

© 2001 International Association for the Evaluation of Educational Achievement (IEA)

Science Benchmarking Report: TIMSS 1999 -Eighth Grade / by Michael O. Martin, Ina V.S. Mullis, Eugenio J. Gonzalez, Kathleen M. O'Connor, Steven J. Chrostowski, Kelvin D. Gregory, Teresa A. Smith, Robert A. Garden

Publisher: International Study Center

Lynch School of Education

Boston College

Library of Congress

Catalog Card Number: 2001087824

ISBN 1-889938-20-3

For more information about TIMSS contact:

The International Study Center Lynch School of Education Manresa House Boston College Chestnut Hill, MA 02467 **United States** 

For information on ordering this report, write to the above address or call +1-617-552-1600

This report also is available on the World Wide Web: http://www.timss.org

Funding for the TIMSS 1999 Benchmarking Study was provided by the National Center for Education Statistics and the Office of Educational Research and Improvement of the U.S. Department of Education, the U.S. National Science Foundation, and participating jurisdictions.

Boston College is an equal opportunity, affirmative action employer.

Printed and bound in the United States

COLUMNIS



#### 1 EXECUTIVE SUMMARY

- 3 Executive Summary
- Major Findings from the TIMSS 1999 **Benchmarking Study**



#### 13 INTRODUCTION

- 15 What Is TIMSS 1999 Benchmarking?
- 16 Why Did Countries, States, Districts, and Consortia Participate?
- 18 Which Countries, States, Districts, and **Consortia Participated?**
- 20 Exhibit 1 Participants in TIMSS 1999 Benchmarking
- 22 What Is the Relationship Between the TIMSS 1999 Data for the **United States and the Data for** the Benchmarking Study?
- 23 How Was the TIMSS 1999 **Benchmarking Study Conducted?**
- 24 What Was the Nature of the Science Test?
- 25 How Does TIMSS 1999 Compare with NAEP?
- **26 How Do Country Characteristics** Differ?
- Exhibit 2 27 Selected Characteristics of TIMSS 1999 Countries
- 28 Exhibit 3 Selected Economic Indicators of TIMSS 1999 Countries
- 29 How Do the Benchmarking **Jurisdictions Compare on Demographic Indicators?**
- 31 Exhibit 4 Selected Characteristics of States, Districts and Consortia
- 32 How Is the Report Organized?

1

#### 33 CHAPTER 1

Student Achievement in Science

### 35 How Do Participants Differ in Science Achievement?

- 38 Exhibit 1.1
- Distribution of Science Achievement
- 40 Exhibit 1.2

Multiple Comparisons of Average Science Achievement

#### 43 How Do Benchmarking Participants Compare with International Benchmarks of Science Achievement?

45 Exhibit 1.3

TIMSS 1999 International Benchmarks of Science Achievement

46 Exhibit 1.4

Percentages of Students Reaching TIMSS 1999 International Benchmarks of Science Achievement

### 48 What Are the Gender Differences in Science Achievement?

50 Exhibit 1.5

Gender Differences in Average Science Achievement

52 Exhibit 1.6

Percentages of Girls and Boys Reaching Each Participant's Own Upper Quarter and Median Levels of Science Achievement 2

#### **55 CHAPTER 2**

Performance at International Benchmarks

#### 58 How Were the Benchmarks Developed?

### 59 How Should the Descriptions Be Interpreted?

### 60 Item Examples and Student Performance

### 61 Achievement at the Top 10% Benchmark

62 Exhibit 2.1

Description of Top 10% TIMSS International Benchmark of Science Achievement

64 Exhibit 2.2–2.6

Top 10% TIMSS International Benchmark Example Items 1-5

### 69 Achievement at the Upper Quarter Benchmark

71 Exhibit 2.7

Description of Upper Quarter TIMSS International Benchmark of Science Achievement

72 Exhibit 2.8-2.12

Upper Quarter TIMSS International Benchmark Example Items 6–10

### 77 Achievement at the Median Benchmark

79 Exhibit 2.13

Description of Median TIMSS International Benchmark of Science Achievement

80 Exhibit 2.14-2.19

Median TIMSS International Benchmark Example Items 11–16

### 86 Achievement at the Lower Quarter Benchmark

87 Exhibit 2.20

Description of Lower Quarter TIMSS International Benchmark of Science Achievement

88 Exhibit 2.21-2.24

Lower Quarter TIMSS International Benchmark Example Items 17–20

### 92 What Issues Emerge from the Benchmark Descriptions?

3

#### 93 CHAPTER 3

Average Achievement in the Science Content Areas

### 97 How Does Achievement Differ Across Science Content Areas?

98 Exhibit 3.1

Average Achievement in Science Content Areas

### 101 In Which Content Areas Are Countries Relatively Strong or Weak?

02 Exhibit 3.2

Countries' Profiles of Relative Performance in Science Content Areas

103 Exhibit 3.3

States' Profiles of Relative Performance in Science Content Areas

104 Exhibit 3.4

Districts' and Consortia's Profiles of Relative Performance in Science Content Areas

### 105 What Are the Gender Differences in Achievement for the Content Areas?

106 Exhibit 3.5

Average Achievement in Science Content Areas by Gender

## CONTENTS

4

#### **109 CHAPTER 4**

Students' Backgrounds and Attitudes Towards Science

### 111 What Educational Resources Do Students Have in Their Homes?

114 Exhibit 4.1

Index of Home Educational Resources (HER)

118 Exhibit 4.2

Students Having a Computer at Home

119 Exhibit 4.3

Frequency with Which Students Speak Language of the Test at Home

120 Exhibit 4.4

Students' Race/Ethnicity

122 Exhibit 4.5

Students' Expectations for Finishing School

#### 123 How Much of Their Out-of-School Time Do Students Spend on Homework During the School Week?

126 Exhibit 4.6

Index of Out-of-School Study Time (OST)

128 Exhibit 4.7

Total Amount of Out-of-School Time Students Spend Studying Science or Doing Science Homework on a Normal School Day

### 129 How Do Students Perceive Their Ability in the Sciences?

132 Exhibit 4.8

Index of Students' Self-Concept in the Sciences (SCS)

136 Exhibit 4.9

Index of Students' Self-Concept in the Sciences (SCS) by Gender

### 138 What Are Students' Attitudes Towards the Sciences?

140 Exhibit 4.10

Index of Students' Positive Attitudes Towards the Sciences (PATS)

144 Exhibit 4.11

Index of Students' Positive Attitudes Towards the Sciences (PATS) by Gender

5

#### **147 CHAPTER 5**

The Science Curriculum

## 151 Science Subjects Offered Up To and Including Eighth Grade

152 Exhibit 5.1

Science Subjects Offered Up to and Including Eighth Grade

# 154 Does Decision Making About the Intended Curriculum Take Place at the National, Regional, or Local Level?

156 Exhibit 5.2

Countries' Science Curriculum

157 Exhibit 5.3

States' Curriculum Frameworks/Content Standards

158 Exhibit 5.4

Districts' and Consortia's Curriculum

## 159 How Do Education Systems Support and Monitor Curriculum Implementation?

161 Exhibit 5.5

Countries' Use of Methods to Support or Monitor Implementation of the Curriculum

162 Exhibit 5.6

States', Districts' and Consortia's Use of Textbooks and Instructional Materials to Support Implementation of the Curriculum

164 Exhibit 5.7

States', Districts' and Consortia's Use of Pedagogical Guides to Support Implementation of the Curriculum

166 Exhibit 5.8

States', Districts' and Consortia's Use of Accreditation to Support Implementation of the Curriculum

### 168 What TIMSS 1999 Countries Have Assessments And Exams in Science?

169 Exhibit 5.9

Countries' System-Wide Assessments in Science

171 Exhibit 5.10

Countries' Public Examinations in Science

### 172 What Benchmarking Jurisdictions Have Assessments in Science?

74 Exhibit 5.11

States' Science Assessments

75 Exhibit 5.12

Status of State-Developed Science Assessments

176 Exhibit 5.13

States' Use of Science Assessments with Consequences

178 Exhibit 5.14

Districts' and Consortia's State and Local Science Assessments

## How Do Education Systems Deal with Individual Differences?

181 Exhibit 5.15

Differentiation of Curriculum for Students with Different Abilities or Interests

### 182 What Are the Major Characteristics of the Intended Curriculum?

183 Exhibit 5.16

Emphasis on Approaches and Processes

### 185 What Science Content Do Teachers Emphasize at the Eighth Grade?

187 Exhibit 5.17

Subject Matter Emphasized Most in General/Integrated Science Class

### 188 What Science Topics Are Included in the Intended Curriculum?

190 Exhibit 5.18

Science Topics Included in the TIMSS Questionnaires

192 Exhibit 5.19

Science Topics in the Intended Curriculum for At Least 90% of Students, Up to and Including Eighth Grade

### 193 Have Students Been Taught the Topics Tested by TIMSS?

197 Exhibit 5.20

Percentages of Students Taught Earth Science Topics

198 Exhibit 5.21

Percentages of Students Taught Biology Topics

199 Exhibit 5.22

Percentages of Students Taught Physics Topics

200 Exhibit 5.23

Percentages of Students Taught Chemistry Topics

201 Exhibit 5.24

Percentages of Students Taught Environmental and Resource Issues Topics

202 Exhibit 5 25

Percentages of Students Taught Scientific Inquiry and the Nature of Science Topics

### 203 What Can Be Learned About the Science Curriculum?

#### 205 CHAPTER 6

Teachers and Instruction

### What Preparation Do Teachers Have for Teaching Science?

213 Exhibit 6.1

Age and Gender of Teachers

214 Exhibit 6.2

Teachers' Major Area of Study in Their BA, MA, or Teacher Training Certification Program

216 Exhibit 6.

Index of Teachers' Confidence in Preparation to Teach Science (CPTS)

### 218 How Much School Time Is Devoted to Science Instruction?

220 Exhibit 6.4

Instructional Time in the Sciences at Grade 8

222 Exhibit 6.5

Number of Hours Science Is Taught Weekly

224 Exhibit 6.6

Frequency of Outside Interruption During Science Lessons

### 227 What Activities Do Students Do in Their Science Lessons?

232 Exhibit 6.7

Science Class Size

233 Exhibit 6.8

Time Spent on Various Activities in Science Class

234 Exhibit 6.9

Students Doing Various Activities in Science Class

236 Exhibit 6.10

Presentational Modes Used in Science Class

238 Exhibit 6.11

Index of Teachers' Emphasis on Scientific Reasoning and Problem-Solving (ESRPS)

240 Exhibit 6.12

Index of Emphasis on Conducting Experiments in Science Classes (ECES)

#### 245 How Are Computers Used?

246 Exhibit 6.13

Frequency of Computer Use in Science Classes

247 Exhibit 6.14

Access to the Internet and Use of the Internet for Science Projects

### What Are the Roles of Homework and Assessment?

250 Exhibit 6.15

Index of Teachers' Emphasis on Science Homework (ESH)

252 Exhibit 6.16

Types of Assessment Teachers Give Quite a Lot or A Great Deal of Weight

## 253 In What Types of Professional Development Activities Do U.S. Science Teachers Participate?

255 Exhibit 6.17

Students Taught by Teachers Who Participated in Professional Development – Classroom Observation

256 Exhibit 6.18

Students Taught by Teachers Who Participated in Professional Development – School- and District-Based Activities

257 Exhibit 6.19

Students Taught by Teachers Who Participated in Professional Development – Workshops, Conferences, and Networks

258 Exhibit 6.20

Students Taught by Teachers Who Participated in Professional Development – Individual Activities

259 Exhibit 6.21

Professional Development Topics Emphasized Quite a Lot or A Great Deal

260 Exhibit 6.22

Content Areas Focused On in Professional Development

261 Exhibit 6.23

Familiarity with Curriculum Documents

## CONTENTS

7

#### **263 CHAPTER 7**

School Contexts for Learning and Instruction

### What Is the Economic Composition of the Student Body?

266 Exhibit 7.1
Students Eligible to Receive Free/Reduced Price Lunch

## 267 What School Resources Are Available to Support Science Learning?

270 Exhibit 7.2
Index of Availability of School Resources for Science
Instruction (ASRSI)

### What Is the Role of the School Principal?

273 Exhibit 7.3
Time Principal Spends on Various School-Related
Activities

### What Are the Schools' Expectations of Parents?

275 Exhibit 7.4
Schools' Expectations for Parental Involvement

### 277 How Serious Are School Attendance Problems?

278 Exhibit 7.5
Index of Good School and Class Attendance (SCA)

280 Exhibit 7.6
Frequency and Seriousness of Student
Attendance Problems

#### 281 How Safe and Orderly Are Schools?

283 Exhibit 7.7
Frequency and Seriousness of Student Behavior
Threatening an Orderly School Environment

284 Exhibit 7.8
Frequency and Seriousness of Student Behavior
Threatening a Safe School Environment

## **R** 1

#### 287 REFERENCE 1

Students' Backgrounds and Attitudes Towards Science

#### 289 Exhibit R1.1

Educational Aids in the Home: Dictionary, Study Desk/Table, and Computer

#### 290 Exhibit R1.2

Number of Books in the Home

#### 291 Exhibit R1.3

Highest Level of Education of Either Parent

#### 292 Exhibit R1.4

Country Modifications to the Definitions of Educational Levels for Parents' Education or Students' Expectations for Finishing School

#### 294 Exhibit R1.5

Students' Perception of the Importance of Various Activities

#### 295 Exhibit R1.6

Students' Perception of Their Mothers' View of the Importance of Various Activities

#### 297 Exhibit R1.7

Students' Perception of Their Friends' View of the Importance of Various Activities

#### 298 Exhibit R1.8

Why Students Need to Do Well in the Sciences

#### 300 Exhibit R1.9

Students' Daily Out-of-School Study Time

#### 301 Exhibit R1.10

Students' Daily Leisure Time

#### 302 Exhibit R1.11

Students' Reports That Science Is Not One of Their Strengths

#### 303 Exhibit R1.12

Students' Liking the Sciences

305

**REFERENCE 2**The Science Curriculum

306 Exhibit R2.1

Organization of Science Instruction

307 Exhibit R2.2

Detailed Information About Topics in the Intended Curriculum, Up to and Including Eighth Grade — Farth Science

308 Exhibit R2.3

Detailed Information About Topics in the Intended Curriculum, Up to and Including Eighth Grade – Biology

309 Exhibit R2.4

Detailed Information About Topics in the Intended Curriculum, Up to and Including Eighth Grade – Physics

310 Exhibit R2.5

Detailed Information About Topics in the Intended Curriculum, Up to and Including Eighth Grade — Chemistry

311 Exhibit R2.6

Detailed Information About Topics in the Intended Curriculum, Up to and Including Eighth Grade — Environmental and Resource Issues

312 Exhibit R2.7

Detailed Information About Topics in the Intended Curriculum, Up to and Including Eighth Grade — Scientific Inquiry and the Nature of Science

313 Exhibit R2.8

When Earth Science Topics Are Taught

314 Exhibit R2.9

When Biology Topics Are Taught

315 Exhibit R2.10

When Physics Topics Are Taught

316 Exhibit R2.11

When Chemistry Topics Are Taught

317 Exhibit R2.12

When Environmental and Resource Issues Topics Are Taught

318 Exhibit R2.13

When Scientific Inquiry and the Nature of Science Topics Are Taught

R 3

#### 319 REFERENCE 3

Teachers and Instruction

320 Exhibit R3.1

Teachers' Confidence in Their Preparation to Teach Science Topics

323 Exhibit R3.2

Shortages of Teachers Qualified to Teach the Sciences Affecting Capacity to Provide Instruction

324 Exhibit R3.3

Percentage of Students Whose Science Teachers Agree or Strongly Agree with Statements About the Nature of Science and Science Teaching

326 Exhibit R3.4

Percentage of Students Whose Science Teachers Think Particular Abilities Are Very Important for Students' Success in Science in School

328 Exhibit R3.5

How Teachers Spend Their Formally Scheduled School Time

329 Exhibit R3.6

Average Number of Instructional Days in the School Year

330 Exhibit R3.7

Asking Students to Do Problem-Solving Activities During Science Lessons

331 Exhibit R3.8

Teachers Demonstrating an Experiment in Science Classes

332 Exhibit R3.9

Students Doing an Experiment or Practical Investigation in Science Classes

333 Exhibit R3.10

Students Using Things from Everyday Life in Solving Science Problems

334 Exhibit R3.11

Amount of Science Homework

335 Exhibit R3.12

Assigning Science Homework Based on Projects and Investigations

336 Exhibit R3.13

Frequency of Having a Quiz or Test in Science Classes

**R 4** 

#### 337 REFERENCE 4

School Contexts for Learning and Instruction

338 Exhibit R4.1

Shortages or Inadequacies in General Facilities and Materials That Affect Schools' Capacity to Provide Science Instruction Some or A Lot

339 Exhibit R4.2

Shortages or Inadequacies in Equipment and Materials for Science Instruction That Affect Schools' Capacity to Provide Science Instruction Some or A Lot

840 Exhibit R4.3

Availability of Computers for Instructional Purposes

341 Exhibit R4.4

Schools' Access to the Internet

## CONTENTS

372

Exhibit A.9

375 Exhibit A.10

Curriculum Questionnaire

Curriculum Ouestionnaire

Country-Specific Variations in Science Topics in the

State-Specific Variations in Science Topics in the

**377 APPENDIX B** 343 APPENDIX A Overview of TIMSS Benchmarking Multiple Comparisons of Average Procedures: Science Achievement Achievement in Science Content Areas 345 History 378 Exhibit B.1 Multiple Comparisons of Average Achievement in Earth Science **Participants in TIMSS Benchmarking** 345 380 Exhibit B.2 Multiple Comparisons of Average Achievement in **Developing the TIMSS 1999** 346 Life Science **Science Test** 382 Exhibit B.3 Multiple Comparisons of Average Achievement in Physics 348 Exhibit A.1 The Three Aspects and Major Categories of the Exhibit B.4 384 Science Frameworks Multiple Comparisons of Average Achievement in Chemistry 349 Exhibit A.2 Distribution of Science Items by Content Reporting 386 Exhibit B.5 Category and Performance Category Multiple Comparisons of Average Achievement in Environmental and Resource Issues 350 TIMSS Test Design 388 Exhibit B.6 Multiple Comparisons of Average Achievement in Scientific Inquiry and the Nature of Science 350 **Background Questionnaires** 351 Translation and Verification 351 **Population Definition and Sampling** 354 Coverage of TIMSS 1999 Target Population - Countries **APPENDIX C** 356 Exhibit A.4 Percentiles and Standard Deviations of School Sample Sizes - Countries Science Achievement Exhibit A.5 358 Student Sample Sizes - Countries 392 Exhibit C.1 Exhibit A.6 360 Percentiles of Achievement in Science Overall Participation Rates — Countries Exhibit C.2 362 Data Collection Standard Deviations of Achievement in Science 363 Scoring the Free-Response Items TIMSS 1999 Within-Country Free-Response Scoring Reliability Data for Science Items 366 Test Reliability 397 APPENDIX D 367 Exhibit A.8 Cronbach's Alpha Reliability Coefficient -Descriptions of Science Items TIMSS 1999 Science Test at Each Benchmark 368 Data Processing 368 IRT Scaling and Data Analysis 369 Estimating Sampling Error 370 Making Multiple Comparisons 413 APPENDIX E Setting International Benchmarks of Acknowledgments **Student Achievement** Science Curriculum Questionnaire