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TIMSS-Mathematics Findings From National and International Perspectives: In search of explanations

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About TIMSS and TIMSS-Repeat

This special issue reports on a number of secondary analyses of the data of the Third International Mathematics and Science Study – Repeat (TIMSS-R). These analyses were driven from the angle of ''searching for explanations''. Authors of three of the articles started from their national perspectives in their search for explanations of the national mathematics achievement results in TIMSS-R: Belgium-Flemish, South Africa, and The Netherlands. However, the authors of the remaining three articles analyzed data from an international perspective to find explanations for differences in achievement results across countries.

In 1994–1995, the Third International Mathematics and Science Study (TIMSS'95) was conducted, under the auspices of the International Association for the Evaluation of Educational Achievement (IEA), at five grade levels in more than 40 countries (the third, fourth, seventh, and eighth grades, and the final year of secondary school). Students were tested in mathematics and science and information about the teaching and learning of mathematics and science was collected from students, teachers, and school principals.

In 1998–1999, the study was repeated (and is known as TIMSS'99 or TIMSS-R) in the upper grade level of the two grade levels containing most of the 13-year-old students, which was grade 8 for most of the 38 countries. TIMSS'99 provides

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countries that participated in TIMSS in 1994 – 1995 the opportunity to monitor trends in mathematics and science education at the eighth grade between 1995 and 1999 from an international perspective. It also provides countries that did not participate in TIMSS'95 originally, the opportunity to compare their levels of mathematics and science achievement, instructional practices, and policies internationally.

Continuing the approach of previous IEA studies, TIMSS was conceptualized as an examination of mathematics and science curricula at three levels (Robitaille & Maxwell, 1996; Robitaille et al., 1993). The *intended* curriculum comprises the mathematics and science instructional and learning goals as defined at the system level. This is embodied in textbooks, in curriculum guides, in the content of examinations, and in policies, regulations, and the official statements generated to direct the educational system. The *implemented* curriculum is the mathematics and science content as interpreted by teachers and made available and taught to students. The *attained* curriculum is the mathematics and science content that students have learned and their attitudes towards these subjects.

At each level, data were collected. The eighth-grade students completed an achievement test in mathematics and science (attained curriculum) and a questionnaire about their classroom experiences, attitudes towards mathematics and science, and home background. Whilst originally developed in English, these instruments were administered to students in the official media of instruction of each participating country (necessitating translations into more than 30 languages). The achievement test was developed on the basis of a rotated test design (meaning that items were distributed across eight test booklets (considered equal in difficulty) and were not administered to all the students) to increase the number of test items included in the test. The test contained items in both the multiple-choice and the open-ended format. Two-digit codes were applied with rubrics specific to each item or task to score students' responses to open-ended items. The first digit designated the correctness level of the response. The second digit, combined with the first, represented a diagnostic code used to identify specific types of approaches, strategies, or common errors or alternative conceptions. The mathematics and science teachers of the tested classes completed questionnaires about their academic preparation and instructional practices (implemented curriculum). School principals provided information about school characteristics and resources. At the level of intended curriculum, a curriculum questionnaire was administered to curriculum experts and a test curriculum matching analysis (TCMA) was carried out. In the TCMA, the appropriateness of each test item for the country's curriculum, was judged by curriculum experts in every country. Furthermore, additional system-level information was provided by each participating country. In a number of countries (such as Belgium-Flanders and South Africa), the national research center included a number of so-called "national option" instruments in their study. These permitted these countries to be able to analyze their achievement results against specifically relevant factors (such as cognitive ability in Belgium, Flanders, or language proficiency in South Africa) for

their country. The TIMSS'99 data collection took place near the end of the school year in every country: in the Southern Hemisphere in October through December 1998, and in most of the participating Northern Hemisphere countries in April and May 1999.

The first international results of the TIMSS'95 study (grades 7 and 8) were published in December 1996 in two reports, one for mathematics (Beaton, Mullis, et al., 1996) and one for science (Beaton, Martin, et al., 1996), whilst similarly the results of TIMSS'99 were published in December 2000 (Martin et al., 2000; Mullis et al., 2000). Those reports provided valuable (predominantly) descriptive information to policy-makers and practitioners in the participating countries about mathematics and science instruction and the achievement of their students from an international perspective. In addition to this, the IEA released the databases of both studies, allowing educational researchers around the world to conduct secondary analyses in search of explanations for the achievement results found.

Special Issue

A number of these secondary analyses are reported in this special issue. Researchers from Belgium (Flemish) (Van den Broeck, Opdenakker, & Van Damme), South Africa (Howie), and The Netherlands (Vos & Kuiper) analyzed their national data from a national comparative perspective, using (in the case of Belgium and South Africa) relational data analyses such as Partial Least Squared (PLS) analysis and multilevel analysis methods. In the other three articles (Shen, O'Dwyer, and Vos & Bos), data from a number of countries were analyzed using similar methods in a search of an "international comparative" explanation for the differences found between countries. Five articles take mathematics achievement as the dependent variable, while one contribution (Shen) includes both mathematics and science achievement in the analyses. Five articles focus exclusively on the data from TIMSS-R, collected in 1998/1999, but one (O'Dwyer) includes the TIMSS'95 data in her analyses so as to be able to examine the variance components within and across TIMSS administrations. Together, the six articles form a varied "pallet" of secondary analyses of the TIMSS data, and are exemplary of the rich possibilities these databases provide to those in search of explanations for achievement results.

The Effects of Student Characteristics on Mathematics Achievement in Flemish TIMSS 1999 Data (Van den Broeck, Opdenakker, & Van Damme)

In Belgium (Flemish), the TIMSS-R test design differed from the international design of the study: Instead of taking one class in each school, two classes per school were selected. Due to this design, the researchers implemented a multilevel model with an intermediate level. Whereas in other countries a division could only be made between one higher level (the school level, which is also the teacher and the class level) and a lower level (student level), in Belgium (Flemish) the higher level was subdivided in a

school and a class level. In a ''null''-model, the variance of the scores on the mathematics test was divided into: about 57% of the variance due to the student level, 29% due to the class level and 14% due to the school level (Van den Broeck, Opdenakker, Hermans, & Van Damme, 2003). To explain the variance on the individual levels, different variables can be entered in the model. In this article, the results of the multilevel analyses with the explanatory variables are presented and discussed. One of the interesting results reported is that the total variance in mathematics achievement is reduced with almost 35% by the variable ''Intelligence score''.

Contextual Factors at the School and Classroom Level Related to Pupils' Performance in Mathematics in South Africa (Howie)

South Africa participated in both TIMSS studies, where the performance was extremely low compared to the other participating countries. In both cases, more than 70% of the pupils wrote the achievement tests in their second or third language. A national option, an English language test, was included as a national option in an attempt to ascertain the level of the pupils' language proficiency as it was believed to be an important explanatory factor in the overall mathematics performance. In the analysis of the class-level and school-level data, PLS analysis was applied using data from 8,147 pupils, 194 school principals, and 189 mathematics teachers. The combined school- and classroom-level model revealed a relationship between the location of the schools, teachers' attitudes and beliefs, teaching load, lesson planning, and class size; all of which had direct effects on the South African pupils' performance in mathematics and explained 27% of the variance in the mathematics scores.

Trends (1995 – 2000) in the TIMSS Mathematics Performance Assessment in The Netherlands (Vos & Kuiper)

In TIMSS-95, participating countries could administer the TIMSS Performance Assessment, in addition to the standard written test. This consisted of practical, investigative tasks. Dutch curriculum experts considered this test to match well with the Dutch intended mathematics curriculum, which is based on the principles of Realistic Mathematics Education (RME). However in 1995, Dutch students did not score as well as expected on this practical test, revealing a discrepancy between the intended and the attained curriculum. Therefore, in 2000, the TIMSS Performance Assessment was repeated, including data collection at the levels of the intended, the implemented, and the attained curriculum. The results show once again a high approval of the test at the level of the intended curriculum; increased teachers' acceptance of the test (at the level of the implemented curriculum), but nevertheless, there was no significant gain in Dutch students' achievements. The authors suggest that this could mean that the implementation of the intended curriculum is still delayed.

Examining the Variability of Mathematics Performance and its Correlates Using Data From TIMSS'95 and TIMSS'99 (O'Dwyer)

International studies in education provide researchers with opportunities to examine how students with both similar and dissimilar formal education systems perform on a single test and provide rich information on the relationships between student outcomes and the factors that affect them. Using hierarchical linear regression techniques and data from TIMSS 1995 and 1999 in 23 countries, this research examines the association between the structure of the environments within which students receive instruction and achievement, and explores the relationship between background characteristics and eighth-grade mathematics achievement. The results of this research are presented in two stages. At first, the unconditional variance components within and across TIMSS administrations are examined and discussed; this is followed by a part in which predictors are included in multilevel models that explain some of the available variance.

How American Middle Schools Differ From Schools of Five Asian Countries: Based on cross-national data from TIMSS 1999 (Shen)

Using multivariate discriminant analysis and the data from TIMSS-99, this article compares middle schools in the United States with those from five Asian school systems individually, which are typically among the top TIMSS participating countries in terms of achievement scores in the two subjects. The discriminant analysis was based on variables related to school and classroom environment as well as students' out-of-school life, home background, and self-perceptions about mathematics and science. The results reveal significant differences between American schools and their Asian counterparts. The author emphasizes the importance of restoring the central position of schooling for American pupils.

The Mathematics Curriculum in The Netherlands: Measuring curricular alignment using TIMSS-99 (Vos & Bos)

When the intended curriculum of a nation is revised, it can be expected that the alignment between intended, implemented, and attained curriculum is disturbed. This seemed to be the case in The Netherlands in 1993, when the intended curriculum for mathematics at junior secondary schools was changed. A study on the alignment of the three curricular levels was carried out using TIMSS-99 data. For benchmarking, identical instruments were used in Belgium (Flanders). The results show that the curricular alignment in The Netherlands had reached a considerable level, 6 years after the introduction of a new intended curriculum.

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