Classroom Teaching and Learning Resources: International Comparisons from TIMSS – A Preliminary Review

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Abstract: This paper explores international comparisons of data collected on classroom teaching and learning resources from TIMSS (Trends in International Mathematics and Science Study) in Mathematics and Science. Since its commencement in 1995, TIMSS has collected data from students, teachers, and principals using questionnaires on the perceptions of classroom teaching and learning resources. The paper examines what classroom teaching and learning resources teachers use in different countries, and explores the extent to which the textbook is still being used as the 'basis' of instruction, or as a 'supplementary' resource in the classrooms. It also explores continuity and change in the way teachers report they provided resources from 2003 to 2007, and 2011. The paper briefly reports on the range of studies using TIMSS data to explore the links between school and classroom factors and student achievement. This current research endeavour and its conceptual frameworks have largely ignored the role of classroom teaching and learning materials. The paper proposes a theoretical framework for considering how classroom teaching and learning materials may afford student achievement and learning. It shows that textbooks are the basis of instruction in an international context. However, it also shows that across countries, teachers value different classroom teaching and learning resources differently. The paper concludes with suggestions for further research to examine the relationship between use of different types of classroom teaching and learning materials, and student achievement based on multi-level analysis, but reminds of the need to reconsider the traditional input – output framework.

Keywords: teaching and learning resources, textbooks, sociocultural approach, TIMSS

This paper undertakes an international comparison of data collected on classroom teaching and learning resources from TIMSS (Trends in International Mathematics and Science Study), which is conducted every four years by the International Association for the Evaluation of Education Achievement (IEA).

Overall, international measures of student achievement, such as TIMSS and PISA (Program for International Student Assessment – conducted by the OECD), have become more and more critical in the development of national and international educational policies. They represent an external benchmarking system that is used to explore the impact of national and international educational reform and policy developments. Increasingly, international measures of student achievement have been used to identify and promote educational policy reform settings from nations that lead these international measures of student achievement.

1 The TIMSS student evaluation

The purpose of TIMSS is to assess performance in mathematics and science of students in grade 4 of schooling, (usually students have a mean age of 9.5 years); and in grade 8 (usually students have a mean age of 13.5 years). TIMSS achievement data was collected in 1995, 1999, 2003, 2007 and 2011, with another round proposed in 2015. In 2011, more than 60 nations participated in the TIMSS study, with a sample of more than 500.000 students worldwide.

The focus in most TIMSS analyses and discussions is around the averages for each country in terms of student achievement, and national comparisons between these averages. TIMSS and PISA develop league tables of student performance on tests that allow comparison between different countries. The focus on making national averages for league table comparison masks great differences, not only between countries, but within them as well.

The development of the TIMSS student evaluation programs has also provided some of the most extensive data sets on students, classrooms, schools, and families in the history of education research. This data allows the explaining and interpreting of students' scores in tests in the contexts of educational and sociocultural settings.

Among other things, TIMSS incorporates specific analysis of classroom teaching and learning resources, and presents some data on how these learning resources correlate with student learning (as measured by TIMSS). The data on classroom teaching and learning resources is but a very small component of the wider data sets. From its commencement in 1995, TIMSS has collected data from students, teachers, and principals, using questionnaires on the perceptions of classroom teaching and learning resources. The TIMSS questionnaires, 1999–2011, typically ask participating principals to identify if there's a shortage of teaching and learning resources, and then teacher's questionnaires ask teachers about classroom resources and materials used in their classrooms.

1.1 Use of TIMSS data to explore links between school and classroom factors, and student achievement

The extensive data sets have provided the impetus for a huge range of studies that explore the impact of different student characteristics, school structures and operations, teaching and pedagogical differences, and socioeconomic and educational systems variations in student achievement within and between countries.

A range of studies have explored these links to analyse educational factors that may contribute to studying learning and achievement. Drent et al. (2013) reported that in particular, secondary analyses studies were increasingly trying to differentiate factors which might have these impacts. Examples of these studies include factors such as class size (Breton, 2014), classroom composition (Chudgar et al., 2013), quality of curriculum (Hook et al., 2006), learning strategies (Kaya & Kablan,

2013), instructional strategies (House, 2009), self-concept and valuing of mathematics (Eklöf, 2007), student self-perception (Shen & Tam, 2008), students' perception of the learning environment (Vandecandelaere et al., 2012), social capital of students (Pugh & Telhaj, 2008).

But very few studies have analysed textbooks, and the studies focused on computers, tablets, and other ICT resources studied them in isolation from other teaching and learning resources used in the classes under study, e.g. study on ICT-use in primary mathematics instruction (Eikelman et al., 2012), or student computer use in science (House, 2012). The only two studies aimed at the school resources and their relationship with student achievement. Afana et al. (2013) compared Israeli Arab, Israeli Hebrew, and Palestinian Authority schools, and focused on shortages of resources as a factor of different achievements. Wilkens (2011) sought to determine whether there was a relationship between the types of textbook approval systems, and students learning outcomes.

Drent et al. (2013) use the generic framework for the review of the TIMSS studies based on classic input – output process. The framework conceptualizes input factors as related to the outputs, but operating to process factors at the class or school level. Scheerens et al. (2007) identified a number of process factors that enhance effectiveness, or 'black box' factors, related to high achievement. According to Drent et al., the process factors include: achievement orientation and expectations; curriculum quality/opportunity to learn; structured instruction; differentiation, adaptive instruction; feedback and reinforcement; evaluative potential; school/class climate; educational leadership; effective learning time; consensus and cohesion among staff, and parental involvement.

2 Theoretical model and research questions

In this paper, we introduce the learning model which allows us to frame the research questions and explore the complexities of use of classroom teaching and learning resources. This model and its applications will be briefly described below.

2.1 Sociocultural approach to classroom teaching and learning resources

Sociocultural approaches to learning have their origins in the approach of Vygotsky. Lantolf (2004) explained sociocultural theory as "a theory of mind … that recognizes the central role that social relationships and culturally constructed artifacts play in organizing uniquely human forms of thinking" (pp. 30–31). So the role of mediational tools – either physical (e.g., calculators, maps, or computers) or psychological (e.g., literacies, pedagogical frameworks, conceptions of learning, and language itself) is an important aspect of learning (Thorne, 2004). Hall (2001) explained the significance of such tools, stating that "the means themselves and the ways in which we

use them in the pursuit of action with others do not simply enhance our individual development, but rather, they fundamentally shape and transform it" (p. 29).

A sociocultural approach to classroom teaching and learning resources emphasises that such resources will be critical tools in the learning process, heavily mediated by the teachers use in making meaning from them, and crucial in creating zones of proximal development for students – learning environments where students can utilise learning tools, and the expertise of others to learn and develop. Following these ideas, "… the most pertinent question may not be *what* is included (or not) in a particular textbook package, but *how* instructors are using it (or not) in their teaching practices, and *why*" (Allen, 2008, p. 7).

Mediational tools are dynamic. That is to say, the use of tools and the role they play in learning depend on the cultures in which they are found, as well as human agency (Lantolf & Thorne, 2006). Given the role of the sociocultural practices that develop in different educational and cultural contexts, it would be expected that different classroom teaching and learning resources will be valued differently in different cultures and communities. Furthermore, classroom teaching and learning resources, and the sociocultural practices of their use, will evolve. An expression of this is that significant differences will be observed between cultures and communities about teaching and learning resources, and the sociocultural practise of their use. Such differences in the primacy of cultural resource practices will include: nature of teaching and learning resources, how they are used, attitudes towards them, their funding and provision; and their heritage history and trajectories. Furthermore, since learning environments are contextually and culturally bound, sociocultural practices will differ in some measure even from school to school, from community to community, from teacher to teacher, from class to class, from student to student.

At the same time, sociocultural approaches to thinking about classroom teaching and learning resources will emphasise their importance and role as powerful cultural learning tools: that are critical for promoting thinking operations, and inducting student learners into disciplinary practices and domains of knowledge. In playing these roles, classroom teaching and learning resources are mediated by teacher and student use, and shape thinking and internalisation. Sociocultural approaches emphasise that the primary role of classroom teaching and learning resources is to scaffold student learning – through providing sources of knowledge and inquiry they should promote self-regulated learning skills. They also assist teachers plan the development of learning environments. It is to be noted that since each discipline has its own practices, e.g.: community of practice, discourse, language, community of learners, different teaching and learning resources also have their aligned sociocultural practices. Different teaching and learning resources provide different forms of scaffolding; they support students learning in different degrees and ways.

Sociocultural approaches emphasize the fact that teachers mediate the use of classroom teaching and learning resources. Teachers use and interpret the resources to develop intersubjectivity, establish common student goals, and to create a zone of proximal development for students. Resources should support drill and practice

in the zone of actual development, but also provide challenging inquiry in the zone of proximal development, and promote conceptual growth. While thinking of the nature and purpose of classroom teaching and learning resources, it is important to consider the resources from learner's perspective, and to consider the role of resources in the learning environment.

2.2 Use of textbooks and digital resources in the classroom: the research questions

TIMSS data is useful in providing evidence to answer many questions relating to the international use of classroom teaching and learning materials. These research questions include:

RQ1: What classroom teaching and learning resources were teachers using in mathematics and science in 2011?

Are teachers using textbooks as the basis for instruction in maths and science in 2011? Do they employ workbooks and worksheets? Is computer software used more as a basis, or as a supplement? Do higher performing countries use more textbooks or computers as the basis for instruction than lower performing countries?

RQ2: Is the use of textbooks falling?

Comparing the data from 2003, 2007, and 2011, what changes can be tracked regarding the extent and way of using textbooks?

Two hypotheses were formulated based on the research question 2:

H1: There is a significant difference between the average percentage of students, whose teachers use textbooks as a basis for instruction in 2003 and 2007; 2003 and 2011; 2007 and 2011 in:

(a) grade-4-science,
(b) grade-4-mathematics,
(c) grade-8-science,
(d) grade-8-mathematics.

H2: There is a significant difference between the average percentage of students, whose teachers use textbooks as a supplement for instruction in 2003 and 2007; 2003 and 2011; 2007 and 2011 in:

(a) grade-4-science,
(b) grade-4-mathematics,
(c) grade-8-science,
(d) grade-8-mathematics.

Regarding classroom teaching and learning resources (CTLR), the data on printed media, i.e. textbooks and workbooks/worksheets, and digital media, i.e. computer software, has been processed. The TIMSS teachers' questionnaires did not define 'textbooks' as printed media explicitly. However, it is obvious from the context that e-materials including digital textbooks were covered by the term 'computer

software'. The extent of CTLR use is expressed in percentages of students in the countries whose teachers use various CTLR in specific ways. The ways of CTLR use involve 'as a basis for instruction', 'as a supplement', and 'not used'. The students' achievement is represented by mean scores the students achieved in TIMSS tests.

3 Methods

The research methodology employed the following steps:

In step 1, the TIMSS data for grade-4 and grade-8 science and mathematics resources that teachers use for teaching was identified from TIMSS 2011, 2007, and 2003 reports. This data was sourced by a large scale teacher survey conducted by TIMSS, where teachers reported the classroom teaching and learning resources that they use to teach the subjects nominated. TIMSS questionnaires incorporated two types of items regarding teaching and learning resources. First, the principals were asked to identify if there is a shortage of CTLR in their schools. We did not analyse this data, because it does not provide direct information on usage in the classrooms. The analysis presented in this article focused on the second data source, the teachers' questionnaires.

TIMSS teachers' questionnaires were targeted on textbooks, workbooks/worksheets, and computer software having been used in science and mathematics, in grade 4 and grade 8. In addition, the science teachers were asked about the reference books. In fact, the questions included one more resource: concrete objects in mathematics and science equipment or materials. The analysis in this article omitted these materials on purpose – it only focused on the text and/or pictorial resources in printed or digital form. In 2003 and 2007 questionnaires, teachers responded to two types of questions: *Do you use a textbook(s) in teaching mathematics/science in the TIMSS class? (Yes/No)* and then *How do you use a textbook(s) in teaching science/mathematics to the TIMSS class? (As a primary basis for my lessons, As a supplementary resource)*. In the 2011 version, the questions had been merged into one item: *When you teach mathematics/science to this class, how you use textbooks?* with the following multiple choice responses offered: *Basis for the instruction, Supplement, Not used*. In addition, the same questions were targeted on workbooks/worksheets, and computer software on both subjects in the TIMSS 2011 study.

The International TIMSS Databases provided data on percentages of students whose teachers use particular CTLR in specific ways (as a basis for instruction, as a supplement, not used), matched to the average scores of students taught by the teachers. The sample based on TIMSS 2011 comprised the data from 50 countries participating in grade-4 study, and 42 countries participating in grade-8 study. For comparisons of 2003, 2007, and 2011 data, only those countries were included that participated in all three studies, i.e. 20 countries for grade-4 analysis, and 29 countries for grade-8 analysis. The changes in time could be followed regarding only textbooks, because TIMSS 2003 and 2007 targeted only this teaching and learning resource.

In step 2, we involved statistical analyses to test the hypotheses H1 and H2 formulated in relation to research question 2. The non-parametric Mann-Whitney U test was applied to examine the differences between the percentage values of students whose teachers use classroom teaching and learning resources in 2003, 2007 and 2011. The non-parametric test was chosen because the data available had not been normally distributed, as shown by the Shapiro-Wilk test, and the skewness and kurtosis examination.

4 Results

4.1 What classroom teaching and learning resources were teachers using in mathematics and science in 2011?

As shown in Table 1, textbooks were used as the very basis for instruction. The mean percentage of students whose teachers use textbooks accordingly, was lowest in the case of science in grade 4 (about 70 percent), and the highest with mathematics in grade 8 (77 percent). Workbooks were used as a basis of instruction comparatively less (34–46 percent of students), and computer software at the lower end (7.3–15.9 percent). The highest ranking of textbooks is cross-referenced by other data. An average 45 percent of students whose science teachers in grades 4 and 8 reported using textbooks in 'every or almost every lesson', and another 25 percent of students whose teachers reported using them in 'about a half of the lessons' (see Table 2).

Table 1 Percentage of students, whose teachers use classroom teaching and learning resources as a basis for instruction: An international average

		Textbooks (%)		Workbooks (%)		Software (%)	
	N	Mean	S.D.	Mean	S.D.	Mean	S.D.
Science: grade 4	50	69.7	28.2	41.0	20.8	11.2	11.3
Maths: grade 4	50	75.5	24.4	45.6	22.4	9.0	8.9
Science: grade 8	42	74.1	21.6	35.4	15.4	15.9	1.3
Maths: grade 8	42	77.2	19.1	33.7	17.9	7.3	6.8

Source: TIMSS 2011 International Database (2013)

Notes: N = number of countries participating in the study; S.D. = standard deviation

Table 2 Percentage of students whose teachers use textbooks or other resource materials in science lessons according to the reported frequency of using (an international average)

Frequency in science	Every, or almost every lesson (%)	About half of the lessons (%)	Some lessons (%)	Never (%)
Grade 4	44.7	25.2	27.0	3.0
Grade 8	45.6	24.3	28.4	1.7

Source: TIMSS 2011 International Database (2013)

The mean values, of course, can be misleading, as we can here infer from relatively high standard deviations values. Among various countries reporting, huge variances existed in the percentages of students whose teachers use *textbooks as a basis for instruction*: from 3.6 percent of grade-4-science in England, up to 99.3 percent of grade-4-mathematics in Chinese Taipei, and science in Georgia. Nevertheless, the questionnaire investigation brought to light following findings:

- Related to grade-4 study, in 26 countries (out of 50 participating), more than 80 percent of students were taught by teachers who reported they used textbooks as a basis for science instruction. The same holds for 29 countries for mathematics instruction.
- Related to grade-8 study, in 22 countries (out of 42 participating), more than 80 percent of students were taught by teachers who reported they used textbooks as a basis for science instruction. The same holds for 26 countries for mathematics instruction.

There were countries in which the percentage of students whose teachers use textbooks as a basis for instruction, was high regardless of the grade or subject, for example Georgia, Armenia, Chinese Taipei, Korea, Saudi Arabia. On the other hand, there were several countries in which the percentage of students, whose teachers use textbooks as a basis, was comparatively very low in both subjects and grades: e.g. England, New Zealand, Australia, and Chile.

The critical terms are, nevertheless, 'as a basis' and 'as a supplement'. The above findings are relevant to the use of textbooks as a basis for instruction. On analysing the data relevant to the textbooks used *as a supplement*, the international average of students whose teachers used textbooks accordingly in 2011 is a little more than 20 percent (22.3 in grade-4-science, 21.1 in grade-4-mathematics, 24.3 in grade-8-science and 21.2 percent in grade-8-mathematics.) It is necessary, however, to take into account that it might be difficult to distinguish between 'as the basis of instruction' and 'as a supplement'. If we consider using the textbooks in the instruction *totally,* i.e. regardless to the way of use, then it is evident that the percentage of students is still lowest in the countries as England, New Zealand, and Australia. But here great discrepancies among subjects and grades have appeared: in grade-4-science the percentage was less than 50 percent, while in grade-4-mathematics it was already about 75 percent, and in grade 8 it rose to more than 85 percent in England, and to more that 90 percent in other countries. To express it in another way, in spite of several countries in which the percentage of students whose teachers do not use textbooks in grade-4-science, is comparatively high (Australia, England, New Zealand, and Malta), the international average of students whose teachers *do not use textbooks* at all, dips to very low figures: 8 percent in grade-4-science, 3.4 percent in grade-4-mathematics, and approaches only 1.6 percent in grade-8-science and mathematics. The distinct difference between grade 4 and grade 8 in the countries at the lower end of textbook usage can be illustrated by the example of Australia: science teachers of 54 percent of students and mathematics teachers of 29 percent

of students reported not using textbooks in grade 4, but science teachers of only 3.7 percent of students and mathematics teachers of only 3.4 percent of students in grade 8.

Using computer *software as a basis* for instruction varied noticeably, from no grade-4-mathematics teacher reporting usage in Poland, up to the exceptional value of 49.9 percent of grade-8-science students from Korea whose teachers reported using software in this way. The situation can be described as really manifold. The highest use of software was reported by countries such as Korea, Hong Kong, Qatar, and Saudi Arabia in both grades and subjects. However, it is important to point out that not all technologically developed and/or comparatively rich countries used software extensively. For example Japan, Finland, and Germany belong among the countries with less than 3 percent of students whose teachers reported the use of software as a basis. The relationship between using *textbooks and software as a basis for instruction* varied noticeably, too. There are countries in which both resources were widely used, e.g. Saudi Arabia (textbooks 91%; software 42% in grade-8-science) and Korea (88%; 49.9%). Then, there are countries, in which teachers distinctly preferred textbooks over software, e.g. Finland (textbooks 94%; software 1.1% in grade-4-science) and Japan (82%; 2%). The only countries reporting predominance of software were New Zealand and England (for grade-4 science and mathematics, and grade-8-science), and Northern Ireland (for grade-4-science), being the countries with the least dependency on whichever text resource used as a basis for instruction, including textbooks and workbooks.

We can conclude that in 2011 all over the world, textbooks still highly prevailed as classroom teaching and learning resources in most countries, regarding science and mathematics, both in primary and lower secondary schools. At the same time, the usage of different resources varied distinctly relating both to the extent and the way in which the resources were introduced into instruction.

4.2 Is the use of textbooks falling?

As we could see above in the text, according to the TIMSS 2011 findings, textbooks stay firmly in place for classroom teaching and learning resources in science and mathematics. But what are the emerging trends, if any? With the widespread use of digital resources, we pose the question of whether teachers across the countries would use textbooks less than in previous years. Two basic hypotheses were formulated:

> H1: There is a significant difference between the average percentage of students whose teachers use textbooks as a basis for instruction in 2003 and 2007; 2003 and 2011; 2007 and 2011; in grade-4-science / grade-4-mathematics / grade-8-science / grade-8-mathematics.
> H2: There is a significant difference between the average percentage of students whose teachers use textbooks as a supplement for instruction in 2003 and 2007; 2003 and 2011; 2007 and 2011; in grade-4-science / grade-4-mathematics / grade-8-science / grade-8-mathematics.

For testing the hypotheses, only the data available from the countries participating in all three TIMSS international studies 2003, 2007, and 2011 were applied to comparison of development in the particular countries. Thus the data sample of 20 countries was selected for grade 4 analysis, and the data sample of 29 countries for grade 8[1]. The mean percentages of students whose teachers used textbooks in 2003, 2007, and 2011, according to the teachers self-reports, are listed in Table 3.

Table 3 Percentages of students whose teachers used textbooks as a basis for instruction and as a supplement for instruction in 2003, 2007 and 2011: An international average

Textbooks use	N	As a basis (%)			As a supplement (%)		
		2003	2007	2011	2003	2007	2011
Science 4	20	57.8	57.2	70.7	27.0	30.8	19.4
Maths 4	20	63.5	63.8	70.8	32.2	32.9	23.7
Science 8	29	57.9	56.5	75.1	38.2	37.0	23.1
Maths 8	29	66.6	62.8	78.7	31.3	32.2	19.5

Sources: TIMSS 2011 International Database (2013); Foy & Olson (2009); Martin (2005)
Note: N = numbers of selected countries

For the statistical analyses of differences among the findings from three separate years, the non-parametric Mann-Whitney test was applied, due to the data not being normally distributed. The main results were as follows:

- In all cases the differences between findings from years 2003 and 2007 are not statistically significant. The percentages of students whose teachers used the textbooks do not differ for either as a basis, or as a supplement. It holds true for grade-4-science, grade-4-mathematics, grade-8-science, and grade-8-mathematics without exception. The hypotheses H1 and H2 have not been proven for the years 2003 and 2007.
- On the contrary, there are statistically significant differences between the percentages of students whose teachers used textbooks as a basis for instruction in 2003 and 2011, as well as in 2007 and 2011. The findings apply to the grade-4-science, grade-8-science, and grade-8 mathematics. Hence hypothesis H1 has been proven for these three cases. From 2003/2007 to 2011, the percentage of students whose teachers use textbooks as a basis for instruction *increased* significantly (see Figures 1 and 2). In the case of the grade-4-mathematics teachers, the differences have not been statistically significant. The detailed results of Mann-Whitney U tests are presented in the Attachment, Table 6, reporting mean ranks, U statistics, and *p*-values.
- The findings with regards to the textbook use as a supplement are similar. There are statistically significant differences between the percentages of students

[1] The total numbers of all the participant countries in grade-4 studies were: 26 in 2003, 36 in 2007, and 50 in 2011.The total numbers of all the participant countries in grade-8 studies were: 47 in 2003, 49 in 2007, and 42 in 2011.

whose teachers used textbooks as a supplement for instruction in 2003 and 2011, as well as in 2007 and 2011. The findings apply to grade-4-science, grade-8-science, and grade-8 mathematics. Hence hypothesis H2 has been proven for these three cases. From 2003/2007 to 2011, the percentage of students whose teachers use textbooks as a supplement for instruction *decreased* significantly (see Figures 1 and 2). In the case of the grade-4-mathematics teachers, the differences have not been significant. For detailed results see Attachment, Table 6.

In order to get better grasp of the changes that have taken place, the examples are reported below, regarding individual countries which took part in the 2007 and 2011 TIMSS studies. Total number of 29 countries participated in the grade-4 study. For instance, if comparing the data on students whose teachers used the textbooks as a basis in grade-4-science, the percentage increased in 25 countries (regardless of the statistical significance). In 10 countries, the reported difference from 2007 to 2011 amounted to 25 percent: e.g. in Austria, Czech Republic, Norway, Kuwait. Only in 4 countries the percentage decreased – most markedly in Singapore (by 7.6 percent). As for grade eight, 35 countries participated both in TIMSS 2007 and 2011. The percentage of students whose teachers used textbooks as a basis increased in 31 countries totally, of which in 14 cases more than by 25 percent, including such countries as Italy, Israel, Turkey, and Slovenia. The percentage fell only in 4 countries, including England (almost by 14 percent) and USA (about 9 percent).

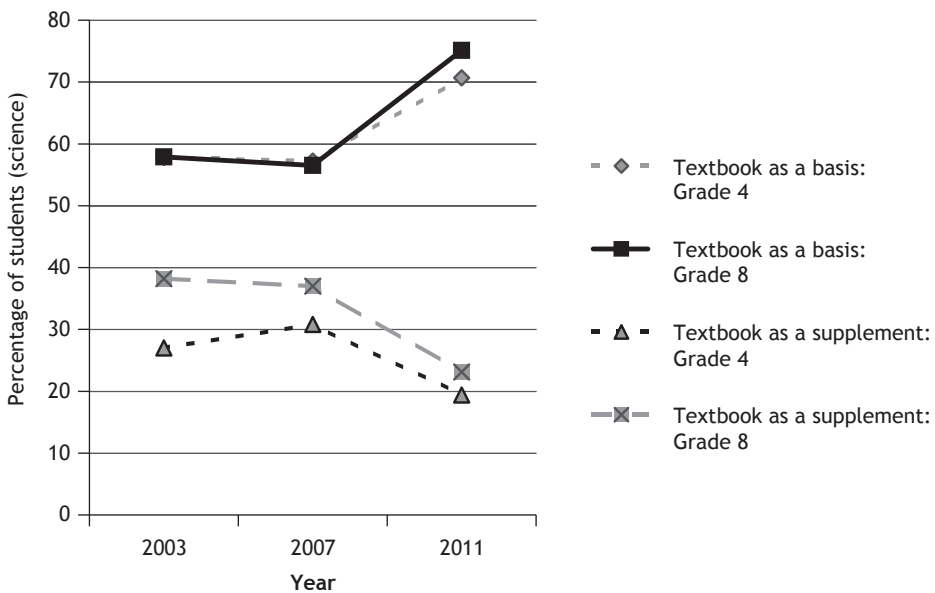

Figure 1 Percentages of students whose teachers used textbooks as a basis for instruction and as a supplement for science instruction in 2003, 2007, and 2011: An international average
Sources: TIMSS 2011 International Database (2013); Foy & Olson (2009); Martin (2005)

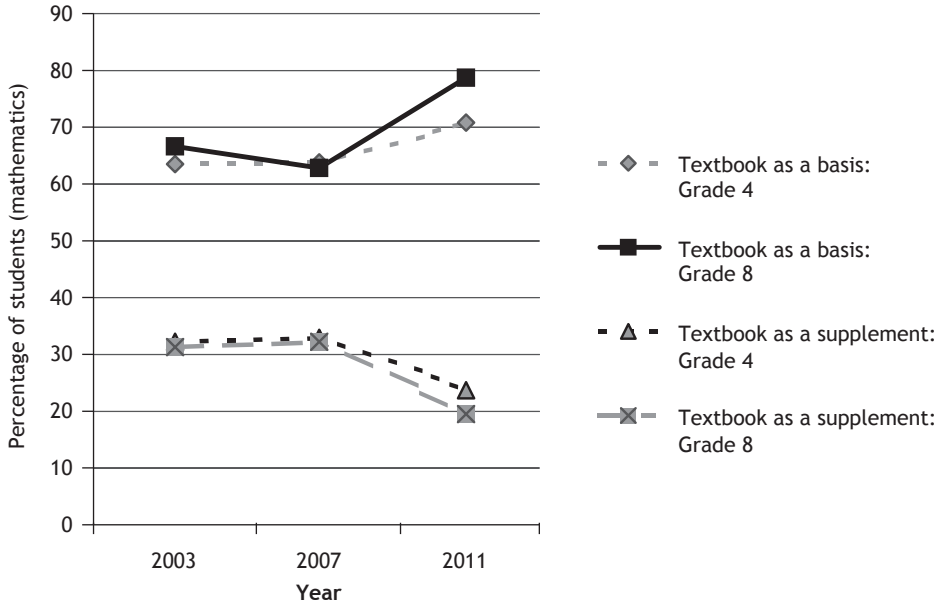

Figure 2 Percentages of students whose teachers used textbooks as a basis for instruction and as a supplement for mathematics instruction in 2003, 2007, and 2011: An international average
Sources: TIMSS 2011 International Database (2013); Foy & Olson (2009); Martin (2005)

On the basis of TIMSS questionnaires data analysis certain conclusions can be derived. Between the years 2003 and 2007, as teachers self-reported, the extent and basic ways of using textbooks did not change. In the next period – in the 2011 study – a considerable change occurred: the percentage of students whose teachers used textbooks as a basis for instruction markedly rose, and at the same time the percentage of students whose teachers used textbooks as a supplement distinctly declined. These changes appeared in both subjects and in both grades, statistical significance has been confirmed for grade-4-science, grade-8-science, and grade-8-mathematics. Hence the decrease of textbook use has not become reality beyond doubt. On the contrary: on an international scale, more teachers used textbooks as a basis for their teaching in 2011 than four or eight years ago. It is of course necessary to factor in the methodology of data gathering based on the teachers' responses in questionnaires. Nevertheless, the findings seem to be consistent.

5 Conclusions and discussion

From several viewpoints, we searched for the answer to two basic questions: what classroom teaching and learning resources teachers use for instruction, and whether any changes can be tracked regarding the extent and way of using textbooks.

As far as the resources use is concerned, textbooks still highly prevail as classroom teaching and learning resources used as a basis for instruction. According to the TIMSS 2011 Study, more than 70 percent of students were taught by teachers using textbooks as a basis of instruction. The other key classroom teaching and learning resources – workbooks/worksheets and computer software – were used as a basis comparatively less (workbooks – about 40 percent, software – about 11 percent in average). For more detailed description see Tables 1 and 2.

Teachers across various countries in the world became even more textbook dependent than before. TIMSS 2011 findings show that the average proportion of students whose teachers use *textbooks as a supplement has decreased*, while the average proportion of students whose teachers use *textbooks as a basis has significantly risen* since 2003 and 2007 (see Table 3). On the other hand, it does not mean that workbooks/worksheets and computer software were not used – teachers used them rather extensively as a supplement. The average values range from 52.7 to 62.2 percent of students whose teachers used workbooks or software as a supplementary aid (see Table 4).

Table 4 Percentage of students whose teachers use classroom teaching and learning resources as a supplement for instruction: An international average

	N	Textbooks (%)	Workbooks (%)	Software (%)
Science: grade 4	50	22.3	55.6	52.7
Maths: grade 4	50	21.1	52.9	55.9
Science: grade 8	42	24.3	60.0	60.5
Maths: grade 8	42	21.2	62.2	54.6

Resource: based on TIMSS 2011 International Database, 2013

Note: N = number of countries participating in the study

At the same time, the situation can be described as diversified with *different resources emphasised in different countries*.The data in Table 5 may well exemplify the great diversity in using classroom teaching and learning resources across countries. As an example, the outcomes of grade-4mathematics have been employed. The percentages of students whose teachers used textbooks and computer software as a basis are presented, reported by teachers from the ten highest ranking countries, and from ten countries ranking at the low end of scale, according to the students' scores. Both among the high achieving countries and among low achieving countries there are huge differences in percentages of students whose teachers self-reported particular CTLR use. The state of affairs in grade-8-mathematics and grade-4 and 8-science is very much alike.

The situation described above is in accord with sociocultural approaches to classroom teaching and learning researches. Given the role of the sociocultural practices that develop in different educational and cultural contexts, it would be expected

that different classroom teaching and learning resources will be valued differently in different cultures and communities.

Table 5 Percentage of students whose teachers used textbooks or software as a basis for instruction in high-achieving and low-achieving countries in grade-4-mathematics

Rank	M4_top 10	CTLR used as a basis		Rank	M4_low 10	CTLR used as a basis	
		Textbooks	Software			Textbooks	Software
1	Singapore	69.6	16.2	41	Bahrain	76.0	17.1
2	Korea, Rep. of	98.6	25.1	42	UAE	80.4	17.8
3	Hong Kong SAR	87.7	34.4	43	Iran	90.5	2.4
4	Chinese Taipei	99.3	17.3	44	Qatar	69.8	29.0
5	Japan	92.0	1.3	45	Saudi Arabia	93.4	29.7
6	Northern Ireland	43.1	12.9	46	Oman	48.5	4.6
7	Belgium (Flemish)	39.3	1.9	47	Tunisia	44.2	5.4
8	Finland	94.6	5.5	48	Kuwait	96.5	9.4
9	England	10.3	23.5	49	Morocco	76.6	6.4
10	Russian Federation	94.6	1.1	50	Yemen	88.9	1.8

Source: TIMSS 2011 International Database (2013)

The TIMSS data analysis raises significant questions about how to conceptualise the way that teachers select and use classroom teaching and learning materials. The role of textbooks seems to be changing. In the traditional concept of teaching based on transmission, textbooks serve mainly as a source of information, the basis for transmission. In the constructivist concept, the function of the control of learning, learning management, is the most important – in the first place, the textbook is an activity and inquiry source (Horsley & Walker, 2005; Sikorová, 2011; Červenková, 2010). At present, two more textbook functions seem to strengthen, which keep themselves in the background with traditional textbooks: co-ordination and integrative functions. Co-ordination function means that textbooks should "co-ordinate using other educational aids", like videos, animations, worksheets, computer programs (Mikk, 2000, p. 18). According to our view, integrative function is even more important nowadays. It means that textbooks underpin the comprehension and integration of knowledge the students receive from other resources. The textbook serves as a background and basis for understanding information. In

the context where multiple resources are provided for student learning, it may be opportune to reconsider traditional understandings of the environment in which textbooks are used. In a context that incorporates multiple learning resources, consideration needs to be given to how such resources interact; and the capacity of resources to be linked and integrated to other resources (Horsley, Knight, & Huntly, 2010).

In relation to both print and digital student educational resources, it is not the quantity or even quality of classroom teaching and learning resources that is critical, but the use to which they are put by teachers and students. More current research (Grubb, 2008) has argued that many resources in schools are complex and compound, in that their use is mediated by other resources. For example, laptops and digital educational resources, and an increasing number of interactive whiteboards, may be provided, but the impact on student performance and educational outcomes of these resources will be dependent on the way that teachers use them. Print and digital textbooks, as well as other teaching and learning resources, are modified, adapted, and customised by teachers to produce classroom teaching and learning materials. According to Grub (2008), this process of resource construction depends on both the level of classroom teaching and learning resource inputs, and the ways that teachers turn these inputs into classroom resources, that support learning.

As we implied above (see Table 5), the relationship between CTLR use and student achievement seems to be unambiguous and inconsistent. So far, this paper has undertaken the descriptive analysis and some related theoretical consideration. But two further research questions have been posed, both focused on analysing the relationships between the types of CTLR, and student achievement. These research questions include:

- Do the students' achievements differ if their teachers use different kinds of classroom teaching and learning resources as a basis for instruction? In other words: if your national education system uses more textbooks or workbooks/worksheets or computer software, do your children achieve more in TIMSS?
- And do the students' achievements differ if their teachers use classroom teaching and learning resources in different ways, i.e. as a basis for instruction or as a supplement?

However, the input–output conceptual framework behind current multilevel frames of analyses are not aligned with theories of learning that show how use of materials by teachers can afford or constrain the development of learning environments to promote learning and development. Modifications to the usual multilevel analyses are being developed by the authors to address these questions.

One finding that any examination of TIMSS data on teacher use of classroom teaching and learning materials proves true is that – digital education is yet to arrive in classrooms; is unlikely to arrive anytime soon; may not be associated with increased achievement; and that politicians' claims that the laptop or tablet is the textbook of the future, is patently untrue.

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Table 6 Results of Mann-Whitney U test: significance of differences between the percentages of students whose teachers used textbooks in 2003, 2007 and 2011

Textbooks used	As a basis				As a supplement		
	Year	Mean Rank	U	Sig.	Mean Rank	U	Sig.
Science: grade 4	2003	21.1	187.5	.735	17.8	148.5	.350
	2007	19.9			21.2		
	2003	17.1	131.0	.042*	23.9	116.0	.038*
	2011	24.0			16.3		
	2007	17.8	129.0	.045*	24.1	111.5	.027*
	2011	21.2			16.1		
Maths: grade 4	2003	20.1	192.5	.839	19.6	179.0	.965
	2007	20.9			19.4		
	2003	18.4	157.5	.250	22.9	134.5	.119
	2011	22.6			17.2		
	2007	18.8	166.0	.358	22.9	135.5	.126
	2011	22.2			17.3		
Science: grade 8	2003	30.8	383.5	.565	29.1	402.5	.955
	2007	28.2			28.9		
	2003	22.4	215.5	.001*	36.0	211.0	.002*
	2011	36.6			22.3		
	2007	21.3	182.5	.0002*	36.3	224.0	.002*
	2011	37.7			22.7		
Maths: grade 8	2003	31.7	358.0	.331	27.9	375.5	.626
	2007	27.3			30.1		
	2003	23.4	244.0	.006*	35.1	236.5	.007*
	2011	35.6			23.2		
	2007	22.3	210.5	.001*	36.3	223.5	.002*
	2011	36.7			22.7		

Resources: based on TIMSS 2011 International Database, 2013; Foy & Olson, 2009; Martin, 2005
U = Mann-Whitney U test statistics; Sig. = p-value at $\alpha = 0.05$ level; *the value is statistically significant at $\alpha = 0.05$ level.