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# The association between science achievement measures in schools and TIMSS science achievements in Sweden

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## ABSTRACT

The aim of this study was to examine the association between students' TIMSS (Trends in Mathematics and Science Study) science achievement, and students' school achievements, in terms of national tests and grades from school years 6 and 9. Further to examine the association with TIMSS science achievement and different subgroups of students based on their home background. The study is based on a unique possibility to analyse TIMSS 2015 data together with register data of the Swedish students' national test results from school years 6 and 9 and their science subject grades from school years 6 and 9. The overall results show that there were moderate associations between TIMSS science achievement and school achievement measures. The association between grades and the high-stakes national tests were stronger than between grades and TIMSS. The students' home background had a clear impact on the results as students with highly educated mothers, who comes from homes with many books and are nonimmigrants had on average higher TIMSS science achievements.

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## KEYWORDS

Correlation; grades; multilevel analysis; national tests; science achievement

## Introduction

The most common student achievement measure across countries is subject grades. However, every year most students in compulsory school also undergo a number of tests including participating in international large scales assessments (LSA) like Trends in Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA). The results from these assessments have received a lot of attention in Sweden in recent years as Swedish student performance overall has dropped over the years. If the associations are strong between grades and different kind of tests including international LSA, the results from them can carry more meaning in relation to school development and educational practice.

In Sweden, both the students' subject grades and national tests in schools are clearly related to the national curriculum. In contrast to other international LSAs, TIMSS is designed to be curriculum-based which imply that there may be an association between

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school measures of science (i.e. subject grades and national tests) and TIMSS results. In order to examine what TIMSS science measure, in comparison to the Swedish national curriculum, Frändberg and Hagman (2017) performed an alignment study. Their conclusions were that the TIMSS framework and items were within the Swedish national curriculum with respect to content and cognitive ability although some central content was lacking. Their study did however not answer how strong the associations are between the students' TIMSS science achievements and students' grades and national test results. To the best of our knowledge, the association between national assessments (e.g. grades and national tests) and TIMSS science achievements has not yet been examined in a research study. Although TIMSS has been recurrent every fourth year in Sweden since 1995, there is no knowledge about how students' TIMSS science achievements are related to the school achievement measures grades and national tests. It is well known that a student's achievement in school is related to the students' home background (see, e.g. Erberber, Stephens, Mamedova, Ferguson, & Kroeger, 2015; Gustafsson & Yang Hansen, 2018; Hanushek & Luque, 2003; Sirin, 2005) and that students' who come from homes with high socioeconomic background tend to perform better in school than students with lower socioeconomic background. This association has been found across countries, school subjects (e.g. science and mathematics), and grades from primary to secondary education (Erberber et al., 2015; OECD, 2011). Against this background, the overarching aim of this study is to examine the association between students' TIMSS science achievement and students' school achievements, in terms of national tests and grades from school years 6 and 9. A further aim is to examine the association with TIMSS science achievement and different subgroups of students based on their home background.

### **Literature review**

To the best of our knowledge, there are no other research study examining the association between grades and data from national assessments with TIMSS science data. Recently, the association between TIMSS mathematics and Swedish school assessments was studied and a strong positive association was found (Wiberg, 2019). However, most TIMSS research studies have only used data from the TIMSS international database (e.g. Caponera & Losito, 2016; Kaleli-Yilmaz & Hanci, 2016; Wiberg & Rolfman, 2013; and Drent, Meelissen, and van der Kleij (2013) for a review of TIMSS studies until 2011). There are however several studies linking national assessments to international LSA. For example, Beaton and González (1993) created a transformation link between the US National Assessment of Educational Progress (NAEP) to the International Assessment of Educational Progress. Other studies link TIMSS to the NAEP scale (e.g. Johnson, 1998; Lim & Sireci, 2017). To create a link between two assessments is not the same as examining the association between individual students' achievements on TIMSS and other school achievement measures such as grades. Although we cannot find similar studies of TIMSS, we have found a study that use PISA 2000 data, such that PISA variables are used to explain the performance on junior certificate examinations in mathematics and science (Sofroniou, Cosgrove, & Shiel, 2002). That study is thus the opposite from the aim of our study where we try to examine TIMSS science achievement results with students' home background variables and school achievement measures. As mentioned earlier, TIMSS

measure a large part of the Swedish curriculum both with respect to content and cognitive reasoning, but some larger content areas are missing (Frändberg & Hagberg, 2017). This is not surprising as TIMSS was not designed, as opposed to national tests or regular tests given in schools, to measure the complete national curriculum instead it was designed from curriculum analyses across multiple countries. Note, it is not necessary the case that international LSA results and national assessment results show the same performance pattern. In Canada, provincial assessment results often are in conflict with international assessment results (Cartwright, Lalancette, Mussio, & Xing, 2003) and Szalaniec, Grudniewska, Kondratek, Kulon, and Pokropek (2013) found that national assessment trends in Poland are not consistent with trends in PISA.

Several TIMSS studies (e.g. Caponera & Losito, 2016; Ilie & Lietz, 2010; Wiberg, 2019; Wiberg & Rolfsman, 2013) have indicated the importance of the students' home background and some have also stressed the importance of the school context in terms of the student composition within a school. Teodorovic (2011) reviewed school effectiveness research and concluded that in rich countries student-level variables are very important when determining student achievement, but less important in poor developing countries. Different measures of students home background have been used in the studies (e.g. parents' education level, income, possessions, occupation, household size, parental involvement in education) but a common conclusion is that students home background is related to school achievements (Chudgar & Luschei, 2009; Schiller, Khmelkov, & Wang, 2002). The association is however different across countries. Chiu (2007) concluded in a multilevel study that science achievement was more strongly associated with the students' home background as measured by number of books at home, home possessions, and cultural communication in wealthier countries than poorer ones, in addition, if the student were native-born the achievement was higher. Hastedt (2016) found that a student migration background can either affect the student achievements positively or negatively depending on the background of the immigrants. Chudgar and Luschei (2009) found in a cross-national study consisting of 25 countries, that family background as measured by home possessions (having a calculator, computer, dictionary, and study desk) and number of books at home had stronger association to achievement than school-level factors in most of the countries. Chiu and Xihua (2008) found in their cross-national study that students with more home possessions, books at home, and cultural communication scored higher than other students and the relations of these variables with achievement were stronger in wealthier countries compared to poorer countries.

Multilevel analyses have been used to analyse TIMSS science achievement with student and school context variables in many countries. Mohammadpour, Shekarchizadeh, and Kalantarrashidi (2015) used multilevel analyses of science achievement in the TIMSS 2007 participating countries and their results indicate that science achievements were heavily influenced by student-level factors. Students' from families with higher socioeconomic status, students with higher self-confidence towards science, boys, and students who spent less time on nonacademic activities and did job at home scored on average higher. They also found that schools had on average higher results when the school climate was positive in terms of high parental involvement and low negative behaviour in class (e.g. skipping class, arriving late at school, and absenteeism). In Caponera and Losito (2016) context factors and student achievement in all participating countries in

TIMSS 2011 mathematics was examined. Their conclusions were that student achievement is positively affected by high socio-economic status and that students from more socioeconomic advantaged schools performed on average better. Wiberg and Rolfsman (2013) used multilevel analyses to model TIMSS science achievement 2003 and 2007 in Sweden and Norway. They concluded that students' home background variables in terms of science self-concept, students' socioeconomic status, if the student had a native father were significant in both years in both countries. Also in Sweden, the aggregated socioeconomic status within the schools was positive and significant and being a boy was negative and significant.

There are also country specific multilevel analyses of TIMSS data. Atar and Atar (2012) examined Turkish students' science achievements on TIMSS with multilevel analyses. They concluded that gender (i.e. girls performed better), home educational resources, student attitudes toward science, and inquiry-based learning were significant predictors of science achievement on student level. Kaleli-Yılmaz and Hanci (2016) examined TIMSS 2011 mathematics achievement in Turkey and found a relationship with TIMSS mathematics achievement, and school marks and parents' educational level. Students had on average higher TIMSS achievement if the mother had a high educational level. They also found that the average TIMSS achievement was higher when the student's mother educational level was used as compared with using fathers' educational level. In a Swedish governmental report (National Agency for Education, 2017), preliminary analyses of the association between TIMSS and students' subject grades and national test grades in mathematics and science from school year 9 were explored. The main finding was that there was a positive association between TIMSS and mathematics and science school measures in school year 9. The report did, however, neither examine possible school effects nor how strong the association was within different student groups and no measures from school year 6 were included in the report. In contrast to that report, we focus only on the students' science results and focus on the students' subject grades and their national test results from school year 6 although school year 9 measures are used at some points.

### **Research questions**

This is a special study as it combines TIMSS science achievements with other school achievement measures using register data. The study is carried out within the national context of Sweden but the results should be of interest for other countries, as most countries use subject grades and many countries have national tests as well as participate in international LSAs. From the literature review and our aims, we focus on the following research questions;

- (1) How are students' achievements in schools in terms of grades and national test results associated with TIMSS science achievement in Sweden?
- (2) How are students' home background variables associated with TIMSS science achievement in Sweden?
- (3) What are the predictive effects of students' grades, national tests scores, student background and the composition of students at school on students' TIMSS science achievement in Sweden?

## Methods

### *Participants*

The students' science achievement results from TIMSS 2015 8th grade (IEA, 2017), referred to in this study as school year 8 in Sweden were used which included 150 schools and 4090 students. TIMSS are given every fourth year and is used to measure trends in mathematics and science. The TIMSS study are given to randomly chosen schools in Sweden and then students in randomly chosen classes within these schools participates. The sampling procedure follows the general TIMSS guidelines so the target population is all Swedish students in school year 8. The TIMSS 2015 administration in Sweden allowed for new possibilities as the social security numbers were collected by the National Agency for Education for all students who participated and the students gave their informed consent that their TIMSS results and information about them from registers could be used together in research. The gathering of social security numbers allowed us the opportunity to connect the TIMSS science achievements among Swedish students to Swedish register data, especially data about the students' national test results from elementary school, school subject grades and some background information about the students. To use register data is common in many research fields, and the use of linked data as a data source about student characteristics is likely to increase in the educational research field in the future. An agreement was made with the National Agency for Education to use the collected data, and after an approval from a regional ethical board in Sweden, we had access to this unique data set. As the Swedish students have a high amount of missing data in some background variables in TIMSS, we used this special opportunity to add additional information to our TIMSS data set. The additional information consisted of the students' parents' educational level and information about the students' migration background.

### *Instruments*

#### *TIMSS science and the Swedish school system*

According to the TIMSS terminology, science consists of the four subjects; Biology, Chemistry, Physics and Geoscience. In TIMSS, the students' performances are summarised in five plausible values for each of these subjects as well as five plausible values for the combination of them. We have chosen to use the combined science plausible values and it is referred to as TIMSS science achievements in the later analyses. As geoscience is not a specific subject in the Swedish schools, but only can be found partly in the subject Geography, we have chosen to only use the subject grades and national test results from Biology, Chemistry and Physics.

#### *The Swedish grades and grading scale*

The overall aim of subject grades is to give a measure of the students' subject knowledge. The Swedish grading system is criterion-referenced and thus evaluates the students' knowledge in comparison to specific criteria. The current grading scale consists of six grade steps; A-F, where A is the highest grade and F is fail. A-E are all different levels of pass and for each grade there are rubrics which describes what the students' needs to know in order to fulfil the requirements for a specific grade. The students' teachers set

the grades at the end of a course or at the end of a school semester. The students' grades are based on all tests and assignments during the school semester and the subject teacher compare the students' results on these tasks towards the different grading criteria when they are setting the students' subject grades. If there is not enough information about a student's knowledge, the student does not receive a grade, which is denoted by (-). The letter grading scale also corresponds to the following numeric grading scale; A = 20, B = 17.5, C = 15, D = 12.5, E = 10, F = 0. The numeric grading scale is commonly used for calculating average grades in the Swedish school system. In this study we used the students' grades in Biology, Chemistry and Physics from school year 6 (and school year 9) although we combined the grades within a school year by adding the numerical grades together and then taking the averaged of them. When needed, the students' average grades were categorised to the closest alphabetical A-F grade. Thus, each student got one Science grade for school year 6 and one Science grade for school year 9. This approach was chosen as the grade distributions (Table 1) were quite similar across each subject. The numeric grading scale is also used for calculating a student's merit value, which is the sum of 16 subject grades when the student is in school year 9. This merit value range from 0 (only F) to 320 (only A:s) (National Agency for Education, 2017) and as it combines the grades from several teachers it is expected to show a greater variability than the Science grades. In this study, we used the students' merit value from school year 9.

**Table 1.** Average TIMSS science achievement (M), standard errors (SE), proportions (%) and distribution of students on TIMSS science achievements divided on their subject grade level in school year 6 (upper part of Table), school year 9 (mid part of Table) and grades on national test in school year 6 and 9 (lower part of Table).

School year 6: TIMSS achievement divided on subject grades								
Grade	Science		Biology		Chemistry		Physics	
	%	M (SE)	%	M (SE)	%	M (SE)	%	M (SE)
A	2.4	622 (6.3)	1.7	613 (8.6)	1.4	613 (9.1)	1.7	611 (9.7)
B	12.6	591 (4.6)	6.8	586 (5.7)	7.4	582 (5.7)	7.2	588 (5.3)
C	30.7	552 (3.6)	18.9	544 (4.5)	17.3	549 (84.4)	18.5	551 (4.2)
D	26.8	514 (3.8)	14.7	518 (5.1)	14.8	517 (5.3)	14.5	515 (5.3)
E	19.3	465 (4.3)	15.1	480 (5.7)	16.4	477 (6.9)	15.3	472 (5.7)
F	1.9	405 (11.6)	1.5	414 (10.3)	1.5	412 (11.7)	1.9	410 (13.5)
-	6.4	454 (24.4)	41.2	519 (5.4)	41.2	521 (5.1)	40.9	520 (5.2)
School year 9: TIMSS achievement divided on subject grades								
Grade	Science		Biology		Chemistry		Physics	
	%	M (SE)	%	M (SE)	%	M (SE)	%	M (SE)
A	9.9	608 (4.7)	12.3	600 (4.4)	10.5	604 (4.6)	11.1	604 (5.2)
B	16.1	579 (4.5)	14.9	571 (4.5)	14.1	579 (4.4)	15.8	580 (3.6)
C	22.0	546 (3.1)	22.7	542 (3.2)	22.8	548 (3.4)	22.0	541 (3.2)
D	22.0	508 (4.0)	21.2	510 (4.1)	19.4	512 (3.9)	19.4	510 (4.3)
E	23.2	466 (4.4)	22.4	465 (4.6)	25.7	471 (4.3)	24.0	469 (4.4)
F	3.4	397 (10.6)	3.1	397 (13.4)	3.6	397 (10.3)	3.8	412 (11.7)
-	3.3	455 (11.5)	3.4	457 (11.3)	4.0	452 (10.4)	3.9	451 (11.0)
School years 6 and 9: TIMSS achievement divided on grades on national tests								
Grade	School year 6		School year 9					
	%	M (SE)	%	M (SE)				
A	3.1	610 (7.8)	14.0	602 (4.1)				
B	17.6	583 (4.3)	13.4	575 (3.9)				
C	40.7	538 (3.4)	19.9	543 (3.9)				
D	16.2	499 (3.3)	19.4	510 (3.9)				
E	11.9	457 (4.4)	19.0	478 (4.7)				
F	3.0	418 (9.0)	6.9	416 (8.6)				
-	7.6	455 (13.4)	7.5	468 (4.1)				

### ***National tests***

National tests in Sweden are administered in school years 3, 6 and 9 in a number of core subjects and are supposed to reflect the national curriculum and the syllabus. The overall aim of the national tests is to give information about how the knowledge demands are fulfilled on a school level and on a national level and to support an equal and fair grading process (National Agency for Education, 2016a). The Swedish national tests consist of several tests given at different occasions and are supposed to be a helpful tool to the teachers in order to provide fair grades to all students. The national tests are constructed to cover the national curriculum and the distribution of multiple-choice items and constructed response items are typically similar over test versions. Note, Science in school year 6 is quite different from science in school year 8 which TIMSS is measuring. The students are given one national science test in either Biology, Chemistry or Physics in school years 6 and 9. The range of the national test grades in this study was the same as for the Science grades and thus ranged between 0 (grade F) and 20 (grade A).

### ***National tests, grades and TIMSS***

The Swedish national tests and the students' grades differ in several important aspects. First, the national tests are only administered in a few subjects while grades are given to students in all subjects. Secondly, the national tests are administered at a single test occasion, only test parts of the curriculum while grades stems from the whole course, and aim to mirror every aspects of the curriculum. Grades typically stem from several assessments at several occasions and they describe an overall judgement of the student. National tests and grades are meaningful for all students as they are given to all students, while the TIMSS result is especially meaningful on an aggregated level as only a smaller sample of students takes TIMSS. TIMSS is built on content requirements and the three-parameter logistic item response theory model, while the national tests are built according to specific content requirements and a certain distribution of multiple choice and constructed response items which is similar across test versions. For both national tests and subject grades, we used both school years 6 and 9 data although TIMSS are given to students in school year 8, which could affect the variability in the sample as the students have learnt more in school year 9 in comparison to school year 8. As all students were examined at the same time points, we do not expect this to flaw the results. To use information about the students from both school years 6 and 9 give us information if the observed pattern is consistent over time and thus can help us to think about how we can improve the education in the early school years for weak students.

### ***Background variables***

Students' home background variables can be used to capture the students' socioeconomic status although we are aware of the difficulties in defining socioeconomic status (National Forum on Education Statistics, 2015). The student home background variables used were selected by availability and what has been learned from previous international research studies of TIMSS. The reason for using separate students' home background variables instead of the available TIMSS home educational resource index was threefold. First, we had access to other relevant information than was collected with TIMSS 2015. Second, we were interested in how separate variables affect the TIMSS achievements. Third, two of the variables in the TIMSS home educational resource are of less interest in the

Swedish context, as most Swedish students have an internet connection (99%) and their own room (93%). In this study, we included the students' sex, the students' migration background (i.e. if the students were born in Sweden or had parents' born in Sweden or not), the student's mothers' educational level and whether they lived in a home with many books or not. Sex differences in TIMSS achievements were examined although it is not part of the definition of socioeconomic status as girls have in general higher grades than boys as compared with their national tests achievements (Nycander, 2006). The girls' grades at the end of the compulsory school are on average better than the boys' grades in all subjects except sports. The smallest difference between boys and girls was observed in mathematics, physics and technology. In the Swedish national tests, girls perform slightly better in biology and physics than boys in school year 9 (National Agency of Education, 2016a). Although we do not expect large sex differences, we believe it is important to include this variable, since there are, observed differences in national test results in school year 9 in Sweden. Students' migration background was used as it was concluded by Hastedt (2016) that student achievements can be affected both positively and negatively depending on which country the students are from. We used students' mothers' educational level as the obtained results are similar regardless if the mothers' or the fathers' education level was used, the amount of missing data was less for the mothers' educational level as compared to the fathers' educational level and it was shown to be useful in Kaleli-Yilmaz and Hanci (2016).

The variable students' *sex* was coded as 0 for girls and 1 for boys. The migration variable was labelled *Swe* if either the student was born in Sweden or their parents were born in Sweden and *Imm* otherwise. The variable mother education was labelled *Med*. *Med* was coded as 1 if the mother had at least one year of higher education after high school education (*HighMed*) and 0 otherwise (*LowMed*). Finally, we used the variable *book*, which was coded as 1 if the student lived in a house with more than 100 book (*Hbook*) and 0 otherwise (*Lbook*).

### **Statistical analysis**

The association between science grades from school years 6 and 9, national test results in science from school years 6 and 9, and TIMSS science were explored. The five plausible values for science in TIMSS were used as a measure of TIMSS science achievement and the analyses were carried out in line with the recommendations given in Laukaityte and Wiberg (2017). Student weights were used when performing the statistical analyses with IEA IDB analyser version 4.0.12, SPSS 24.0 and HLM. We examined descriptive statistics such as average scores, standard errors and correlations between the students' TIMSS science achievements, science national test results and science grades from school years 6 and 9.

Linear regressions and multilevel analyses (Snijders & Bosker, 2012) were used in order to achieve a deeper understanding of the association between TIMSS science achievements and the school year 6 school achievement measures and the student home background. Multilevel analyses were used to estimate school-level effects. In the linear regressions and the multilevel analyses only school year 6 measures (grades and national tests) are used as school year 9 measures take place after TIMSS has been given to the students in school year 8. All the displayed coefficients in the linear regressions and multilevel

analyses were significant on at least level 0.05. To examine the contribution of school-level variables in comparison to student-level variables the intraclass correlation coefficient (ICC) was used. Listwise deletion was used to exclude missing data (Tabachnik & Fidell, 2007) as in general the amount of missing data were low in the used variables, ranging from 0.3% (sex) to 8.2% (national test results in school year 9). The missing data in national tests are due to students who were absent on the day of testing. Although it is in general better to impute missing data, we choose this approach as only a few cases were deleted and thus we do not expect that the performed analyses would give different overall results if another approach had been used.

## Results

The results in Tables 1 and 2 can be used to answer the first research question. In Table 1, the average scores and standard errors on TIMSS science achievements are presented and also divided into the three core subjects; Biology, Chemistry and Physics for students in school years 6 and 9 as well as national test result in school years 6 and 9. Note, although the results are presented in one table one should concentrate on one school year at the time (6 or 9) and either subject grades (upper and mid part of Table 1) or national test results (lower part of Table 1). As the students only take one national test in science in each examined school year, the national test results are not divided into core subjects in Table 1. Note, the large amount of missing observation (about 40%) on the individual science subjects in school year 6, is due to the fact that many schools do not give these subjects as separate subjects in school year 6 but only as an overall science subject and thus the students only get an overall science grade. The grade distributions within school year 6 across the different subjects are similar and likewise the grade distributions per subject are similar within school year 9. The grade distributions within school years 6 and 9 are however different. The overall science grade differs in school year 6 as compared with the subject grade due to large amount of missing observations. There is also a difference in grade distributions between science grades and national test grades in school year 6 especially for grade C and D. Further, the grade distributions and national tests for school year 9 is similar. As the grades are criterion-referenced, it is expected that more students have a grade of A in school year 9 as compared with school year 6. The overall pattern in Table 1 across subjects, school grades, and national test results is that students with high grades or high national test result also have on average a high result on TIMSS science.

To further examine the association between TIMSS science achievement and the students' school grades and national test results, correlation analyses were carried out and

**Table 2.** Significant correlations between TIMSS science achievements and the different school science achievements.

Variables	TIMSS	G6	NT6	G9	NT9
G6	.56				
NT6	.52	.76			
G9	.61	.59	.51		
NT9	.60	.54	.50	.77	
Merit value G9	.63	.63	.53	.91	.74

Notes: G6/9 = Science grade in school year 6/9. NT6/9 = National test in school years 6/9, Merit value = Joint grade value from 16 subjects from school year 9. Significant level: 0.05.

are displayed in Table 2. TIMSS science achievement and science grade in school year 9 exhibited moderately high correlation (0.60–0.63). TIMSS science achievement and school year 6 measures, both national test results and science grades, had low correlations; .52 and .56, respectively. This is not surprising as science in school year 6 is quite different from science in school year 8 which TIMSS is measuring. Table 2 also shows that science grades in school year 9 and merit values had an extremely high correlation (.91), which is probably due to the fact that the science grade consists of three subjects and merit value consists of 16 subjects. The correlation between grades in school year 9 (and school year 6) and the national test results from school year 9 (and school year 6) was quite high .77 (and .76) as expected, as the national tests are used to support an equal and fair grading and thus can be used to calibrate the students grades across Sweden.

To answer the second research question we examined different subgroups of the students, based on their home background. The different subgroups included 52% boys, 20% who was either not born in Sweden or had parents not born in Sweden, 48% had mothers with a higher education than high school, and 37% of the student lived in homes with more than 100 books. The correlations were quite similar within the different subgroups, more specifically they were similar to the correlations in Table 2 and thus the specific correlations for the different subgroups are excluded here. The largest differences (0.06) were found in the national test results in school year 6 between native and non-native students, and among students of whom their mother's educational level exceeded high school level or not.

To further examine how the students' home background variables are associated with TIMSS science achievement as well as to answer the third research question we used linear regressions and multilevel analyses with the achievement measures from school year 6, the students' home background variables and the school context in terms of average student background variables (Table 3). Note, each column in Table 3 represents a different linear regression (columns 1, 2, 4 and 5) or multilevel analysis (columns 3 and 6). The first and fourth columns only use the students' background variables; the second and fifth column also use either the grades or the national test results. Finally, the third and sixth columns contain multilevel analyses where also the school variables are included. The lower part of Table 3 shows the results when no home background variables were included in the analyses. In all the linear regressions and multilevel analyses, the results indicate that on average being a boy means that your average score is higher on TIMSS science achievement. Regardless which variable was used for grades, if the student live in a home with many books or if the mother has a higher education means that on average the TIMSS science achievement is higher than for student from homes without these characteristics. For non-native students, the TIMSS science achievements were on average reduced. Although we examined the student composition by using the average of all different student background variables on the school level – only one school-level variable (aggregated books at home) was significant. This means that TIMSS achievement was on average higher if the schools had students from homes with many books. All the models which contained both grades and students' home background had reasonable explained variance; .30 (national test in school year 6) and .34 (science grade in school year 6). The explained variance with only home background in the model was low; 0.14 (grades in school year 6) and 0.15 (national test in school year 6). The ICC were .12 (grades in school year 6) and 0.11 (national test in school year 6) indicating that the only significant school-level

**Table 3.** Linear regressions and multilevel analyses with TIMSS science achievement as dependent variable and student background variables and either science grade or national test as science achievement measures (achieve) as independent variables.

Variables	G6	G6	G6	NT6	NT6	NT6
<i>Student</i>						
Intercept	529.0 (2.7)	530.6 (2.4)	531.1 (2.3)	529.4 (2.7)	529.9 (2.4)	530.3 (2.2)
Achieve*		11.1 (0.5)	11.1 (0.5)		9.2 (0.4)	9.1 (0.4)
Sex		5.6 (2.3)	5.7 (2.3)		4.9 (2.3)	5.0 (2.3)
Imm	-33.6 (4.2)	-22.8 (3.5)	-22.0 (3.5)	-33.3 (4.2)	-21.12 (3.6)	-20.1 (3.6)
Book	39.8 (2.5)	27.5 (5.6)	26.1 (2.3)	40.6 (2.5)	29.5 (2.1)	28.1 (2.2)
Medu	29.9 (2.9)	17.9 (2.7)	17.4 (2.7)	28.9 (3.0)	20.3 (2.8)	19.7 (2.9)
<i>School</i>						
Book_A			66.4 (13.3)			61.8 (12.8)
R <sup>2</sup>	.14	.34	.34	.15	.30	0.30
ICC			.12			.11
<i>No BV</i>						
Intercept	528.3 (3.0)			527.4 (3.0)		
Achieve*	13.1 (0.6)			11.0 (0.6)		
R <sup>2</sup>	.28			.23		

Notes: G6 = Science grade in school year 6, NT6 = National test in science in school year 6, \*Achieve = G6 or NT6 see column name, Sex = 1 if student is a boy, 0 if girl. Imm = Students or students' parents not born in Sweden, Medu = Student's mother has higher education than high school education, book = Student lives in a home with more than 100 books, Book\_A = aggregated book. R<sup>2</sup> = Explained variance, ICC = Intraclass correlation coefficient.

variable – student composition in terms of number of books at student's home – had only a small influence on the variance as compared with the individual student background.

## Discussion

In this study, we had the possibility to examine the association between students' TIMSS science achievements, grades and national test result while including information from register data about the students' home background. The general conclusion is that there is a moderate association between TIMSS science achievements and the examined school achievement measures in Sweden (grades and national tests), although the association is stronger with the school achievement measures from school year 9 than from school year 6. The results about TIMSS and school measures from school year 6 are new and have never been examined before, while the results about school measures from school year 9 is in line with the results by the National Agency of Education (2017). The observed moderate association between school achievement measures and TIMSS science achievement differ from the strong positive association Wiberg (2019) observed when examining the association between Swedish school achievement measures and TIMSS mathematics achievement. As expected, the association between grades and the high-stakes national tests (which both follow the national curriculum), were stronger than between grades and TIMSS which is a low stake test. The high correlation between the subject grades and the national test results suggest that the national test do exactly what they are aimed to do – helping the teacher in the grading process. It was interesting to note that the results were consistent over time and thus it is likely that high achievers in school year 6 are also high achievers in school year 9. This longitudinal perspective in connection to TIMSS achievement measure has not been examined before. In the future, it would be interesting to examine this further and to examine other countries school achievement measures over several school years in connection to TIMSS achievement.

The obtained results question somewhat how to interpret the results from TIMSS science achievements in Sweden. TIMSS science achievement can probably be used as an indicator of the students' results over time but it cannot be seen as the only truth on the actual students' performance in science in Swedish schools. The results for the different student groups were in general in line with previous research (e.g. Erberber et al., 2015; Gustafsson & Nilsen, 2016; Hanushek & Luque, 2003; OCED, 2011; Sirin, 2005). Sex differences were small as expected and in line with results from other studies (National Agency of Education, 2016a; Nycander, 2006). From the linear regressions and multilevel analyses, it was clear that if the students' mothers' educational level was high, if the student's home had many books and the student's migration background had high impact on the average TIMSS science result. Although it is well known that student's parental educational level is associated with the students' TIMSS achievements – it has not been studied before with information about students' performance from school year 6. The results point to the ongoing challenge of how to assure that students having parents with a lower educational level and students, who comes from other countries, can get a good education regardless of their home background. The fact that only one school-level variable was significant is not surprising. It is in line with previous research on students' achievement on TIMSS in Sweden, which have concluded that only a small number of school factors have a modest impact on students' TIMSS achievement in science (Wiberg & Rolfman, 2013) or in mathematics (e.g. Rolfman, Wiberg, & Laukaityte, 2013; Wiberg, 2019; Wiberg, Rolfman, & Laukaityte, 2013). In addition, the obtained rather low ICC values are in line with previous studies in an international context. It is also unlikely that a high-income country like Sweden would have any large school effects according to the Heyneman-Loxley effect, which states that the quality of schools has a greater impact on achievement in low-income countries than it does in high-income countries. The result that students' home background has a strong effect on the students' achievements is also typical seen in higher-income countries (Ilie & Lietz, 2010). In the future, it would be interesting to examine this further by linking the students' parents' income level to student achievement in order to examine different socio-economic definitions and the possible impact on the students' result.

Some might argue that it is limiting that the study only contained Swedish students but this kind of study is only possible to perform in a national context where one can relate TIMSS to relevant national school achievement measures. The obtained results should however not only be viewed in a national context but it can be viewed as evidence that TIMSS studies are relevant in a country and one should encourage other countries to perform similar studies in order to examine the value of international LSAs like TIMSS in their country. Note, our choice of subgroups may be specific for the Swedish context, e.g. our choice of using the mothers' educational level instead of the fathers' educational level. This may not be contingent in countries with another distribution among women and men in higher education. It would also be interesting in the future to perform similar studies with other international LSA such as PISA.

An obvious limitation is that the results could not be related to any other country study, as there are no similar TIMSS studies within other national contexts. There are however other LSA such as the US scholastic assessment test (SAT) which have been studied by Zwick and colleagues (Zwick, 2017; Zwick & Green, 2007; Zwick & Sklar, 2005). For

example, Zwick and Sklar (2005) found that student with a different first language was disadvantaged on SAT, a result that is in line with our result that non-native students were disadvantages on TIMSS science. In the future, it would be interesting to study this topic more closely to examine if the actual country the student or the student's parents come from has an impact. Other aspects associated with assessments may also be of importance to consider in the future, e.g. the effect of the item format and linguistic features which have different implications for different subgroups of students, e.g. low-performing students (Persson, 2015).

To perform deepened and extended analyses of data from international LSAs like TIMSS is important and to conduct validity research, in order to know how to interpret the results in comparison to national achievement measures. In line with the results in Cartwright et al. (2003) and Szaleniec, Grudniewska, Kondratek, Kulon, and Pokropek (2013) we found that the international LSA TIMSS and the Swedish national assessments did not show exactly the same performance pattern. This is not surprising, although TIMSS measure a large part of the Swedish curriculum both with respect to content and cognitive reasoning some larger content areas are missing. As the national tests are designed to follow the national curricula, they cover larger content areas than TIMSS and there are more items that require constructed responses than in TIMSS (Frändberg & Hagberg, 2017). Still, by examining the performance among different subgroups on international LSA, and how the performance correlate with performance on other school achievement measures, the practical value could be raised for educational professionals and students. These kinds of studies can be used to motivate a more strategically use of TIMSS results within a country. If the association is strong, the results can be used order to develop schools and thereby promote student success in the schools. As we only found a moderate association between TIMSS science achievements and the Swedish school achievement measures, the role of TIMSS for development of schools and the educational practice in Sweden is however not clear. In the future, it would, therefore, be interesting to study if this moderate association is consistent over time and if the size of the association is similar or different in other countries.

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