TIMSS ADVANCED 2008

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TIMSS Advanced 2008 Overview

Good morning. We are very pleased to be here at the University of Oslo for the international release of IEA's *TIMSS Advanced 2008 International Report*. As the international study directors, we will be providing an introduction to the study and a summary of the major findings across all of the participating countries.

Introduction

TIMSS Advanced 2008 was designed to assess students in the final year of secondary school who had studied advanced mathematics and physics. IEA first assessed such students in 1995, and, thus, the 2008 assessment provides trends between 1995 and 2008 for several countries.

Ten courageous countries participated in TIMSS Advanced 2008, including Armenia, Italy, Iran, Lebanon, the Netherlands, Norway, the Philippines, the Russian Federation, Slovenia, and Sweden. Italy, Norway, the Russian Federation, Slovenia, and Sweden also participated in 1995. We say courageous, because this study assesses the end result of secondary education for a crucial segment of students who will now enter further university training or other future endeavors.

At the end of the upper secondary school, the population of students becomes increasingly select. First, varying proportions of the age cohort may no longer be in school, because students either completed programs with an earlier exit point, or they have dropped out of school. Second, and very relevant for this study, there is a range of program and curricular choices available to students who

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continue in school so that typically not all students at this level study all subjects, or at least not at the same intensity.

It is important to recognize that the percentage of students enrolled in advanced mathematics or physics courses or tracks varies across countries, depending on the curricular choices available to students, whether students elect to specialize in these areas, and, in some cases, the selectivity of a country in accepting students into these courses. That is, students become more differentiated in their educational interests and course taking as they progress through school, typically with only small percentages specializing in particular areas such as advanced mathematics and physics. Moreover, those concentrating on advanced mathematics and physics are often among the "best and brightest."

The TIMSS Advanced 2008 report provides extensive data on contexts for learning collected from students, their teachers and schools, and from the participating countries. Much of the value of TIMSS Advanced 2008 resides in considering the achievement results in relation to key contextual variables, such as aspects of the countries educational programs and students' educational experiences.

The key policy issue raised by TIMSS Advanced is "How many students *can* be educated to a high level of educational attainment in mathematics and physics?" That is, the "yield" of an educational system from the perspective of how many students can and do climb how high up the educational ladder. On one hand there is the imperative for equality as expressed in the mantras of "Education for all," or "Mathematics for all." On the other hand are practical considerations as well as strategic planning about how many specialists are necessary for a country to remain economically healthy in a globally competitive environment.

The students assessed in TIMSS Advanced 2008 represent carefully defined populations of students taking courses in advanced mathematics and/or physics in their final year of secondary school. For the most part, they are specialists who have taken courses covering high level mathematics and physics content as an integral part of their pre-university coursework or training for the future, and often are in particular mathematics or science programs or tracks that last for three to five years.

The TIMSS Advanced 2008 Frameworks described what algebra, calculus, and geometry the students should have been taught in advanced mathematics, as well as the physics content they should have studied in mechanics, electricity and magnetism, heat and temperature, and atomic and nuclear physics. There was careful consultation with each country to identify the courses that covered this advanced material. Then, students enrolled in these courses were those assessed for TIMSS Advanced.

Considering all of the students in an age cohort that possibly could have been enrolled in these courses, the percentages of students actually surviving the pipeline and having studied this complex content is often relatively small, but varies considerably across the participating countries. In order to be taking such advanced courses at the end of upper secondary school, students will have had to

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have remained in school and studied challenging content in mathematics and science all through their school careers.

TIMSS created the TIMSS Advanced coverage index to quantify the variation in the proportion of students taking advanced courses in the final year of secondary school. It may be helpful to consider this index as a fraction expressed as a percentage. First, TIMSS used census data to estimate the size of the entire national population of students that could have been assessed if all of the students in the age cohort were still in school and taking advanced courses in their final year of school. That is the denominator. Then, as the numerator, TIMSS used the results of the study to estimate the size of the population of students actually having studied advanced mathematics and physics.

Results for Advanced Mathematics

The percentages of students having received the most elite mathematics education in each of the participating countries ranged from nearly half the students in Slovenia—40.5 percent—to 1.4 percent in the Russian Federation and just about 1 percent in the Philippines. Italy had about 20 percent according to the TIMSS Advanced 2008 Mathematics Coverage Index, Norway and Sweden from 11 to 13 percent, and the rest of the participants from about 4 to 6 percent.

The amount of time these students have spent studying mathematics is also of interest. Students in Italy were in their 13th year of school, whereas students in most countries were in the 12th year of school. In the Russian Federation, where reforms extending the number of years of school affected the cohort of students assessed, some students had 10 years of school and others 11 years. In Armenia, the students in their final year had 10 years of school, as did students in the Philippines. As would be anticipated from the differences in years of school across countries, there also were differences in the ages of students. Those in Italy, Slovenia, Norway, and Sweden were among the oldest—about 19 years old. The students in most other countries were about 18 years old, while those in the Philippines were much younger—about 16 years old.

Countries’ mathematics programs varied considerably in duration and intensity. Students in the Netherlands and Lebanon were in programs with the greatest number of hours of instruction—760 and 750 hours, respectively—across programs lasting 3 years (although some of these hours in the Netherlands included home study). Students in Iran, also in 3-year programs, had a total of 660 hours of instruction. In the Philippines, students had about 600 hours spread over a 4-year program, and Italian students had 500 hours across a 5-year program. In the Russian Federation, students were in a special program of intensive study requiring at least 6 hours weekly instruction, totaling about 500 hours over 2 years. The students in the remaining countries had fewer hours of instruction, ranging from 420 hours in Slovenia over 4 years to 280 hours in Norway over 2 years.

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Five of the countries had special criteria for entry into their advanced mathematics programs, most often success on an examination. The countries with selective criteria for students to participate in these advanced mathematics programs included: Iran, the Philippines, Italy, the Russian Federation, and Armenia.

The 10 countries participating in the advanced mathematics assessment had considerable differences in their average achievement. At the top is a group of three countries—the Russian Federation, the Netherlands, and Lebanon. Each of the three top-performing countries had average achievement higher than the international scale average of 500, and similar to each other. Iran had average achievement very close to the scale average (497). The rest of the participating countries all had average achievement significantly below the scale average, including Slovenia, Italy, Norway, Armenia, Sweden, and the Philippines. The bar graphs show the range of scores across the achievement distributions, with most countries having wide ranges. The Netherlands had the narrowest gap between its highest and lowest scoring students.

In most countries, the majority of students taking advanced courses in mathematics were male, with the greatest gender imbalance in the Netherlands, at 77 percent. Italy, Norway, Lebanon, and Sweden had at least 60 percent male students. In contrast, there was a 60/40 split favoring females in Slovenia and the Philippines. There was essentially no difference in advanced mathematics achievement between male and female students in the Netherlands, Italy, Norway, and Armenia. Although females had higher achievement in Lebanon, males had higher achievement in the remaining countries.

The Russian Federation showed little change in average achievement since 1995. However, average achievement declined between the two assessments in Slovenia, Italy, and Sweden, with Sweden decreasing 89 points. The TIMSS coverage index was comparable for Italy and the Russian Federation in both assessments. In contrast, it was considerably less in 2008 for Slovenia, decreasing from about 75 to 41 percent, and reduced somewhat for Sweden.

Results for Physics

In physics, the TIMSS coverage index was more comparable across countries than was the case for advanced mathematics, ranging from 11 percent in Sweden to 2.6 percent in the Russian Federation.

Also, students had fewer instructional hours in physics than in mathematics. Students in the Netherlands, Italy, and Lebanon were in programs with about 500 hours of instruction. These were spread over 3 years for the Netherlands and Lebanon, but over 5 years in Italy. The programs in Iran, Armenia, and Slovenia consisted of somewhat more than 300 hours, over 3 years for Iran and Armenia, but over 4 years in Slovenia. Students in Norway had 280 hours of physics over a 2-year program, whereas those in Sweden had 225 hours over a 3-year program. In the Russian Federation, students were in a special 2-year program of study consisting of at least three hours of weekly instruction, for a total of about 200 hours. The countries with special criteria for entry into their physics programs include Italy, Iran, Armenia, and the Russian Federation.

The Netherlands was the top-performing country in physics, by nearly 50 score points. The next highest achieving countries, Slovenia and Norway, had very similar average achievement. These three countries, together with the Russian Federation, performed above the scale average. Sweden and Armenia had average achievement very close to the scale average, and Iran, Lebanon, and Italy had average achievement below the scale average. With the exception of the Netherlands, most countries had a wide range between the highest and lowest achieving students, particularly the Russian Federation.

In all countries, except Armenia, more males than females were studying physics. At the extreme, 81 percent of physics students were male in the top-performing Netherlands, and more than 70 percent were male in Slovenia, Lebanon, and Norway. There was no or little difference in average achievement between female and male students in Slovenia, Armenia, Sweden, and Lebanon. In the other five countries – the Netherlands, Norway, Italy, Iran, and the Russian Federation, males had higher average achievement than females.

Slovenia had essentially no change in average physics achievement between the 1995 and 2008 assessments, and the Russian Federation showed some signs of decline. However, in Norway and Sweden, average achievement declined between the two assessments – 47 points in Norway and even more, 81 points, in Sweden. Although there was no change in average achievement in Slovenia, there was a considerable decrease in the coverage index, from 38.6 percent to 7.5 percent. Sweden also had a decrease in coverage, from 16.3 percent to 11 percent.

Selected Policy Issues

Over the past decades, there has been increasing interest in and debate about the role of technology in education. The data from TIMSS Advanced indicate that calculators are used much more frequently than computers in advanced mathematics and physics classes.

In advanced mathematics, almost all students in the Netherlands, Norway, and Sweden use calculators in almost every lesson. Students in the high-use countries of the Netherlands, Norway, and Sweden use graphing calculators, primarily for plotting functions but also for solving equations. About half the students use calculators in almost every lesson in Slovenia, the Philippines, and Lebanon. Students in these countries use scientific calculators, most often for solving equations. Calculator use was much less prevalent in Armenia, Italy, the Russian Federation, and, particularly, Iran. Although scientific calculators are used in Italy, simple calculators are used most often in the other countries or calculators are not used at all.

It can be noted that calculator use is not related to achievement across countries. For example, among high-achieving countries, the Netherlands uses calculators extensively, and the top-performing Russian Federation much less.

There was relatively widespread use of calculators in physics classes. Ninety-two percent of the Norwegian students and 81 percent of the Dutch students use calculators in almost every lesson, as do about three-fourths of the Slovenian and Swedish students, and about two-thirds of the students in Lebanon and the Russian Federation. As might be anticipated, the countries use the same types of calculators in physics as in mathematics. In physics, calculators are used most for solving equations, but also for processing and analyzing data, and for doing scientific procedures or experiments.

As mentioned, computer use remains far from prevalent in advanced mathematics and physics classes in the TIMSS Advanced countries. More than three-quarters of students in most the countries and at least two-thirds in the rest **never** use a computer in their advanced mathematics classes. Similarly, a majority of students from every country **never** use a computer in their physics classes, except in the Netherlands and Slovenia.

Almost all advanced mathematics and physics students indicated that they planned to continue their education after finishing secondary school. Advanced mathematics students are planning to enter various fields of study, but engineering is the most popular choice, with more students choosing it than any other field in more than half of the countries. For physics students, engineering also was the most popular choice, with more students choosing it than any other in six of the nine countries. Business was the next most popular choice among mathematics and physics students, followed by health science and social science.

The results concerning characteristics of the teachers of TIMSS Advanced classes were interesting from several perspectives. For one thing, teachers of advanced mathematics tended to be either mostly men or mostly women in the TIMSS Advanced countries. In Lebanon, the Netherlands, Norway, Sweden, and Iran, most students at this level were taught by men. Italy was the only country with approximately equal proportions of advanced mathematics students taught by male and female teachers. In the Philippines, Slovenia, Armenia, and the Russian Federation, most were taught by women. At the extremes, in Lebanon, 90 percent of the advanced mathematics students were taught by men; while in the Russian Federation, 90 percent were taught by women.

The results for physics teachers were similar, but with a preponderance of male teachers. In the Netherlands, Sweden, Norway, and Lebanon, nearly all of the students had male teachers – from 89 to 95 percent. About 70 percent of the Slovenian and Iranian students were taught by men. Italy, with 56 percent taught by men and 44 percent by women, came closest to gender parity. In the Russian Federation and Armenia, 77 and 87 percent, respectively, of physics students were taught by women.

Perhaps the most striking feature concerning the TIMSS Advanced teachers is that many are approaching their retirement years. In Norway, the Netherlands,

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and Lebanon, two-thirds or more of the advanced mathematics students were taught by teachers who were at least 50 years old. In Sweden, the figure was almost 60 percent, and in the Russian Federation, Armenia, and Italy, about 45 to 50 percent. For physics, in Norway, the Netherlands, Lebanon, and Sweden, about 60 percent of the students were taught by teachers who were at least 50 years old. In the Russian Federation, Armenia, Italy, and Slovenia, the figure was around 40 percent. As indicated by their ages, these teachers are very experienced, and they are also very well educated with many having postgraduate degrees, raising issues about the challenges of replacing them as they retire.

Teachers were asked about their plans for the future. Fortunately, the teachers of most advanced mathematics students – about 80 percent or more in most countries – intend to continue their teaching careers for as long as they can. The situation is similar for physics teachers. It appears that these specialist teachers like their jobs and will remain in them, at least for a while.

In conclusion, the TIMSS Advanced 2008 results point to several areas of concern for educators and policy makers. First, achievement in 2008 was disappointing in a number of the participating countries. Also, the trend results, although limited, indicate declines in educational yield, both in the percentages of students taking advanced courses and particularly in their achievement. As fewer students enter and survive the pipeline supplying fields related to mathematics, science, engineering, and technology, some countries may lack sufficient numbers of people with sufficient skills to be economically healthy and globally competitive.

Further, the few students graduating from these programs mostly are planning careers in engineering and business, rather than continuing their studies in mathematics and science. With the supply of highly educated teachers dwindling just as a significant part of the existing teaching force nears retirement, the potential exists for serious teacher shortages in science and technology in the years ahead.

With teachers in short supply, countries seeking to improve their educational situation in advanced mathematics and physics will face an even greater challenge. The TIMSS Advanced results suggest that attracting more students into advanced mathematics and physics courses, and specifically into teaching these subjects, is becoming a compelling necessity.

To stimulate further research into these and other crucial issues, the TIMSS Advanced 2008 international database, together with a complete set of reports – Assessment Frameworks, International Report, Technical report, and User Guide – are available from the TIMSS & PIRLS international website (timssandpirls.bc.edu) at Boston College.

Thank you very much.