multiple comparison procedure (i.e., Bonferroni method) will be used to hold the significance level at 0.05 (Beaton and Gonzalez, 1997).

This Study

This study will take advantage of the rich TIMSS database (IEA, 1997) using mathematical scale scores, item responses, background questionnaires, and student sampling weights in order to investigate gender differences in mathematics achievement for the following two TIMSS international populations (Foy, 1997; Mullis, et al., 1998):

> **Upper grade (8th Grade) of TIMSS Population 2**: students enrolled in the upper of the two adjacent grades that contain the largest proportion of students of age 13 years at the time of testing. The upper of these two grades represented eight years of formal schooling in most countries or the 8th grade in the United States (Beaton, et al., 1996).
>
> **Final Year of Secondary School (12th Grade) of TIMSS Population 3**: students in their final year of secondary education, including students in vocational education programs; Final Year of Secondary School has two optional subpopulations: students having taken advanced mathematics and students having taken physics. The final year of secondary school represented twelve years of formal schooling in most countries or the 12th grade in the United States (Martin and Kelly, 1997)

In Part 1 of the study, TIMSS performance data will be analyzed by gender for low-, middle-, and high-performers to determine if differences are related to overall achievement levels. Part 2 will examine TIMSS performance data by gender and by cognitive demand[3] to see if the processes for solving problems in mathematical tasks differ for males and females. Part 3 of the study will examine TIMSS achievement data by gender and by item format to decide if performance differs for males and females by the type of item (i.e., multiple choice, short answer, or extended response).

[3] Cognitive demand , knowing and procedures as differentiated from reasoning and problem solving, was developed in conjunction with the TIMSS performance expectations or aspects as a way of describing the expected behavior students' may exhibit when completing a mathematics item. Knowledge and reasoning are the two dimensions most commonly used when investigating large-scale mathematics achievement results (NAEP, 1996; Kuppermintz, et al, 1995; Kuppermintz and Snow, 1997).

Gender Differences for Low- and High- Performing Students

Few differences in mathematics have been found to exist between males and females in the 8th grade but as students get older males tend to outperform females in mathematics achievement. Some previous studies have found that these gender differences are not distributed uniformly across the ability range. For example, Willingham and Cole (1997) found that males outnumber females in the top 10 percent on mathematics tests 1.5 to 1, and more males than females scoring in the lowest 10 percent of mathematics tests. The following analysis will be performed to explore the distribution of test scores for males and females in the TIMSS data. In particular, are females underrepresented among higher levels of achievement in mathematics?

In part 1 of the study, TIMSS achievement data will be analyzed by gender for low-, middle-, and high-performers to determine if gender differences in mathematics achievement are related to overall achievement levels. Students will be placed into one of three groups based on their performance on the mathematics achievement tests. The three groups represent low performing students - bottom 25%, the middle performing students - middle 50%, and the high performing students - top 25% part of the distribution. The cutoff scores corresponding to the percentiles are presented in Appendix A - each percentile point indicates the percentages of students performing below and above that point on the scale. For example, in the United States, 25% of 8th graders scored below the score of 435, 50% of 8th graders scored between 435 and 563, and 25% scored above 563 or above the 75th percentile.

To explore the distribution of test scores for males and females, the percentage of students by gender will be calculated for each performance range for each country and each grade. The student percentages will undergo a logit transformation used to transform the percents correct into an additive scale that permits simple and appropriate arithmetic calculations on proportions (Beaton and Gonzalez, 1997)

$$\ell n\left(\frac{P_g}{1-P_g}\right)$$

where $\boldsymbol{P}$ is the mean p-value
and g is the gender of the student.

In addition, differences in percentages by gender for low-, middle-, and high-performing students will be presented. Significant differences between males and females will be highlighted.

In order to determine if males outperform females in the top 25% and in the lowest 25% of the performance distribution, differences between males and females must be examined. For each grade and each country, average mathematics achievement scores will be calculated for males and females in the low, middle, and high ranges of the performance distribution. For each grade and each country, differences between males and females in average mathematics performance will be determined and tested to see if the average male scores are significantly higher than the average female scores. The mean score for females will be subtracted from the mean score for females for each

jackknife pseudo-replication[4] of the sample. This method takes into account that for TIMSS, males and females come from the same school or class, therefore the sample of males and is not completely independent of females. Significant differences between males and females in average mathematics performance will be identified for each grade and for each country. Standard errors will be presented.

Gender Differences in Mathematics Achievement by Cognitive Demand

Previous large-scale assessments have found that males have traditionally outperformed females on items requiring higher-order thinking skills (Garden and Robitaille, 1989; Hanna, et al., 1990; Willingham and Cole, 1997). For rote knowledge items, the difference between males and females mathematics performance is not as great. The TIMSS curriculum framework was developed to provide the schema for further investigating the nature of differences in mathematics achievement. The content aspect is a breakdown of the subject matter into varying levels of specificity. The content aspect of the mathematics framework is partitioned into ten major categories listed as follows: numbers, measurement, geometry: position, geometry: symmetry, proportionality, functions, data representation, elementary analysis, validation and structure, and other content (Robitaille, et al., 1993).

The performance expectations or aspects are a reconceptualization of the cognitive-behavior dimension which were used in earlier studies to categorize curriculum units or achievement test items (Robitaille, 1993). The performance expectations or processes of inquiry involve the concepts of understanding, investigating, and communicating. In the TIMSS frameworks, performance expectation aspects describe the kinds of performance that students will be expected to demonstrate while engaged with the content. Their purpose is to describe, in a non-hierarchical way, the many kinds of performance or behavior that a given test item might elicit from students. The five main categories of performance expectations in mathematics are: knowing, using routine procedures, investigating and problem solving, and communicating (Robitaille, et al., 1993).

For this study, items formerly classified by one of five TIMSS performance expectations (i.e., knowing, using, mathematical reasoning, problem solving, and communicating) will be reclassified into two classifications: knowing/using procedures, and reasoning/problem solving. Collapsing the items into the two classifications was necessary due to the varied number of TIMSS items in each of the performance expectations and to maintain the two primary dimensions for investigating mathematics achievement in large-scale assessments. As shown in Table 2, TIMSS' cognitive demand classification scheme is similar to other large-scale assessments such as NAEP or NELS:88 (NAEP, 1997; Kuppermintz and Snow, 1997).

Insert Table 2 about here

[4]For information on jackknifing procedures used in standardizing the TIMSS international scale scores see *TIMSS Technical Report Volume II: Implementation and Analysis Primary and Middle School Years* (Martin and Kelly, 1997).

For this study, the TIMSS achievement data will be analyzed for gender differences by cognitive demand or performance expectation -- knowledge and reasoning which have been identified as the primary dimensions for investigating mathematics achievement in large-scale assessments (Hiebert, 1987; Mullis, 1991). The nature of mathematics performance is generally subdivided into two categories: computation and problem solving (Hyde and Lynn, 1986). A recent investigation on the dimensionality of the NELS:88 mathematics tests indicates that these tests have two meaningful dimensions – mathematical knowledge and mathematical reasoning (Kuppermintz, et al., 1995; Kuppermintz and Snow, 1997). As shown in Appendix B, TIMSS items formerly coded as knowing items or using routine procedure items (i.e., TIMSS performance expectation) were collapsed into the knowing / using cognitive demand; similarly, investigating and problem solving items, mathematical reasoning items, and communicating items were collapsed into the solving problems cognitive demand.

For each grade and each country, average mathematics performance will be calculated for TIMSS items by cognitive demand for males and females. Differences between males and females in average mathematics performance will be determined by testing to see if male averages are significantly different than the female averages. Standard errors will be presented. The two cognitive demand dimensions were not constructed using scale scores, as a result average percent correct technology that TIMSS used to determine achievement and differences in performance by subject content in the 8th grade will be used here.

The procedures used to identify the relative differences in mathematics performance by males and females across the cognitive demand dimensions are analogous to TIMSS' relative performance by content area[5] (Beaton and Gonzalez, 1997) . As a result, the relative performance for males and females within each country on the cognitive demand dimensions will be examined separately for each cognitive demand (Beaton and Gonzalez, 1997). The average mathematics performance or p-value for males and females will be converted into logits using the formula below to show differences while controlling for any potential interaction effect.

$$\ell n\left(\frac{P_g}{1-P_g}\right)$$

where $\boldsymbol{P}$ is the mean p-value
and **g** is the gender of the student.

For more information on relative performance by content area please read (Beaton and Gonzalez, 1997).

International Gender Differences in Mathematics Achievement by Item Format

In part 3 of this study, gender differences in mathematics achievement will be examined by item format – does the specific format of TIMSS items influence the relative performance of males and females? TIMSS used three types of items: multiple-choice, short answer (scored dichotomously as correct or incorrect), and extended response (scored according to a partial credit model) (Beaton and Gonzalez, 1997). Previous studies on gender

[5] In addition to performance on mathematics overall, it was of interest to see how countries performed on the content areas within each subject relative to their performance on the subject overall.

differences on standardized tests have found that multiple-choice items favor males and constructed response favor females (Klein, et al, 1997; Chipman, et al., 1985; Haney, 1981). Yet, Willingham and Cole (1997) suggest that gender differences in item format may more likely be related to the "types of constructs" tapped by items. The 1992 NAEP examination of student performance by gender on multiple choice versus constructed response items showed little evidence of any format effect associated with gender (Dossey, et al., 1993). Despite studies showing little or no differences in achievement related to item format, males and females often perform differently on items of differing format, therefore an examination of gender differences by item format will be undertaken for this study.

TIMSS used IRT scale scores for determining overall mean achievement scores, however, TIMSS used average percent correct technology to report mathematics achievement results for subject content areas by gender (Martin and Kelly, et al., 1997). This study of gender performance differences by items format will use average proportion correct technology to compute the students' average mathematics performance. For each grade and each country, the average percent correct will be calculated for males and females for each type of item: multiple-choice, short-answer, and extended response. Log odd differences between males and females in average mathematics performance will be determined to see if males score significantly higher than females. Jackknifed standard errors will be presented. The distribution of TIMSS items by item format are presented in Appendix C.

RESULTS

Results for Part 1 of this study are presented in Tables 3-5; Part 2 results are presented in Tables 6-8; Part 3 results are presented in Tables 9-11. For the purposes of this paper, only U.S. and international results will be discussed.

For Part 1 of this study TIMSS achievement data were analyzed by gender for low-, middle-, and high-performing students in the 8th grade, and in mathematics literacy and advanced mathematics in the 12th grade. For each country mean scores and standard errors were calculated for males and females so that differences could be determined. Sampling weights provided in the TIMSS database for the three grades were used in the calculation of these results.

As presented in Table 3, there are no statistically significant differences between 8th grade males and females in the United States in the low-, middle-, and high-performing groupings. Upon closer examination of the high performing students, males outperformed females in a majority of the countries. For the high-performing 8th graders overall (i.e., international), males significantly outperformed females.

Insert Table 3 about here

Table 4 shows no statistically significant differences between 12th grade U.S. males and females in the low-, middle-, and high-performing groupings on the mathematics literacy assessment. Although the average differences between U.S. 12th grade males and females on the mathematics literacy assessment were not statistically significant, the males outperformed the females in all three groupings and the difference was greatest at the high performing level. Statistically significant differences between international 12th grade males and females were found in both the middle-, and high-performing levels.

Insert Table 4 about here

As presented in Table 5, the achievement differences between U.S. 12th grade males and females taking the advanced mathematics assessment were similar to those found in Table 4. U.S. 12th grade males outperformed their female counterparts in all three groupings but the differences were not statistically significant. The greatest difference between U.S. 12th grade males and females in the advanced grouping was found at the high performing level. Statistically significant differences between international 12th grade males and females were found at the high-performing level.

Insert Table 5 about here

In Part 2 of this study, average mathematics performance were calculated for TIMSS items by cognitive demand (described earlier) for males and females. Differences between males and females in average mathematics performance were determined by testing to see if male averages are significantly different than the female averages. Standard errors are presented. The two cognitive demand dimensions were not constructed using scale scores, as a result average percent correct technology that TIMSS used to determine achievement and differences in performance by subject content in the 8th grade will be used here.

The procedures used to identify the relative differences in mathematics performance by males and females across the cognitive demand dimensions are analogous to TIMSS' relative performance by content area[6] (Beaton and Gonzalez, 1997). As a result, the relative performance for males and females within each country on the cognitive demand dimensions were examined separately for each cognitive demand (Beaton and Gonzalez, 1997).

As presented in Table 6, there were no real differences between U.S. 8th grade males and females on the TIMSS mathematics assessment. Upon closer examination both males and females performed better on Knowing and Procedures items compared to Reasoning and Problem Solving items. Statistically significant differences between international 8th grade males and females were found on the Reasoning and Problem Solving items.

Insert Table 6 about here

Table 7 shows that in the U.S. for students taking the mathematics literacy assessment there were no real differences between males and females. Once again, both males and females performed better on Knowing and Procedures items compared to Reasoning and Problem Solving items. In a majority of countries and internationally, however, males significantly outperformed females both the Knowing and Procedures items and the Reasoning and Problem Solving items.

[6] In addition to performance on mathematics overall, it was of interest to see how countries performed on the content areas within each subject relative to their performance on the subject overall.

Insert Table 7 about here

As presented in Table 8, U.S. males significantly outperformed females on the 12th grade advanced mathematics assessment on those items classified as Reasoning and Problem Solving items. For the advanced group males and females performed better on Knowing and Procedures items compared to Reasoning and Problem Solving items. As with the mathematics literacy group, males significantly outperformed females both the Knowing and Procedures items and the Reasoning and Problem Solving items in a majority of countries and internationally.

Insert Table 8 about here

In part 3 of this study, gender differences in mathematics achievement were examined by item format – multiple-choice, short answer (scored dichotomously as correct or incorrect), and extended response (scored according to a partial credit model) (Beaton and Gonzalez, 1997). This study of gender performance differences by items format used average proportion correct technology to compute the students' average mathematics performance. For each grade and each country, the average percent correct was calculated for males and females for each type of item. Significant differences between males and females in average mathematics performance are based on log odd differences. Jackknifed standard errors are presented.

As presented in Table 9, there were no differences between U.S. 8th grade males and females on the mathematics assessment. The lack of significant gender differences on the 8th grade assessment within each item format category are consistent with what is generally reported in the literature, especially for 8th grade students. Statistically significant differences between international 12th grade males and females were found on multiple choice items.

Insert Table 9 about here

As Table 10 shows, there were no statistically significant differences between U.S. 12th grade males and females on the TIMSS mathematics literacy assessment. The differences that were found showed that males outperformed females on both multiple choice and short answer items. In a majority of countries, statistically significant differences favoring males were found in both item formats administered in the mathematics literacy assessment. In addition, both males and females scored much higher on the multiple choice items in contrast to their relatively lower performance on the short answer items.

Insert Table 10 about here

Table 11 presents the average percent correct by item format for 12th grade students who took the advanced mathematics assessment. There were statistically significant differences between U.S. 12th grade males and females on items on the constructed response items. U.S. males outperformed females on both multiple choice and short

answer items but the differences were not significant. In a majority of countries, statistically significant differences favoring males were found in all three item formats included in the advanced mathematics assessment. Once again, both males and females scored much higher on the multiple choice items in contrast to their relatively lower performance on the short answer items.

Insert Table 11 about here

Conclusions

The present study explored some potential gender differences in mathematics achievement using data from the IEA's Third International Mathematics and Science Assessment. Specifically, this study looked at the mathematics achievement data of males and females on the 8th mathematics assessment, and on a mathematics literacy and an advanced mathematics assessment in the 12th grade.

In Part 1 of the study, TIMSS performance data was analyzed by gender for low-, middle-, and high-performers to determine if differences are related to overall achievement levels. Part 2 examined TIMSS performance data by gender and by cognitive demand to see if the processes for solving problems in mathematical tasks differ for males and females. Part 3 of the study examined TIMSS achievement data by gender and by item format to decide if performance differs for males and females by the type of item (i.e., multiple choice, short answer, or extended response).

The study observed few differences in mathematics performance between 8th grade males and females. Greater gender differences developed in the 12th grade mathematics literacy assessment and even larger gender differences were observed. In the 12th grade, high-performing males (i.e., top 25%) tended to outperform females in a majority of the countries. This finding is concurrent with the literature that argues that although gender differences are shrinking overall males typically outperform their female counterparts at the high end of the ability distribution (Fennema, et al, 1997). In general, 12th grade males outperformed females on items classified as problem solving items and multiple-choice items in both the mathematics literacy and advanced mathematics assessments. An examination of gender differences in mathematics performance by item format found few differences at the 8th grade but larger differences in all three item formats in the 12th grade.

The observed gender differences in these three analyses is practically meaningful and warrants our attention, since these students are very likely to be those going into science, mathematics, technology, or engineering related areas. The general pattern of increasing gender differences by 12th grade both in the United States and internationally is a signal to educators and policy makers that the current curricular practices are not giving females an equal mathematical experience.

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Table 1

TIMSS Countries Testing in 8th Grade Mathematics, and in Mathematics Literacy and Advanced Mathematics in the Final Year of Secondary School (12th Grade)

Population 2 – 8th Grade Mathematics (34 countries)	Population 3 Final Year of Secondary School Mathematics Literacy (19 countries)	Population 3 Final Year of Secondary School Advanced Mathematics (14 countries)
Australia	Australia	Australia
Austria	Austria	Austria
Belgium (Fl)	Canada	Canada
Belgium (Fr)	Cyprus	Cyprus
Canada	Czech Republic	Czech Republic
Colombia	France	France
Cyprus	Germany	Germany
Czech Republic	Hungary	Italy
England	Iceland	Lithuania
France	Italy	Russian Federation
Germany	Lithuania	Slovenia
Hong Kong	Netherlands	Sweden
Hungary	New Zealand	Switzerland
Iceland	Norway	United States
Iran, Islamic Rep.	Russian Federation	
Ireland	Slovenia	
Japan	Sweden	
Korea	Switzerland	
Latvia (LSS)	United States	
Lithuania		
Netherlands		
New Zealand		
Norway		
Portugal		
Romania		
Russian Federation		
Scotland		
Singapore		
Slovak Republic		
Slovenia		
Spain		
Sweden		
Switzerland		
United States		

SOURCE: (MARTIN AND KELLY, 1997)

Table 2

Primary Dimensions for Investigating Mathematics Achievement for NELS:88, NAEP, TIMSS, and Gender Analysis

Dimension	NELS:88[1]	NAEP[2]	TIMSS[3]	Cognitive Demand
1 Knowledge	• Mathematical Knowledge	• Procedural Knowledge or Conceptual Understanding	• Knowing • Using Routine Procedures	• Knowing and Using Procedures
2 Reasoning	• Mathematical Reasoning	• Problem Solving	• Investigating and Problem Solving • Mathematical Reasoning • Communicating	• Reasoning and Problem Solving

[1] Kuppermintz and Snow, (1997); Kuppermintz, et al., (1995).
[2] Mullis, et al., (1994); Mullis, (1991); Mullis, et al., (1993)
[3] Robitaille, et al., 1993; Beaton, et al, (1996); Mullis, et al., (1998)

Table 3

Differences in Achievement in Mathematics by Gender for Low-, Middle-, and High-Performing Students

Mathematics - Eighth Grade*

Country	Low Performing		Middle Performing		High Performing	
	Males	Females	Males	Females	Males	Females
Australia	403 (5.0)	407 (2.8)	528 (5.8)	529 (3.6)	656 (5.1)	657 (4.6)
Austria	423 (5.4)	423 (4.5)	537 (3.6)	539 (4.0)	660 (4.0)	655 (4.0)
Belgium (Bl)	439 (14.1)	454 (4.9)	565 (7.1)	568 (5.7)	685 (4.0)	678 (4.2)
Belgium (Br)	413 (10.0)	418 (5.4)	528 (6.6)	528 (3.9)	636 (4.1)	631 (4.8)
Canada	415 (2.6)	422 (5.1)	527 (2.6)	526 (3.5)	639 (3.8)	639 (4.2)
Colombia	309 (4.8)	311 (3.2)	380 (4.5)	380 (2.7)	470 (7.5)	469 (5.6)
Cyprus	365 (3.3)	367 (3.1)	469 (3.0)	471 (2.7)	592 (3.7)	585 (3.7)
Czech Republic	448 (3.0)	449 (4.5)	559 (5.6)	559 (6.6)	688 (6.8)	687 (7.8)
England	391 (2.6)	389 (5.7)	502 (3.4)	503 (3.5)	628 (4.6)	628 (4.0)
France	447 (4.1)	443 (3.9)	537 (2.9)	536 (4.2)	638 (3.5)	638 (5.4)
Germany	404 (4.9)	398 (3.9)	508 (6.1)	505 (4.9)	629 (5.6)	625 (5.7)
Hong Kong	453 (12.4)	460 (9.2)	594 (6.9)	590 (6.0)	713 (6.0)	709 (5.9)
Hungary	424 (4.0)	419 (4.4)	536 (4.6)	532 (3.4)	657 (4.5)	660 (3.9)
Iceland	390 (6.6)	395 (4.2)	482 (7.9)	486 (3.8)	586 (5.0)	587 (6.3)
Iran, Islamic Rep.	357 (2.5)	356 (3.2)	427 (2.1)	422 (2.6)	507 (3.2)	506 (3.0)
Ireland	406 (7.3)	414 (4.9)	527 (5.8)	524 (5.9)	649 (4.4)	645 (7.3)
Japan	469 (2.5)	† 478 (3.2)	609 (2.4)	604 (2.3)	736 (2.6)	730 (2.2)
Korea	467 (5.6)	467 (3.5)	611 (2.7)	608 (3.3)	745 (3.2)	741 (4.5)
Latvia (LSS)	396 (4.3)	393 (3.4)	487 (3.8)	489 (3.0)	603 (5.1)	603 (4.6)
Lithuania	378 (5.3)	378 (3.5)	473 (4.8)	476 (3.6)	583 (5.2)	581 (4.6)
Netherlands	428 (10.8)	426 (10.0)	540 (7.5)	539 (8.1)	656 (8.1)	654 (7.5)
New Zealand	394 (6.0)	397 (3.1)	506 (5.6)	504 (4.8)	627 (5.9)	624 (6.1)
Norway	401 (3.8)	399 (2.2)	500 (2.9)	500 (2.3)	617 (2.9)	609 (4.0)
Portugal	380 (2.9)	376 (2.1)	452 (2.9)	448 (2.2)	540 (4.4)	538 (3.5)
Romania	370 (3.1)	372 (4.7)	478 (4.3)	477 (5.9)	602 (4.7)	597 (6.2)
Russian Federation	415 (5.4)	423 (6.1)	535 (6.9)	535 (6.3)	659 (4.9)	648 (4.3)
Scotland	393 (4.0)	391 (4.0)	494 (5.9)	493 (6.1)	619 (8.4)	610 (7.3)
Singapore	531 (6.2)	533 (5.3)	642 (5.9)	643 (5.4)	754 (5.1)	758 (5.0)
Slovak Republic	431 (6.1)	433 (2.7)	543 (6.0)	545 (3.3)	667 (3.9)	667 (5.4)
Slovenia	429 (3.8)	432 (3.2)	540 (3.8)	536 (3.9)	658 (4.0)	654 (3.5)
Spain	400 (2.1)	398 (2.7)	484 (2.4)	482 (2.6)	588 (3.6)	583 (3.6)
Sweden	415 (3.4)	409 (4.1)	517 (3.2)	516 (3.7)	632 (3.9)	626 (2.6)
Switzerland	430 (4.2)	435 (5.4)	548 (2.3)	546 (3.7)	657 (2.7)	653 (3.2)
United States	386 (4.1)	389 (4.1)	496 (5.2)	496 (5.5)	618 (4.9)	621 (6.7)
International	412 (1.0)	413 (0.8)	520 (0.9)	519 (0.8)	† 637 (0.9)	634 (0.9)

* Eighth Grade in most countries; see Appendix D for information about the grades tested in each country.
† Difference from other gender statistically significant at .05 level, adjusted for multiple comparisons.
( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.
SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

Table 4

Differences in Achievement in Mathematics by Gender for Low-, Middle-, and High-Performing Students

Mathematics Literacy - Final Year of Secondary School*

Country	Low Performing		Middle Performing		High Performing	
	Males	Females	Males	Females	Males	Females
Australia	397 (16.0)	399 (12.8)	525 (12.9)	521 (9.2)	649 (8.3)	639 (14.5)
Austria	420 (10.3)	421 (4.4)	521 (7.6)	514 (5.6)	628 (8.9)	617 (7.0)
Canada	413 (4.3)	405 (4.9)	517 (3.7)	516 (4.3)	643 (4.6)	628 (4.6)
Cyprus	354 (8.1)	359 (3.4)	444 (5.3)	442 (2.8)	545 (6.8)	536 (4.9)
Czech Republic	361 (6.3)	346 (13.7)	456 (10.8)	453 (17.9)	† 611 (13.4)	588 (12.8)
France	424 (6.1)	422 (6.4)	528 (5.7)	519 (5.5)	629 (8.7)	619 (5.3)
Germany	388 (8.6)	371 (10.3)	496 (7.5)	494 (7.9)	618 (8.9)	612 (7.5)
Hungary	369 (4.3)	372 (3.0)	477 (4.6)	479 (3.3)	613 (6.4)	596 (5.9)
Iceland	432 (4.1)	422 (2.8)	537 (3.1)	528 (3.2)	652 (4.5)	643 (4.8)
Italy	367 (7.3)	366 (9.6)	476 (5.7)	474 (6.7)	591 (8.4)	581 (9.3)
Lithuania	366 (9.4)	359 (8.8)	470 (5.0)	470 (7.9)	581 (6.0)	574 (6.9)
Netherlands	450 (8.3)	437 (6.9)	567 (4.8)	559 (6.5)	674 (7.0)	668 (8.8)
New Zealand	397 (11.2)	394 (7.4)	526 (7.2)	518 (4.1)	653 (4.6)	638 (4.8)
Russian Federation	414 (5.9)	412 (5.7)	530 (5.7)	518 (3.9)	657 (7.3)	641 (4.7)
Norway	374 (5.2)	365 (5.1)	468 (8.0)	463 (6.6)	586 (10.0)	584 (13.3)
Slovenia	400 (20.7)	400 (9.6)	520 (8.4)	512 (9.8)	625 (8.5)	612 (12.0)
Sweden	428 (6.4)	428 (4.8)	552 (5.3)	546 (4.1)	687 (6.2)	670 (7.2)
Switzerland	433 (7.0)	422 (9.6)	541 (6.6)	539 (7.3)	† 658 (4.7)	645 (4.3)
United States	353 (2.6)	350 (5.1)	457 (3.9)	454 (3.9)	586 (6.3)	577 (4.8)
International	397 (2.1)	392 (1.8)	† 506 (1.6)	501 (1.7)	† 626 (1.8)	614 (1.9)

* See Appendix D for Characteristics of Students Sampled
† Difference from other gender statistically significant at .05 level, adjusted for multiple comparisons.
( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.
SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

Table 5

Differences in Achievement in Mathematics by Gender for Low-, Middle-, and High-Performing Students

Advanced Mathematics - Final Year of Secondary School*

Country	Low Performing		Middle Performing		High Performing	
	Males	Females	Males	Females	Males	Females
Australia	387 (20.2)	379 (23.7)	529 (11.5)	528 (9.7)	658 (17.2)	657 (11.5)
Austria	331 (20.6)	315 (14.1)	449 (7.1)	435 (8.0)	555 (8.9)	533 (7.2)
Canada	388 (4.3)	385 (8.9)	509 (4.5)	507 (6.7)	† 645 (8.3)	617 (5.9)
Cyprus	401 (7.7)	414 (10.2)	521 (4.0)	522 (5.2)	626 (8.1)	611 (7.7)
Czech Republic	364 (8.7)	347 (9.9)	466 (10.4)	452 (9.2)	618 (21.9)	595 (24.0)
France	470 (6.2)	468 (5.5)	560 (4.8)	557 (4.6)	647 (4.4)	641 (8.0)
Germany	359 (8.6)	359 (7.4)	468 (6.1)	463 (7.6)	578 (6.5)	568 (7.8)
Italy	356 (18.4)	348 (18.6)	478 (9.2)	475 (10.2)	588 (11.5)	594 (31.3)
Lithuania	415 (8.7)	413 (5.5)	515 (3.3)	510 (4.7)	632 (6.2)	613 (16.9)
Russian Federation	411 (8.7)	398 (14.3)	544 (10.1)	535 (10.1)	690 (12.0)	679 (17.2)
Slovenia	361 (12.2)	353 (8.6)	471 (12.9)	473 (8.9)	601 (12.3)	584 (8.9)
Sweden	403 (7.5)	404 (7.4)	513 (4.4)	511 (8.4)	624 (5.5)	603 (12.3)
Switzerland	433 (6.6)	424 (7.7)	532 (6.4)	522 (5.6)	† 657 (8.5)	632 (8.2)
United States	326 (7.4)	321 (6.5)	439 (8.3)	436 (8.2)	574 (8.6)	563 (13.1)
International	386 (3.1)	381 (3.1)	499 (2.1)	495 (2.1)	† 621 (2.9)	606 (3.9)

* See Appendix D for characteristics of students sampled.
† Difference from other gender statistically significant at .05 level, adjusted for multiple comparisons.
( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.
SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

Table 6

Average Percent Correct by Cognitive Demand and Gender Mathematics - Eighth Grade*

Country	Knowing and Procedures		Reasoning and Problem Solving	
	Males	Females	Males	Females
Australia	61 (1.1)	62 (1.0)	52 (1.3)	53 (1.2)
Austria	65 (0.8)	65 (1.1)	58 (0.9)	56 (1.4)
Belgium (Fl)	69 (2.0)	70 (1.7)	59 (2.0)	60 (2.3)
Belgium (Fr)	63 (1.1)	62 (0.9)	53 (1.3)	52 (1.1)
Canada	62 (0.8)	63 (0.6)	53 (0.9)	54 (0.7)
Colombia	33 (1.7)	32 (0.9)	25 (1.4)	23 (1.3)
Cyprus	50 (0.7)	52 (0.6)	42 (0.9)	42 (0.8)
Czech Republic	71 (1.0)	69 (1.1)	59 (1.2)	57 (1.7)
England	56 (1.2)	56 (0.9)	49 (1.5)	48 (1.1)
France	67 (0.7)	66 (0.9)	54 (1.0)	52 (1.1)
Germany	59 (1.2)	59 (1.2)	46 (1.5)	46 (1.3)
Hong Kong	75 (1.6)	71 (1.7)	66 (1.9)	62 (1.9)
Hungary	66 (0.9)	67 (0.8)	53 (0.9)	53 (1.0)
Iceland	53 (1.1)	54 (1.3)	44 (1.7)	44 (1.4)
Iran, Islamic Rep.	43 (0.9)	40 (0.9)	33 (0.8)	30 (0.9)
Ireland	62 (1.6)	60 (1.3)	56 (1.8)	54 (1.6)
Japan	78 (0.5)	76 (0.4)	67 (0.6)	67 (0.5)
Korea	77 (0.6)	74 (0.7)	† 67 (0.8)	63 (0.9)
Latvia (LSS)	56 (1.0)	56 (0.9)	45 (1.1)	43 (1.0)
Lithuania	53 (1.1)	54 (1.1)	40 (1.2)	40 (1.1)
Netherlands	64 (1.6)	61 (1.5)	55 (2.3)	54 (1.8)
New Zealand	58 (1.3)	56 (1.2)	49 (1.5)	48 (1.4)
Norway	56 (0.6)	57 (0.6)	49 (0.7)	48 (0.7)
Portugal	48 (0.9)	46 (0.8)	37 (0.8)	35 (0.7)
Romania	53 (1.2)	53 (1.0)	43 (1.2)	43 (1.1)
Russian Federation	64 (1.5)	66 (1.1)	52 (1.3)	52 (1.6)
Scotland	56 (1.6)	53 (1.2)	49 (2.0)	46 (1.5)
Singapore	80 (1.0)	81 (0.9)	76 (1.2)	77 (1.2)
Slovak Republic	68 (0.9)	67 (0.8)	54 (0.9)	54 (1.0)
Slovenia	67 (0.8)	65 (0.8)	54 (1.0)	52 (0.8)
Spain	57 (0.7)	54 (0.7)	45 (0.9)	43 (0.8)
Sweden	58 (0.7)	58 (0.7)	51 (1.0)	52 (1.0)
Switzerland	65 (0.8)	64 (0.7)	59 (1.0)	57 (0.8)
United States	58 (1.2)	57 (1.1)	46 (1.2)	45 (1.2)
International	61 (0.2)	60 (0.2)	† 51 (0.2)	50 (0.2)

* Eighth Grade in most countries; see Appendix D for information about the grades tested in each country.
† Difference from other gender statistically significant at .05 level, adjusted for multiple comparisons.
( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.
SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

Table 7

Average Percent Correct by Cognitive Demand and Gender - Mathematics Literacy – Final Year of Secondary School*

Country	Knowing and Procedures		Reasoning and Problem Solving	
	Males	Females	Males	Females
Australia	67 (2.8)	63 (2.2)	61 (2.0)	54 (2.3)
Austria	† 68 (1.5)	60 (1.2)	† 63 (1.8)	52 (1.4)
Canada	† 67 (1.1)	60 (0.9)	† 58 (1.2)	51 (1.1)
Cyprus	47 (1.7)	45 (1.2)	38 (1.5)	34 (1.2)
Czech Republic	53 (2.3)	43 (4.8)	47 (2.4)	39 (3.2)
France	† 68 (1.2)	61 (1.3)	† 59 (1.3)	48 (1.3)
Germany	60 (1.8)	54 (2.0)	† 54 (2.0)	45 (2.2)
Hungary	52 (1.1)	51 (1.0)	45 (1.2)	44 (1.1)
Iceland	† 71 (0.8)	62 (0.7)	† 64 (1.0)	53 (0.8)
Italy	56 (1.9)	50 (1.5)	50 (2.0)	43 (1.6)
Lithuania	51 (2.2)	50 (2.1)	46 (1.9)	42 (2.1)
Netherlands	† 76 (1.0)	65 (1.3)	† 73 (1.2)	58 (1.6)
New Zealand	68 (1.4)	63 (1.3)	† 61 (1.0)	54 (1.6)
Norway	† 70 (1.0)	58 (1.1)	† 61 (1.2)	49 (1.2)
Russian Federation	53 (1.8)	48 (1.6)	50 (1.7)	45 (1.7)
Slovenia	65 (2.6)	57 (1.9)	† 66 (2.9)	54 (2.4)
Sweden	† 72 (1.0)	65 (0.8)	† 68 (1.3)	59 (0.9)
Switzerland	69 (1.5)	62 (1.7)	64 (2.1)	56 (1.7)
United States	55 (0.9)	52 (1.0)	42 (1.6)	39 (1.0)
International	† 63 (0.4)	56 (0.4)	† 56 (0.4)	48 (0.3)

* See Appendix D for Characteristics of Students Sampled
† Difference from other gender statistically significant at .05 level, adjusted for multiple comparisons.
( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.
SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

Table 8

Average Percent Correct by Cognitive Demand and Gender – Advanced Mathematics – Final Year of Secondary School*

Country	Knowing and Procedures		Reasoning and Problem Solving	
	Males	Females	Males	Females
Australia	55 (2.6)	53 (2.3)	50 (2.8)	48 (3.1)
Austria	† 48 (1.7)	36 (1.4)	† 38 (1.9)	25 (1.6)
Canada	† 55 (1.3)	49 (0.8)	† 44 (1.3)	37 (1.1)
Cyprus	57 (0.9)	52 (1.6)	44 (1.2)	40 (2.4)
Czech Republic	† 52 (2.4)	39 (1.3)	† 45 (2.5)	28 (1.7)
France	65 (0.9)	63 (1.1)	53 (2.0)	48 (2.0)
Germany	† 47 (1.1)	42 (1.0)	† 36 (1.6)	28 (1.5)
Italy	46 (2.1)	44 (2.8)	36 (2.0)	32 (1.7)
Lithuania	† 56 (0.7)	47 (1.1)	† 48 (1.0)	36 (1.0)
Russian Federation	† 62 (1.9)	54 (1.6)	† 51 (2.2)	41 (2.0)
Slovenia	47 (1.8)	44 (1.8)	35 (2.3)	30 (2.2)
Sweden	52 (1.1)	50 (0.9)	45 (1.6)	41 (1.9)
Switzerland	† 59 (1.0)	51 (1.1)	† 50 (1.0)	38 (1.5)
United States	43 (1.4)	38 (1.3)	† 32 (1.1)	26 (1.4)
International	† 53 (0.5)	47 (0.4)	† 43 (0.6)	36 (0.5)

* See Appendix D for Characteristics of Students Sampled
† Difference from other gender statistically significant at .05 level, adjusted for multiple comparisons.
( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.
SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

Table 9

Average Percent Correct by Item Format and Gender Mathematics - Eighth Grade*

Country	Multiple Choice		Short Answer		Constructed Response	
	Males	Females	Males	Females	Males	Females
Australia	62 (1.1)	63 (1.0)	51 (1.6)	53 (1.4)	34 (1.5)	37 (1.4)
Austria	66 (0.8)	64 (1.0)	62 (1.1)	63 (1.5)	43 (1.3)	41 (2.2)
Belgium (Bl)	70 (1.9)	71 (1.7)	60 (3.2)	61 (3.2)	41 (2.0)	41 (2.4)
Belgium (Br)	64 (1.0)	63 (0.9)	54 (1.9)	53 (1.4)	35 (1.6)	34 (1.4)
Canada	63 (0.7)	63 (0.6)	53 (1.1)	53 (0.9)	35 (1.3)	38 (1.2)
Colombia	34 (1.7)	33 (0.9)	21 (1.8)	20 (0.9)	8 (1.1)	9 (2.3)
Cyprus	51 (0.6)	52 (0.6)	44 (1.1)	47 (1.2)	26 (1.5)	28 (1.2)
Czech Republic	71 (0.9)	68 (1.2)	64 (1.5)	64 (1.6)	43 (1.9)	42 (2.4)
England	58 (1.2)	57 (0.9)	44 (1.5)	43 (1.4)	35 (2.0)	33 (1.5)
France	68 (0.8)	66 (0.9)	57 (1.2)	55 (1.3)	33 (1.5)	32 (1.6)
Germany	59 (1.2)	58 (1.2)	50 (1.7)	49 (1.8)	28 (1.9)	29 (1.4)
Hong Kong	75 (1.5)	71 (1.6)	71 (2.0)	66 (2.5)	52 (2.3)	47 (2.4)
Hungary	65 (0.8)	65 (0.8)	61 (1.4)	64 (1.2)	37 (1.2)	37 (1.4)
Iceland	55 (1.2)	55 (1.2)	39 (1.8)	41 (1.9)	26 (1.8)	27 (2.3)
Iran, Islamic Rep.	44 (0.9)	40 (0.8)	34 (1.7)	31 (1.3)	16 (1.3)	15 (1.3)
Ireland	63 (1.6)	60 (1.3)	58 (2.0)	59 (1.8)	40 (2.1)	38 (2.2)
Japan	77 (0.5)	76 (0.4)	73 (0.7)	72 (0.8)	58 (1.2)	57 (1.0)
Korea	† 77 (0.6)	73 (0.7)	72 (0.9)	70 (1.1)	† 54 (1.3)	47 (1.5)
Latvia (LSS)	57 (1.0)	56 (0.8)	46 (1.5)	47 (1.2)	27 (1.5)	23 (1.3)
Lithuania	53 (1.1)	53 (1.0)	44 (1.6)	45 (1.6)	21 (1.4)	22 (1.4)
Netherlands	66 (1.6)	63 (1.6)	50 (2.4)	48 (1.9)	38 (2.9)	38 (2.0)
New Zealand	59 (1.3)	58 (1.2)	47 (1.6)	44 (1.6)	32 (2.0)	32 (1.7)
Norway	58 (0.6)	57 (0.6)	47 (1.0)	49 (1.2)	35 (1.1)	32 (1.0)
Portugal	50 (0.8)	47 (0.7)	34 (1.2)	34 (1.1)	18 (0.9)	16 (0.9)
Romania	53 (1.1)	52 (0.9)	47 (1.5)	48 (1.5)	28 (1.6)	29 (1.5)
Russian Federation	63 (1.5)	64 (1.1)	57 (1.7)	60 (1.3)	36 (1.4)	38 (2.5)
Scotland	58 (1.6)	54 (1.2)	45 (2.0)	42 (1.6)	33 (2.4)	31 (1.8)
Singapore	80 (1.0)	81 (0.9)	82 (1.3)	84 (1.0)	68 (1.7)	68 (1.7)
Slovak Republic	67 (0.9)	66 (0.8)	61 (1.1)	62 (1.1)	37 (1.4)	38 (1.4)
Slovenia	67 (0.7)	64 (0.7)	58 (1.2)	57 (1.1)	37 (1.6)	36 (1.3)
Spain	56 (0.6)	54 (0.7)	49 (1.1)	46 (1.2)	28 (1.4)	26 (0.9)
Sweden	60 (0.8)	60 (0.7)	45 (1.1)	47 (0.9)	35 (1.4)	36 (1.5)
Switzerland	67 (0.8)	66 (0.7)	57 (1.0)	56 (1.0)	42 (1.5)	38 (1.1)
United States	58 (1.1)	57 (1.0)	47 (1.5)	47 (1.5)	29 (1.3)	29 (1.3)
International	† 61 (0.2)	61 (0.2)	52 (0.2)	52 (0.2)	35 (0.3)	34 (0.3)

* Eighth Grade in most countries; see Appendix D for information about the grades tested in each country.
† Difference from other gender statistically significant at .05 level, adjusted for multiple comparisons.
( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.
SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

Table 10

Average Percent Correct by Item Format and Gender Mathematics – Mathematics Literacy – Final Year of Secondary School*

Country	Multiple Choice		Short Answer	
	Males	Females	Males	Females
Australia	69 (2.6)	64 (2.1)	54 (2.4)	45 (2.6)
Austria	† 72 (1.5)	63 (1.1)	† 49 (1.9)	40 (1.6)
Canada	† 68 (1.1)	62 (0.9)	† 51 (1.4)	41 (1.3)
Cyprus	51 (1.6)	49 (1.3)	23 (1.8)	20 (1.2)
Czech Republic	58 (2.3)	47 (5.0)	32 (2.3)	26 (1.9)
France	† 71 (1.1)	63 (1.2)	† 47 (1.9)	36 (1.5)
Germany	63 (1.9)	57 (2.0)	† 43 (1.9)	33 (2.2)
Hungary	56 (1.1)	56 (1.1)	29 (1.3)	26 (1.0)
Iceland	† 74 (0.7)	64 (0.6)	† 53 (1.4)	42 (1.2)
Italy	60 (1.9)	54 (1.5)	36 (2.3)	29 (1.6)
Lithuania	57 (2.2)	56 (2.4)	28 (1.8)	23 (1.8)
Netherlands	† 80 (1.0)	69 (1.4)	† 60 (1.4)	45 (1.7)
New Zealand	69 (1.1)	64 (1.4)	† 55 (1.3)	48 (1.6)
Norway	† 71 (1.0)	60 (1.1)	† 55 (1.4)	40 (1.2)
Russian Federation	58 (1.7)	53 (1.5)	34 (1.9)	29 (2.1)
Slovenia	72 (2.9)	62 (2.1)	† 50 (2.7)	38 (2.0)
Sweden	† 74 (0.9)	67 (0.8)	† 61 (1.7)	50 (1.0)
Switzerland	72 (1.6)	66 (1.7)	† 51 (2.0)	43 (1.7)
United States	54 (1.0)	51 (1.0)	37 (1.4)	34 (1.0)
International	† 66 (0.4)	59 (0.4)	† 45 (0.4)	36 (0.3)

* See Appendix D for Characteristics of Students Sampled
† Difference from other gender statistically significant at .05 level, adjusted for multiple comparisons.
( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.
SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

Table 11

Average Percent Correct by Item Format and Gender – Advanced Mathematics – Final Year of Secondary School*

Country	Multiple Choice		Short Answer		Constructed Response	
	Males	Females	Males	Females	Males	Females
Australia	57 (2.3)	55 (2.3)	50 (3.3)	48 (3.0)	40 (3.0)	39 (4.1)
Austria	† 48 (1.4)	37 (1.3)	† 44 (2.4)	27 (2.1)	† 25 (2.5)	15 (1.7)
Canada	† 56 (1.1)	50 (0.7)	† 44 (1.6)	36 (1.2)	† 39 (1.7)	30 (1.3)
Cyprus	59 (1.0)	55 (1.7)	39 (1.1)	35 (2.9)	36 (1.9)	34 (2.4)
Czech Republic	† 54 (2.2)	40 (1.3)	† 41 (2.7)	24 (1.4)	† 41 (3.3)	25 (2.6)
France	63 (0.9)	60 (1.2)	63 (1.9)	56 (2.2)	40 (2.6)	39 (2.1)
Germany	† 48 (1.1)	43 (1.0)	† 38 (1.6)	31 (1.9)	† 25 (1.9)	18 (1.5)
Iran, Islamic Rep.	48 (1.8)	45 (2.9)	36 (2.8)	30 (3.7)	26 (2.7)	26 (3.4)
Lithuania	† 59 (0.9)	51 (0.9)	† 39 (1.3)	26 (1.6)	† 46 (1.3)	34 (1.3)
Russian Federation	† 62 (1.8)	54 (1.8)	† 49 (2.3)	39 (2.0)	49 (3.2)	40 (2.5)
Slovenia	47 (1.9)	45 (1.8)	34 (2.1)	28 (2.0)	31 (3.1)	28 (2.5)
Sweden	57 (1.1)	53 (1.0)	39 (2.1)	37 (2.0)	34 (2.0)	32 (4.7)
Switzerland	† 61 (1.0)	52 (1.3)	† 49 (1.4)	39 (1.9)	† 41 (1.7)	31 (2.2)
United States	45 (1.3)	41 (1.3)	30 (1.5)	24 (1.8)	† 22 (1.4)	16 (1.1)
International	† 55 (0.5)	49 (0.4)	† 42 (0.6)	34 (0.6)	† 35 (0.7)	29 (0.7)

* See Appendix D for Characteristics of Students Sampled
† Difference from other gender statistically significant at .05 level, adjusted for multiple comparisons.
( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.
SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

Appendix A –Cutoff Scores Corresponding to 25th and 75th Percentiles

As presented in Tables A-1, A-2, and A-3, cutoff Scores corresponding to the percentiles of achievement are listed for 8th Grade mathematics, and for mathematics literacy and advanced mathematics in the Final Year of Secondary School.

TABLE A-1 PERCENTILES OF ACHIEVEMENT IN MATHEMATICS UPPER GRADE (8TH GRADE*)

Country	25th Percentile	75th Percentile
Australia	460 (1.5)	600 (7.2)
Austria	474 (4.1)	608 (2.6)
Belgium (Fl)	502 (8.7)	631 (5.7)
Belgium (Fr)	467 (1.1)	587 (3.7)
Bulgaria	460 (4.2)	621 (13.8)
Canada	468 (2.0)	587 (2.4)
Colombia	343 (4.4)	421 (6.1)
Cyprus	412 (1.2)	535 (3.2)
Czech Republic	496 (2.6)	633 (8.5)
England	443 (4.8)	570 (2.7)
France	484 (1.4)	591 (2.5)
Germany	448 (9.4)	572 (7.5)
Hong Kong	526 (6.8)	659 (4.9)
Hungary	471 (2.1)	602 (2.7)
Iceland	435 (3.3)	540 (4.8)
Iran, Islamic Rep.	388 (2.2)	466 (5.8)
Ireland	462 (4.9)	594 (9.6)
Japan	536 (6.8)	676 (1.4)
Korea	540 (5.0)	682 (2.7)
Latvia (LSS)	435 (2.6)	550 (4.3)
Lithuania	422 (3.1)	533 (4.3)
Netherlands	477 (9.1)	604 (7.4)
New Zealand	443 (4.0)	570 (5.5)
Norway	445 (2.0)	560 (3.1)
Portugal	411 (1.0)	495 (6.7)
Romania	418 (3.0)	544 (5.2)
Russian Federation	471 (5.6)	600 (8.2)
Scotland	436 (3.2)	559 (7.1)
Singapore	584 (8.9)	704 (4.5)
Slovak Republic	483 (0.6)	612 (3.9)
Slovenia	477 (3.6)	604 (4.0)
Spain	436 (2.5)	536 (3.5)
Sweden	460 (6.0)	579 (3.4)
Switzerland	485 (2.1)	607 (2.9)
United States	435 (3.4)	563 (8.2)

( ) Standard errors appear in parentheses.
SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

TABLE A-2 PERCENTILES OF ACHIEVEMENT IN MATHEMATICS LITERACY FINAL YEAR OF SECONDARY SCHOOL (12TH GRADE)

Country	25th Percentile	75th Percentile
Australia	459 (9.4)	585 (9.5)
Austria	461 (7.9)	573 (6.4)
Canada	457 (4.6)	579 (3.8)
Cyprus	395 (2.2)	493 (4.0)
Czech Republic	394 (10.3)	530 (16.5)
France	468 (6.3)	578 (6.9)
Germany	432 (11.3)	554 (8.9)
Hungary	417 (3.1)	545 (3.5)
Iceland	472 (4.0)	592 (3.2)
Italy	417 (7.5)	534 (4.6)
Lithuania	412 (9.1)	529 (8.3)
Netherlands	498 (7.1)	622 (5.2)
New Zealand	453 (7.0)	589 (5.2)
Norway	461 (6.1)	592 (4.5)
Russian Federation	410 (4.8)	528 (7.8)
Slovenia	451 (8.5)	573 (6.6)
Sweden	483 (5.1)	620 (4.1)
Switzerland	478 (7.9)	601 (5.5)
United States	395 (3.8)	521 (6.7)

( ) Standard errors appear in parentheses.
SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

TABLE A-3 PERCENTILES OF ACHIEVEMENT IN ADVANCED MATHEMATICS FINAL YEAR OF SECONDARY SCHOOL (12TH GRADE)

Country	25th Percentile	75th Percentile
Australia	456 (17.5)	597 (10.4)
Austria	379 (11.4)	497 (8.8)
Canada	443 (5.4)	576 (7.2)
Cyprus	465 (5.7)	574 (5.2)
Czech Republic	399 (9.2)	524 (15.6)
France	511 (5.1)	603 (6.4)
Germany	408 (8.0)	522 (5.6)
Italy	419 (13.4)	534 (8.3)
Lithuania	461 (5.5)	567 (3.3)
Russian Federation	465 (9.3)	618 (9.4)
Slovenia	408 (9.5)	537 (8.5)
Sweden	458 (10.5)	568 (7.0)
Switzerland	473 (6.2)	587 (5.9)
United States	375 (7.1)	504 (6.1)

() Standard errors appear in parentheses.
SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

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Appendix B – **Number of TIMSS mathematics items by cognitive demand and performance expectation**

As presented in Tables B-1, B-2, and B-3 the number of TIMSS mathematics items by cognitive demand and performance expectation for 8th Grade mathematics, and for mathematics literacy and advanced mathematics in the Final Year of Secondary School.

TABLE B-1 NUMBER OF TIMSS MATHEMATICS ITEMS BY COGNITIVE DEMAND AND PERFORMANCE EXPECTATION– 8TH GRADE

Cognitive Demand	Knowing / Using			Solving Problems			
TIMSS Performance Expectations	Number of Knowing Items	Number of Using Routine Procedures Items	Total Number of Knowing / Using Items	Number of Investigating and Problem Solving Items	Number of Mathematical Reasoning Items	Number of Commun -icating Items	Total Number of Knowing / Using Items
Number of items	33	70	103	52	4	4	60

TABLE B-2 NUMBER OF TIMSS MATHEMATICS ITEMS BY COGNITIVE DEMAND AND PERFORMANCE EXPECTATION– MATHEMATICS LITERACY - FINAL YEAR OF SECONDARY SCHOOL (12TH GRADE)

Cognitive Demand	Knowing / Using			Solving Problems			
TIMSS Performance Expectations	Number of Knowing Items	Number of Using Routine Procedures Items	Total Number of Knowing / Using Items	Number of Investigating and Problem Solving Items	Number of Mathematical Reasoning Items	Number of Commun -icating Items	Total Number of Knowing / Using Items
Number of items	8	19	27	21	2	3	26

TABLE B-3 NUMBER OF TIMSS MATHEMATICS ITEMS BY COGNITIVE DEMAND AND PERFORMANCE EXPECTATION– ADVANCED MATHEMATICS - FINAL YEAR OF SECONDARY SCHOOL (12TH GRADE)

Cognitive Demand	Knowing / Using			Solving Problems			
TIMSS Performance Expectations	Number of Knowing Items	Number of Using Routine Procedures Items	Total Number of Knowing / Using Items	Number of Investigating and Problem Solving Items	Number of Mathematical Reasoning Items	Number of Commun -icating Items	Total Number of Knowing / Using Items
Number of items	9	31	40	28	8	4	40

Appendix C – Distribution of TIMSS Items by Item Format

TABLE C-1 DISTRIBUTION OF MATHEMATICS ITEMS BY ITEM FORMAT – 8TH GRADE

Total Number of Items	Number of Multiple Choice Items	Number of Short-Answer Items	Number of Extended Response Items	Number of Score Points
151	125	19	7	163

TABLE C-2 DISTRIBUTION OF MATHEMATICS LITERACY ITEMS BY ITEM FORMAT – FINAL YEAR OF SECONDARY SCHOOL (12TH GRADE)

Total Number of Items	Number of Multiple Choice Items	Number of Short-Answer Items	Number of Extended Response Items	Number of Score Points
44	34	8	2	53

TABLE C-3 DISTRIBUTION OF ADVANCED MATHEMATICS ITEMS BY ITEM FORMAT – FINAL YEAR OF SECONDARY SCHOOL (12TH GRADE)

Total Number of Items	Number of Multiple Choice Items	Number of Short-Answer Items	Number of Extended Response Items	Number of Score Points
65	47	10	8	82

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