Chapter 1

The Developmental Project to Report TIMSS 2003 Mathematics Achievement in Cognitive Domains

Overview of TIMSS

TIMSS 2003 is the third and most recently completed round of IEA's Trends in International Mathematics and Science Study, a very ambitious series of international assessments carried out in countries around the world to measure trends in mathematics and science learning at the fourth and eighth grades. Conducted first 'Ctheir students' achievement in mathematics and scienc countries participated in TIMSS 2003, with 23 having participated in all three assessments and another 14 having participated in two rounds. In developing the instruments and procedures for TIMSS 2007, IEA is currently working with more than 60 countries.

The TIMSS 2003 Assessment Frameworks and International Reports

For TIMSS 2003, the frameworks underlying the mathematics and science assessments and questionnaires were updated through a major effort. In particular, the mathematics and science frameworks were organized along two dimensions – content domains and cognitive domains. With additional financial support from the US National

Science Foundation and the US National Center for Education Statistics,

expressed a need for comparative information about how students perform in the cognitive domains. To provide enhanced information from TIMSS 2003 and facilitate planning for TIMSS 2007, a number of participating countries supported a developmental project for IEA's TIMSS & PIRLS International Study Center to examine mathematics achievement by cognitive domains. Although focusing on mathematics as the first step, if successful the project was intended also to serve as a roadmap for achieving similar goals in science.

Led by the United States, with funding also provided by Chinese Taipei, Cyprus, New Zealand, Norway, Ontario, Quebec, Singapore, and Sweden, the developmental project involved several major activities. Prior to preparing this report of the results of the development study, IEA's TIMSS & PIRLS ISC first convened an international meeting of experts in mathematics and mathematics education to confirm the mapping of TIMSS 2003 mathematics items to cognitive domains. Then, IEA's TIMSS & PIRLS ISC conducted the various phases of the analytic work necessary to create the cognitive domain scale scores.

Mapping the TIMSS 2003 Mathematics Items to Cognitive Domains

The developmental project began with a special meeting of mathematics experts held in February 2005 in Amsterdam, with the purpose of examining the classification of items according to the cognitive domains articulated in the TIMSS 2003 mathematics framework. The 10 participants (see Appendix B) expressed great enthusiasm for the meeting goal – facilitating TIMSS reporting according to cognitive domains. Nevertheless, all members expressed reservations about using the cognitive domains as they stood.

In developing the TIMSS 2003 Assessment Framework for Mathematics, there were no plan[illegible]

accomplished at the special Mathematics Cognitive Domains meeting and worked toward refining the classifications and their descriptions to better reflect the essence of the three cognitive domains. This resulted in an excellent foundation for scaling the TIMSS 2003 achievement data by cognitive domains.

Also, IEA's TIMSS & PIRLS ISC examined the distribution of the items within the three cognitive domains by item type, content domain, and difficulty to ensure that there was sufficient coverage of each of the newly defined domains. As described in Appendix B (and summarized in Exhibit B.1), there was a substantial number of items in each domain: 65 in knowing, 93 in applying, and 36 in reasoning at eighth grade; and 58 in knowing, 63 in applying, and 38 in reasoning at fourth grade. Within each domain, there was a good spread of item type (constructed-response or multiple-choice) at both grades, although as might be expected, relatively more of the knowing items were multiple choice and relatively more reasoning items constructed response. There also was a good spread of items across content domains within each of the three cognitive domains, although there was some unevenness in some areas. For example, it would have been preferable to have a higher proportion of number items in the reasoning domain at the eighth grade, and a higher proportion of patterns and relationship items in the knowing domain and measurement items in the reasoning domain at fourth grade. For TIMSS 2007, an effort

further refinements for TIMSS 2007 as published in the *TIMSS 2007 Assessment Frameworks* (Mullis, Martin, Ruddock, O'Sullivan, Arora, and Erberber, 2005).

The Scaling Methodology

The methodology used to create the mathematics cognitive domain scales was identical to that used to report mathematics achievement results and achievement in the mathematics content domains in

Summary of Overall Mathematics Achievement Nationally and by Gender for the TIMSS 2003 Countries

To provide a context for considering mathematics achievement at the

to grade. Thus, even though TIMSS devoted considerable effort to maximizing comparability across the grades tested there was some variation. Most notably, in the eighth-grade population, students in Norway, most of Slovenia, and parts of the Russian Federation had fewer years of formal schooling than their counterparts in other countries, while those in England, Scotland, New Zealand, and parts of Australia had more years of schooling. In the fourth-grade population, some students in Slovenia and parts of the Russian Federation had only three years of formal schooling, and students in England and Scotland as well as some in Australia and New Zealand had five years. Also, equivalence of chronological age does not necessarily mean that students have received the same number of year of formal schooling or studied the same curriculum. At the eighth grade, students were on average between 14 and 15 years old, but the range of policies and situations in the participating countries led to considerable variation. At the fourth grade, students in most countries were on average between 10 and 11 years old.

As can be seen in the right-hand portion of both pages of Exhibit 1.1, at both the eighth and fourth grades, the difference in overall mathematics performance by gender was negligible in many countries. The situation did vary by country, however. At the eighth grade, girls had significantly higher achievement in Singapore, Armenia, Serbia, Moldova, Cyprus, Macedonia, Jordan, Bahrain, and the Philippines. Boys had significantly higher achievement than girls in Belgium (Flemish), Hungary, the United States, Italy, Lebanon, Tunisia, Chile, Morocco, Ghana, the US state of Indiana, and the Canadian province of Quebec. At the fourth grade, girls had significantly higher average mathematics achievement in Singapore, Moldova, Armenia, and the Philippines. Boys had higher average achievement in the Netherlands, the United States, Cyprus, Italy, Scotland, and in the two Canadian provinces.