Special Aspects of TIMSS related to Mathematics Education. Part 1*

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Introduction

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The Third International Mathematics and Science Study (TIMSS) was unique in a couple of respects: It was the biggest international comparison ever done, it combined two areas in the same test, mathematics and the sciences, and it was constructed not only as an achievement test but also tapped several other data sources. The latter was a consequence drawn from the experience gained by the earlier studies of the IEA[1], i.e. the Study of Achievement in Mathematics in 1964 (later called FIMS) and the Second International Mathematics Study SIMS in 1980–1982, or respectively the Science Studies FISS – a part of the Six Subject Study – and SISS. In some respects, the even more interesting parts of TIMSS from the point of view of mathematics education are the additional data sources supplementing the achievement study. They describe the background in which teaching, learning and the outcomes of tests are anchored and against which they should be interpreted.

In these two thematic issues of Zentralblatt für Didaktik der Mathematik (ZDM) we therefore concentrate on these additional aspects and data which provide mathematics education with a lot of information, most of them still waiting to be used and interpreted from the point of view of their value for promoting mathematics teaching and learning. These thematic issues are therefore also meant as an invitation to the Mathematics Education Community to use this information which is available for the scientific community now, for further detailed studies. The articles collected in these thematic issues of ZDM may stimulate such further writing, as we discuss only a small part of possible research questions, focusing mainly on one age group (Population II), giving ample space to a deeper look into one country (Japan), selecting mainly the Case Study and the Video Study part of TIMSS, and considering gender issues. Shortly, the term "Special Aspects" in the title of this volume is to be taken rather literally.

Studies on the mathematics education aspects of TIMSS could be of benefit for both the discipline of mathematics education and the development of mathematics teaching and learning in the classroom; cf. the resp. Handbook article in Grouws 1992 and more recently Kaiser et al. 1999 for a broader overview on international comparisons in mathematics education. Even admitting all the known objections, i.e. that international comparisons are difficult to be valued from the content-orientated perspective (Freudenthal 1975), that mathematics education sets out some content based conditions for a good translation of the items (Hanna 1993), that the technical efforts may not correspond properly to the outcomes for improving mathematics teaching and learning (Keitel & Kilpatrick 1998), or even taking seriously the methodological problems and pitfalls of international large scale assessments (Baumert 1998), there is still a big value in such studies. It is the "view from outside" which allows to reflect upon one's own practices. The often uncritical perpetuation of how to teach, how to learn, how to cope with a subject such as mathematics will be questioned, provided however, the international comparison gives more than the mere percentages of correct answers to selected items.

In this introduction we (1) give an overview of the data sources of TIMSS and the TIMSS-components, and (2) describe the contributions to both issues. The added list of literature is understood as a guide to relevant publications on the TIMSS mathematics issues now available. This basic list of references is supplemented by the special references in the papers.

1. Overview of TIMSS

It is not necessary to go into detail here, as there is easily available information about the aims, structure and outcomes of TIMSS. The most comprehensive publications

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[1]IEA = International Association for the Evaluation of Educational Achievement, Den Haag (NL) and Vancouver (CD).

for the international parts of TIMSS are Robitaille & Garden (1996), Beaton et al. (1996), Mullis et al. (1997), Mullis et al. (1998); in addition there are numerous national reports on TIMSS, as e.g. Baumert & al. (1997), Baumert et al. (1998), Moser et al. (1997), Lie et al. (1997), Schmidt (1998), to mention only a few; furthermore, there are some reports concentrating on special interpretations of the achievement results from a mathematics education viewpoint, e.g. Blum & Neubrand (1998), Götz & Reichel (1998), Ramseier (1999), to mention only the interpretations for the German-speaking countries. However, most of these reports and discussions focus mainly on the achievement test. Therefore, we describe here all the components of TIMSS to locate the articles in this ZDM-issue within the TIMS-study, and to exhibit a picture of the structure of the whole TIMSS project.

A predecessor of TIMSS was the so called Six Countries Study (Survey of Mathematics and Science Opportunity – SMSO, Schmidt et al. 1996) which played an important role in developing the instruments of TIMSS, and already identified different teaching methods, curricular trends, backgrounds and contexts in six countries: France, Japan, Norway, Switzerland (German speaking), Spain and the USA. Within SMSO some information was collected which later was also published under the TIMSS label. Howson's comparison of Grade 8 mathematics textbooks (Howson 1995) is of special interest to mathematics educators.

The overall structure and organization of the field explored in TIMSS is oriented on the three possible levels of a curriculum: the level of "intended curriculum" which comprises the syllabi in a country including the goals and aims of teaching in that country, the level of "implemented curriculum", i.e. what aspects rule the teaching and learning of mathematics in a certain school and in a class, and the level of "attained curriculum", on the basis of which the achievement of the student and his or her views on mathematics will be described.

There are several instruments to gain data at each of these levels; cf. Robitaille & Garden 1996. The TIMSS-framework underlying the achievement test and the curriculum study is published as Robitaille et al. 1993. Essentially, TIMSS consisted of the Main Study and three major additional components, the TIMSS-Curriculum Study, the TIMSS-Video Study and the TIMSS-Case Study.

1.1 TIMSS – Main Study

Basically, the TIMSS Main Study was an achievement test, and of course most of the testing time was given to working on the mathematical achievement tasks[2]. Three populations were tested: Children at the end of the period of primary education, i.e. about 10 year olds, in Population I; students of seventh and eighth grades in Population II, drawing the biggest attention in the wider public; and students at the end of the final year of secondary education in Population III, divided into math generalists and math specialists. TIMSS developed for this population the "MSL"-test: Mathematics and Science Literacy. It was the first time that the construct literacy was also defined in relation to the subjects mathematics and science (Orpwood & Garden 1997)[3]. However, besides the most often reported "horse-race" – results, the TIMSS Main Study contains much more data than only the records of how students of different countries answered to the achievement items:

The main study also consisted of school questionnaires which give information of the local organization of mathematics (and science) teaching, and the teacher questionnaires which provide information on the aims and goals teachers have when teaching mathematics. Both these questionnaires collected data on the "implemented curriculum" level. A student questionnaire supplemented the information from the achievement test by information on how students appreciate mathematics, what believes they hold concerning mathematics, how they feel they are taught mathematics, etc. Some of this information is available in the international data, some was only collected in national supplements to TIMSS, in some countries. Most of these data are still waiting to be interpreted and published from the mathematics education point of view.

Moreover, in some countries also the option to test along extended task formats was adapted. In this respect, TIMSS provided also a so-called "performance assessment test" which aimed at authentic problem solving processes in mathematics and science. Harmon et al. 1997 is the international report on this part of the achievement test, Stebler et al. 1998 contains the results of the performance test in Switzerland (German speaking part), Lie et al. 1997 reports Scandinavian experience also with this testing format.

The results of the achievement tests in general are reported in detail in the references cited. Additional information is available from TIMSS on the educational systems in the participating countries, as a background for all the collected data (Robitaille 1997). The more technical aspects of the TIMSS achievement test are documented in the Technical Reports (Martin & Kelly 1996/1997/1998) and in the Quality Assurance Report (Martin & Mullis 1996), both also available from the TIMSS web pages. The data itself are open for scientific purposes, as well as from the IEA upon request.

1.2 TIMSS – Curriculum Study

The TIMSS- Curriculum Study aimed to provide information on the selection of contents to be taught in schools in the different countries. Despite the existence of a relatively homogeneous core curriculum, this study also revealed the surprisingly different ways of how the contents are combined and distributed at the different grades. This study showed that the "intended curriculum" is diverse over the world in spite of a common core which is relatively broad as compared to the field of the sciences. Schmidt et al. 1997 reported the curriculum study. This study too would deserve a closer look and a detailed elaboration of some

[2] Approx. 2/3 of the items are avilable to the public as "released items" from the web pages of TIMSS (access via several addresses, e.g. http://www.ed.gov or http://timss.bc.edu); all items are available upon request from IEA for research purposes.

[3] Mathematical literacy with an enlarged definition is now going to be the focus of the OECD project PISA (Programme for international student assessment), starting right now.

of the "visions" that are briefly sketched (Schmidt et al. 1997), from the mathematics education perspective.

1.3 TIMSS – Case Study

The TIMSS-Case Study was set out to collect deeper information about the context of the teaching and learning of mathematics. Since there was a very close look at the students' behavior in the classroom, the teachers' preparations of the lessons, the parents' support of learning, the peer groups' roles and the social factors which influence teaching and learning, only three countries were visited by the Case Study researchers, i.e. Germany, Japan and the USA. There are three reports, one for each country, all of which are also available under the web address www.ed.gov (see: National Institute on Student Achievement, Curriculum and Assessment 1999 a, b, c)

1.4 TIMSS – Video Study

The three countries Japan, Germany and the US were also observed in the TIMSS-Video Study. This study provided a bigger collection of average lessons in each country. Some surprisingly clear differences could be observed in the styles of how mathematics is taught in each of the three countries. Obviously, there are differences in teaching mathematics within each of the countries. Since however the differences turned out to be bigger between the countries, it seems to be justified to speak of certain "cultural scripts" that govern mathematics teaching, a result which is surprising considering the apparently "universal" character of mathematics.

Stigler, Hiebert et al. (1997 and 1999) gave an overview of the many aspects of this study; Manaster (1998) described characteristics of the mathematical content treated in the lessons; Neubrand (1998) and Neubrand & Neubrand (1999) interpreted single lessons of this study under mathematics education viewpoints; Stigler & Hiebert (1999) formulate proposals for teaching mathematics, drawn from the experiences made when inspecting the video tapes.

2. The papers in these ZDM thematic issues on special aspects of TIMSS

According to the subject of this paper, i.e. the additional components of TIMSS, the papers for these ZDM issues were selected to show some special aspects, focusing on background information on the known reports on TIMSS. There are some major topics around which the articles are grouped: Teaching and learning of mathematics in Japan; the identification of teaching styles, pointing to the cultural constraints on mathematics teaching; and the gender issues.

Sawada starts with "Japanese perspectives on TIMSS", and explains in greater detail the content structure of the Japanese mathematical achievement in TIMSS. The following two articles of Kinney & Zusho and Shimizu can be seen as providing additional background information. Two aspects of teaching and learning mathematics are in the focus of these papers: that mathematics teaching and learning is embedded in a socially defined setting, as the Case Study could demonstrate (Kinney & Zusho), and how teachers in consequence reflect their profession (Shimizu).

That the content itself is filtered by the cultural script for teaching mathematics is pointed out by Hiebert, Stigler & Manaster, now bridging from Japan to US and Germany, on the basis of the inspection of the videotaped lessons. Reusser & Stebler give also a look at different teaching styles – "progressive, classical or balanced" – they found in Swiss schools when conducting a national version of TIMSS in Switzerland, based on an evaluation of extended student questionnaires. This paper can also show that some national complementary studies are part of TIMSS. These additional studies can give us a closer look into mathematics classrooms in several countries.

Hanna and Kaiser & Steisel discuss inhowfar gender differences in mathematics achievement can be extracted from TIMSS. They interprete their findings in a long-term perspective from FIMS to TIMSS (Hanna), and by interpretation of selected items (Kaiser & Steisel).

3. Literature

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