International Association for the Evaluation of Educational Achievement

MATHEMATICS ACHIEVEMENT IN THE
MIDDLE SCHOOL YEARS:
IEA'S THIRD INTERNATIONAL MATHEMATICS
AND SCIENCE STUDY (TIMSS)

Albert E. Beaton Ina V.S. Mullis Michael O. Martin Eugenio J. Gonzalez Dana L. Kelly Teresa A. Smith

November 1996



TIMSS International Study Center Boston College Chestnut Hill, MA, USA Mathematics Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study / by Albert E. Beaton, Ina V.S. Mullis, Michael O. Martin, Eugenio J. Gonzalez, Dana L. Kelly, and Teresa A. Smith

Publisher: Center for the Study of Testing, Evaluation, and Educational Policy,

Boston College.

Library of Congress Catalog Card Number: 96-71251

ISBN 1-889938-02-5

For more information about TIMSS contact:

TIMSS International Study Center

Center for the Study of Testing, Evaluation, and Educational Policy

Campion Hall

School of Education

Boston College

Chestnut Hill, MA 02167

United States

For information on ordering this report, write the above address or call +1-617-552-4521.

This report also is available on the World Wide Web:

http://www.csteep.bc.edu/timss

Funding for the international coordination of TIMSS is provided by the U.S. National Center for Education Statistics, the U.S. National Science Foundation, the IEA, and the Canadian government. Each participating country provides funding for the national implementation of TIMSS.

Boston College is an equal opportunity, affirmative action employer.

Printed and bound in the United States.

Contents

EXECUTIVE SUMMARY	. 1
INTRODUCTION	7
Which Countries Participated?	8
Table 1: Countries Participating in TIMSS	9
Table 2: Information About the Grades Tested	11
What Was the Nature of the Mathematics Test?	12
How Do Country Characteristics Differ?	13
Table 3: Selected Demographic Characteristics of TIMSS Countries	14
Table 4: Public Expenditure on Education at Primary and Secondary Levels in TIMSS Countries	15
Figure 1: Centralization of Decision-Making Regarding Curriculum Syllabi	17
Figure 2: Centralization of Decision-Making Regarding Textbooks	18
Figure 3: Centralization of Decision-Making Regarding Examinations	19
CHAPTER 1 : INTERNATIONAL STUDENT ACHIEVEMENT IN MATHEMATICS	21
What Are the Overall Differences in Mathematics Achievement?	21
Table 1.1: Distributions of Mathematics Achievement - Upper Grade (Eighth Grade)	. 22
Figure 1.1: Multiple Comparisons of Mathematics Achievement - Upper Grade (Eighth Grade)	. 23
Table 1.2: Distributions of Mathematics Achievement - Lower Grade (Seventh Grade)	. 26
Figure 1.2: Multiple Comparisons of Mathematics Achievement - Lower Grade (Seventh Grade)	. 27
What Are the Increases in Achievement Between the Lower and Upper Grades?	28
Table 1.3: Achievement Differences in Mathematics Between Lower and Upper Grades (Seventh and Eighth Grades)	. 29
What Are the Differences in Performance Compared to Three Marker Levels of International Mathematics Achievement?	30
Table 1.4: Percentages of Students Achieving International Marker Levels in Mathematics - Upper Grade (Eighth Grade)	31
Table 1.5: Percentages of Students Achieving International Marker Levels in Mathematics – Lower Grade (Seventh Grade)	. 32
What Are the Gender Differences in Mathematics Achievement?	33
Table 1.6: Gender Differences in Mathematics Achievement - Upper Grade (Eighth Grade)	. 34
Table 1.7: Gender Differences in Mathematics Achievement - Lower Grade (Seventh Grade)	. 35

What Are the Differences in Median Performance at Age 13?	36
Table 1.8: Median Mathematics Achievement: 13-Year-Old Students	37
CHAPTER 2 : AVERAGE ACHIEVEMENT IN THE MATHEMATICS CONTENT AREAS	39
How Does Achievement Differ Across Mathematics Content Areas?	39
Table 2.1: Average Percent Correct by Mathematics Content Areas - Upper Grade (Eighth Grade)	41
Table 2.2: Average Percent Correct by Mathematics Content Areas – Lower Grade (Seventh Grade).	42
Table 2.3: Profiles of Relative Performance in Mathematics Content Areas - Lower and Upper Grade (Seventh and Eighth Grades)	
What Are the Increases in Achievement Between the Lower and Upper Grades?	46
Figure 2.1: Difference in Average Percent Correct Between Lower and Upper Grades (Seventh and Eighth Grades) Overall and in Mathematics Content Areas	47
What Are the Gender Differences in Achievement for the Content Areas?	50
Table 2.4: Average Percent Correct for Boys and Girls by Mathematics Content Areas - Upper Grade (Eighth Grade)	
Table 2.5: Average Percent Correct for Boys and Girls by Mathematics Content Areas – Lower Grade (Seventh Grade)	
Chapter 3 : performance on items within each mathematics content ar	EA 57
What Have Students Learned About Fractions and Number Sense?	57
Table 3.1: Percent Correct for Fractions and Number Sense Example Items - Lower and Upper Grade (Seventh and Eighth Grades)	
Figure 3.1: International Difficulty Map for Fractions and Number Sense Example Items - Lower and Upper Grades (Seventh and Eighth Grades)	60
Fractions and Number Sense Example Items	62
What Have Students Learned About Geometry?	65
Table 3.2: Percent Correct for Geometry Example Items - Lower and Upper Grades (Seventh and Eighth Grades)	
	66
Figure 3.2: International Difficulty Map for Geometry Example Items - Lower and Upper Grades (Seventh and Eighth Grades)	
	68
(Seventh and Eighth Grades)	68
(Seventh and Eighth Grades)	68 69

Algebra Example Items	76
What Have Students Learned About Data Representation, Analysis, and Probability?	78
Table 3.4: Percent Correct for Data Representation, Analysis, and Probability Example Items – Lower and Upper Grades (Seventh and Eighth Grades)	80
Figure 3.4: International Difficulty Map for Data Representation, Analysis, and Probability Example Items – Lower and Upper Grades (Seventh and Eighth Grades)	82
Data Representation, Analysis, and Probability Example Items	83
What Have Students Learned About Measurement?	86
Table 3.5: Percent Correct for Measurement Example Items - Lower and Upper Grades (Seventh and Eighth Grades)	88
Figure 3.5: International Difficulty Map for Measurement Example Items - Lower and Upper Grades (Seventh and Eighth Grades)	90
Measurement Example Items	91
What Have Students Learned About Proportionality?	93
Table 3.6: Percent Correct for Proportionality Example Items - Lower and Upper Grades (Seventh and Eighth Grades)	94
Figure 3.6: International Difficulty Map for Proportionality Example Items - Lower and Upper Grades (Seventh and Eighth Grades)	96
Proportionality Example Items	97
CHAPTER 4 : STUDENTS' BACKGROUNDS AND ATTITUDES TOWARDS MATHEMATICS	99
What Educational Resources Do Students Have in Their Homes?	
Table 4.1: Students' Reports on Educational Aids in the Home: Dictionary, Study Desk/Table, and Computer Upper Grade (Eighth Grade)	
Table 4.2: Students' Reports on the Number of Books in the Home - Upper Grade (Eighth Grade)	101
Table 4.3: Students' Reports on the Highest Level of Education of Either Parent - Upper Grade (Eighth Grade)	103
Figure 4.1: Country Modifications to the Definitions of Educational Levels for Parents' Highest Level of Education	104
What Are the Academic Expectations of Students, Their Families, and Their Friends?	. 106
Table 4.4: Students' Reports on Whether They Agree or Strongly Agree That It is Important to Do Various Activities - Upper Grade (Eighth Grade)	108
Table 4.5: Students' Reports on Whether Their Mothers Agree or Strongly Agree That It is Important to Do Various Activities - Upper Grade (Eighth Grade)	109
Table 4.6: Students' Reports on Whether Their Friends Agree or Strongly Agree That It is Important to Do Various Activities - Upper Grade (Eighth Grade)	110

How Do Students Spend Their Out-of-School Time During the School Week?	111
Table 4.7: Students' Reports on How They Spend Their Daily Out-of-School Study Time - Upper Grade (Eighth Grade)	112
Table 4.8: Students' Reports on How They Spend Their Daily Leisure Time - Upper Grade (Eighth Grade)	113
Table 4.9: Students' Reports on Total Amount of Daily Out-of-School Study Time - Upper Grade (Eighth Grade)	114
Table 4.10: Students' Reports on the Hours Spent Each Day Watching Television and Videos - Upper Grade (Eighth Grade)	
How Do Students Perceive Success in Mathematics?	. 11 <i>7</i>
Table 4.11: Students' Self-Perceptions About Usually Doing Well in Mathematics - Upper Grade (Eighth Grade)118
Figure 4.2: Gender Differences In Students' Self-Perceptions About Usually Doing Well in Mathematics – Upper Grade (Eighth Grade)	119
Table 4.12: Students' Reports on Things Necessary to Do Well in Mathematics – Upper Grade (Eighth Grade)	121
Table 4.13: Students' Reports on Why They Need to Do Well in Mathematics - Upper Grade (Eighth Grade) .	123
What Are Students' Attitudes Towards Mathematics?	. 124
Table 4.14: Students' Reports on How Much They Like Mathematics - Upper Grade (Eighth Grade)	126
Figure 4.3: Gender Differences in Liking Mathematics - Upper Grade (Eighth Grade)	127
Table 4.15: Students' Overall Attitudes Towards Mathematics - Upper Grade (Eighth Grade)	128
Figure 4.4: Gender Differences in Students' Overall Attitudes Towards Mathematics - Upper Grade (Eighth Grade)	129
CHAPTER 5 : TEACHERS AND INSTRUCTION	. 131
Who Delivers Mathematics Instruction?	. 132
Table 5.1: Requirements for Certification Held by the Majority of Lower- and Upper-Grade (Seventh- and Eighth-Grade) Teachers	134
Table 5.2: Teachers' Reports on Their Age and Gender – Upper Grade (Eighth Grade)	136
Table 5.3: Teachers' Reports on Their Years of Teaching Experience – Upper Grade (Eighth Grade)	137
What Are Teachers' Perceptions About Mathematics?	. 138
Figure 5.1: Percentage of Students Whose Mathematics Teachers Agree or Strongly Agree with Statements About the Nature of Mathematics and Mathematics Teaching - Upper Grade (Eighth Grade)	
Figure 5.2: Percent of Students Whose Mathematics Teachers Think Particular Abilities Are Very Important for Students' Success in Mathematics in School - Upper Grade (Eighth Grade)	142

How Do Mathematics Teachers Spend Their School-Related Time?	144
Table 5.4: Teachers' Reports on the Proportion of Their Formally Scheduled School Time Spent Teaching Mathematics - Upper Grade (Eighth Grade)	. 146
Table 5.5: Teachers' Reports on Average Number of Hours Mathematics Is Taught Weekly to Their Mathematics Classes - Upper Grade (Eighth Grade)	. 147
Table 5.6: Average Number of Hours Students' Teachers Spend on Various School-Related Activities Outside the Formal School Day During the School Week - Upper Grade (Eighth Grade)	. 148
Table 5.7: Teachers' Reports on How Often They Meet with Other Teachers in Their Subject Area to Discuss and Plan Curriculum or Teaching Approaches - Upper Grade (Eighth Grade)	. 149
How Are Mathematics Classes Organized?	151
Table 5.8: Teachers' Reports on Average Size of Mathematics Class - Upper Grade (Eighth Grade)	. 152
Figure 5.3: Teachers' Reports About Classroom Organization During Mathematics Lessons - Upper Grade (Eighth Grade)	. 154
What Activities Do Students Do in Their Mathematics Lessons?	156
Table 5.9: Teachers' Reports on Their Main Sources of Written Information When Deciding Which Topics to Teach and How to Present a Topic - Upper Grade (Eighth Grade)	157
Figure 5.4: Teachers' Reports About Using a Textbook in Teaching Mathematics - Upper Grade (Eighth Grade)	. 158
Table 5.10: Teachers' Reports on How Often They Ask Students to Practice Computational Skills – Upper Grade (Eighth Grade)	159
Table 5.11: Teachers' Reports on How Often They Ask Students to Do Reasoning Tasks – Upper Grade (Eighth Grade)	. 160
Table 5.12: Students' Reports on Frequency of Using Things from Everyday Life in Solving Mathematics Problems - Upper Grade (Eighth Grade)	. 161
How Are Calculators and Computers Used?	162
Table 5.13: Students' Reports on Having a Calculator and Computer in the Home - Upper Grade (Eighth Grade)	. 163
Table 5.14: Teachers' Reports on Frequency of Students' Use of Calculators in Mathematics Class – Upper Grade (Eighth Grade)	164
Table 5.15: Teachers' Reports on Ways in Which Calculators Are Used at Least Once or Twice a Week – Upper Grade (Eighth Grade)	165
Table 5.16: Students' Reports on Frequency of Using Calculators in Mathematics Class - Upper Grade (Eighth Grade)	. 166
Table 5.17: Teachers' Reports on Frequency of Using Computers in Mathematics Class to Solve Exercises or Problems - Upper Grade (Eighth Grade)	. 167

	Table 5.18: Students' Reports on Frequency of Using Computers in Mathematics Class - Upper Grade (Eighth Grade)	168
Н	low Much Homework Are Students Assigned?	169
	Table 5.19: Teachers' Reports About the Amount of Mathematics Homework Assigned - Upper Grade (Eighth Grade)	17C
	Table 5.20: Teachers' Reports on Their Use of Students' Written Mathematics Homework - Upper Grade (Eighth Grade)	1 <i>7</i> 1
V	Vhat Assessment and Evaluation Procedures Do Teachers Use?	172
	Table 5.21: Teachers' Reports on the Types of Assessment Given "Quite A Lot" or "A Great Deal" of Weight in Assessing Students' Work in Mathematics Class - Upper Grade (Eighth Grade)	173
	Table 5.22: Teachers' Reports on Ways Assessment Information Is Used "Quite A Lot" or "A Great Deal" – Upper Grade (Eighth Grade)	1 <i>7</i> 4
	Table 5.23: Students' Reports on Frequency of Having a Quiz or Test in Their Mathematics Lessons – Upper Grade (Eighth Grade)	175
	ENDIX A: OVERVIEW OF TIMSS PROCEDURES: MATHEMATICS ACHIEVEMENT ESULTS FOR SEVENTH- AND EIGHTH-GRADE STUDENTS	A-1
Н	listory	A-1
Tł	he Components of TIMSS	A-1
	Figure A.1: Countries Participating in Additional Components of TIMSS Testing	A-4
D	Developing the TIMSS Mathematics Test	A-5
	Figure A.2: The Three Aspects and Major Categories of the Mathematics Framework	A-6
	Table A.1: Distribution of Mathematics Items by Content Reporting Category and Performance Category	A-7
TI	IMSS Test Design	A-9
S	ample Implementation and Participation Rates	A-9
	Table A.2: Coverage of TIMSS Target Population	A-10
	Table A.3: Coverage of 13-Year-Old Students	A-12
	Table A.4: School Participation Rates and Sample Sizes - Upper Grade (Eighth Grade)	A-13
	Table A.5: Student Participation Rates and Samples Sizes - Upper Grade (Eighth Grade)	A-14
	Table A.6: School Participation Rates and Sample Sizes - Lower Grade (Seventh Grade)	A-15
	Table A.7: Student Participation Rates and Samples Sizes - Lower Grade (Seventh Grade)	A-16
	Table A.8: Overall Participation Rates - Upper and Lower Grades (Eighth and Seventh Grades)	A-17
ln	ndicating Compliance with Sampling Guidelines in the Report	. A-18
	Figure A.3: Countries Grouped for Reporting of Achievement According to Their Compliance with	Δ_10

Data Collection	A-20
Scoring the Free-Response Items	A-21
Table A.9: TIMSS Within-Country Free-Response Coding Reliability Data for Population 2 Mathematics Items	A-22
Table A.10: Percent Exact Agreement for Coding of Mathematics Items for International and Within-Country Reliability Studies	A-24
Test Reliability	A-25
Table A.11: Cronbach's Alpha Reliability Coefficients - TIMSS Mathematics Test - Lower and Upper Grade (Seventh and Eighth Grades)	
Data Processing	A-25
IRT Scaling and Data Analysis	A-27
Estimating Sampling Error	A-28
APPENDIX B: THE TEST-CURRICULUM MATCHING ANALYSIS	B-1
Table B.1: Test-Curriculum Matching Analysis Results - Mathematics - Upper Grade (Eighth Grade)	B-3
Table B.2: Test-Curriculum Matching Analysis Results - Mathematics - Lower Grade (Seventh Grade)	B-4
Table B.3: Standard Errors for the Test-Curriculum Matching Analysis Results - Mathematics - Upper Grade (Eighth Grade)	B-7
Table B.4: Standard Errors for the Test-Curriculum Matching Analysis Results - Mathematics - Lower Grade (Seventh Grade)	B-8
APPENDIX C: SELECTED MATHEMATICS ACHIEVEMENT RESULTS FOR THE PHILIPPINES	C-1
Table C.1: Philippines - Selected Mathematics Achievement Results - Unweighted Data	C-2
APPENDIX D: SELECTED MATHEMATICS ACHIEVEMENT RESULTS FOR DENMARK, SWEDEN, AND SWITZERLAND (GERMAN-SPEAKING)-EIGHTH GRADE	D-1
Table D.1: Denmark - Selected Mathematics Achievement Results	D-2
Table D.2: Sweden - Selected Mathematics Achievement Results	D-3
Table D.3: Switzerland (German-Speaking) - Selected Mathematics Achievement Results	D-4
APPENDIX E: PERCENTILES AND STANDARD DEVIATIONS OF MATHEMATICS ACHIEVEMENT.	E-1
Table E.1: Percentiles of Achievement in Mathematics – Upper Grade (Eighth Grade)	E-2
Table E.2: Percentiles of Achievement in Mathematics - Lower Grade (Seventh Grade)	E-3
Table E.3: Standard Deviations of Achievement in Mathematics - Upper Grade (Eighth Grade)	E-4
Table E.4: Standard Deviations of Achievement in Mathematics - Lower Grade (Seventh Grade)	E-5
APPENDIX F. ACKNOWLEDGMENTS	F_1