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Gender gaps in science are not a given.

Evidence on international trends in gender gaps in science over 20 years

SUMMARY

- IEA's Trends in International Mathematics and Science Study (TIMSS) data from the late 1990s onwards, show that an increasing number of countries are achieving gender equity in students' science achievement in grade four and eight.
- Although there is a persisting trend of an overrepresentation of male students in the group of high achievers in science, female students are catching up:
  - In 2011, the overrepresentation of male students reduced slightly in grade four and reduced more clearly in 2015 in grade eight in most countries.
  - Whereas from 1995 to 1999, achievement gaps in science widened from grade four to eight in most countries, this was not the case 16 years later, where the (now already less pronounced) overrepresentation of male students remained rather similar from 2011 in grade four to 2015 in grade eight.
- For the low achieving students, 10 out of the 11 participating countries have reached equal gender distributions since the late 1990s:
  - In 1995 in grade four and even more in grade eight in 1999, more female students were among the low achievers in science.
  - In 2011, equal proportions of female and male students comprised the group of low achievers in grade four in most countries assessed; a picture that hasn't changed four years later when this cohort attended grade eight in 2015.

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IMPLICATIONS

- TIMSS data show that gender equity in science achievement can be and has already been achieved in several countries.
- Hence, there are ways to overcome gender inequalities. Countries should learn from each other and consider adopting related measures of countries that successfully addressed this challenge.
- Looking at high and low performing students separately gives way for better tailored policy approaches for students at both ends of the performance distribution.

INTRODUCTION

Gender equality

The United Nations Education, Scientific and Cultural Organization (UNESCO) declared gender equality as one of the most important goals for education (UNESCO 2015b), and ultimately incorporated this aim within the framework of the Sustainable Development Goals (United Nations 2018). However, even long before this, the "gender gap"—the term frequently used for differences in achievement between female and male students—had become an important topic for educational research with clear political and economic implications (UNESCO 2015a; Hausmann et al. 2009). These differences are frequently seen as a matter of inequality in opportunity (Klasen 2002). Especially in the education context, efforts towards gender equity are perceived as a general measure of justice and fairness (EGREES 2005).

While gender equality and equity in education is an issue under discussion for more than a century, in many developed economies fairly equal opportunities to learn have been established for both genders (Mullis et al. 2016a). However, traditional patterns continue to influence the life course of male and female students in very powerful ways. For example, the IEA Trends in International Mathematics and Science Study (TIMSS) Advanced study on upper secondary students studying advanced mathematics and physics conducted in 2015 found far more male students in these courses in most of the participating countries (Mullis et al. 2016b). On average, in most countries male students also achieve significantly higher in mathematics and physics than female students (Mullis et al. 2016b). Further, female students—as opposed to male students—still opt more for professions within the social sector and less often for sectors related to the STEM (science, technology, engineering, and mathematics) subjects.

Earlier publications indicate unequal performance of male and female students being more likely at the extreme ends of the mathematics and science achievement distribution than on average (Baye and Monseur 2016; Bergold et al. 2016), which is why this brief will focus on these populations. Identifying such patterns will help to target measures to the right audience.

Students performing at the tails of the science achievement distribution

In light of the above, in this brief we examine TIMSS science achievement of the 20% highest and the 20% lowest performing fourth and eighth graders in 11 countries. To do so, we compare achievement distributions across countries, using measures of relative equality within countries. Such an examination provides detailed insights into variation, and has the potential to reveal tailored options for addressing various issues. For example, if gender gaps exist at the lower end of the achievement distribution, policies addressing the specific weaknesses of low achieving students of the disadvantaged gender would be more effective than any generalized measures implemented for all students. Therefore, we compare (i) general changes in gender gaps in science achievement at the tails of the achievement distribution over time, and (ii) the development of gender gaps between grade four and grade eight within a cohort of students at two different points in time, 16 years apart.

FOLLOWING COHORTS TO MEASURE CHANGE OVER TIME WITH TIMSS DATA

TIMSS has been conducted every four years since 1995 in both grade four and eight. This facilitates trend analysis of cohorts within countries. For this brief, we selected those education systems that participated in TIMSS at grade four in 1995 and 2011, and at grade eight in 1999 and 2015. We thus followed up two cohorts in 11 countries: the cohort with students who attended grade four in 1995 and grade eight in 1999, and another cohort 16 years later, with students attending grade four in 2011 and grade eight in 2015. Due to reasons like grade retention, migration, or school dropout, the grade four cohort does not perfectly correspond to the grade eight cohort four years later, but sufficiently for measuring trends within the cohort.

We first identified the 20% highest and 20% lowest performers in science in each country and cycle per grade, using the overall science achievement scores. The achievement levels of these groups could differ greatly among countries, but these differences are not of interest for this brief. Instead, our focus is purely on the gender gap within and across countries, and time. Hence, in a second step, we estimated the differences in percentages of male and female students within those groups. The results of these analyses were the relative distributions of female and male students in the groups of "high" and "low" performers.

RESULTS: CLOSING THE GAPS IN SCIENCE

Overall, our findings show that the gaps in science achievement between male and female students are closing. Table 1 and 2 show the gender gaps in science achievement and their trends following up two cohorts from grade four to eight. In both tables, the columns "Gap difference between grade 4 and 8" show the development of gender gaps over four years of schooling within the same cohort of students. The first cohort represents students attending grade four in 1995 and grade eight in 1999. The second cohort represents students attending grade four in 2011 and grade eight in 2015. In what follows, we will have a separate, detailed look at the results for the high and low achievers.

Twenty percent highest performing students

In science achievement, there is a clear and generalizable pattern (see Table 1). Specifically, more male than female students were found in the group of high achieving students in science at grade four in both cycles (1995 and 2011). In the first cohort assessed (1995 and 1999), this overrepresentation increased between grades four and eight, with New Zealand being the only country where this overrepresentation of male students was insignificant at both grades.

Gender gaps were not as severe in the second considered cohort (students that attended grade four 16 years later). Similar to the first cohort, relatively more male students were among the top performers at grade four, with significant differences in six countries. However, the gap did not significantly increase further over the next four school years, but remained stable or even slightly decreased. Thereby, the gender gap at grade eight was smaller in 2015 than in 1999 in all countries. It is worth mentioning that the average achievement remained stable or even significantly increased in all considered countries between 1999 and 2015, with the exception of Hungary and Iran (Martin et al. 2016), so the smaller gap in 2015 is rather due to an increase in the performance of female students, and not due to a decrease of male students' achievement.

Table 1: Gender gaps in percent of group membership related to science achievement, cohort trends between grades 4 and 8, 20% highest achieving students

Country	Cohort 1			Cohort 2		
	1995 (grade 4)	1999 (grade 8)	Gap change between grade 4 and 8	2011 (grade 4)	2015 (grade 8)	Gap change between grade 4 and 8
Australia	-5.0 *	-8.8 *	-3.8	-2.8	-2.6	0.2
England	-4.5 *	-11.6 *	-7.1 *	-1.6	1.2	2.8
Hong Kong, SAR	-6.7 *	-9.5 *	-2.8	-5.5 *	-8.0 *	-2.5
Hungary	-5.6 *	-11.1 *	-5.5 *	-4.0 *	-5.3 *	-1.3
Iran, Isl. Rep. of	-5.3	-10.7 *	-5.4	-2.9	0.6	3.5
Japan	-4.8 *	-8.2 *	-3.4	-4.2 *	-2.3	1.9
Korea, Rep. of	-7.5 *	-7.1 *	0.4	-6.6 *	-4.8 *	1.8
New Zealand	-1.2	-4.3	-3.1	-2.3	-2.7	-0.4
Singapore	-4.2 *	-9.0 *	-4.8	-3.2 *	-5.1 *	-1.9
Slovenia	-4.1 *	-7.8 *	-3.6	-4.6	-0.2	4.4
United States	-3.9 *	-9.0 *	-5.1 *	-5.3 *	-3.7 *	1.6
Table average	*-4.8 **	*-8.8 **	*-4.0 **	*-3.9 **	*-3.0 **	*0.9*

Notes: * Significant gap or gap change (p < 0.05). Red bars indicate higher (or increasing) percentages of female students, blue bars indicate higher (or increasing) percentages of male students.
Interpretation example: In England, the group of the 20% highest performing students contained 4.5% more male students than female students at grade 4 in 1995.

Twenty percent lowest performing students

The gender gap is less pronounced in the group of low performing students (Table 2). In 1995, at grade four, only four countries showed significant gender gaps. In Hong Kong (SAR), Hungary, and Korea more female students were among the low-performing students, but more male students were in this group in New Zealand. While New Zealand reached gender equity four years later, the gap persisted in the other three countries and widened in England and Iran, again with a higher proportion of female students.

Table 2: Gender gaps in percent of group membership related to science achievement, cohort trends between grade 4 and 8, 20% lowest achieving students

Country	Cohort 1: 1995 (grade 4)	Cohort 1: 1999 (grade 8)	Cohort 1: Gap change between grade 4 and 8	Cohort 2: 2011 (grade 4)	Cohort 2: 2015 (grade 8)	Cohort 2: Gap change between grade 4 and 8
Australia	-0.3	2.6	2.8	-2.0	1.1	3.1
England	0.1	8.4 *	8.3 *	-1.7	0.3	2.0
Hong Kong, SAR	3.8 *	3.6	-0.2	0.5	1.3	0.8
Hungary	2.7 *	6.7 *	4.0	-0.4	5.5 *	5.9 *
Iran, Isl. Rep. of	1.8	9.8 *	8.0 *	-1.1	-3.8	-2.6
Japan	1.0	2.4	1.4	1.0	-2.1	-3.1
Korea, Rep. of	4.6 *	6.6 *	2.1	1.2	-1.7	-2.9
New Zealand	-4.8 *	0.3	5.1	-2.0	-2.6	-0.6
Singapore	-0.7	3.4	4.1	0.2	-2.6	-2.8
Slovenia	2.4	2.1	-0.3	0.1	-2.4	-2.5
United States	0.4	2.6	2.1	2.6 *	-0.2	-2.8 *
Table average	*1.0 **	*4.4 **	*3.4*	*-0.2*	*-0.7*	*-0.5*

Notes: * Significant gap or gap change (p < 0.05). Red bars indicate higher (or increasing) percentages of female students, blue bars indicate higher (or increasing) percentages of male students.
Interpretation example: In England, the group of the 20% lowest achieving students contained 0.1% more female students than male students at grade 4 in 1995 (non-significant gap). Four years later, this gap had increased to 8.4% and became significant. The gap change of 8.3% is significant.

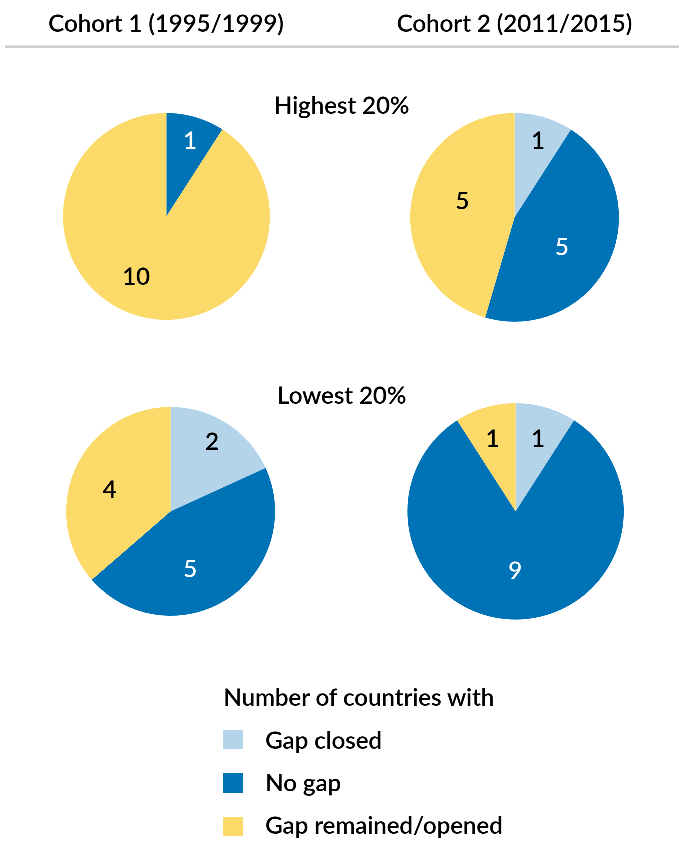
However, the cohort attending grades four and eight 16 years later showed minimal gender gaps at both grades, with the exception of Hungary, where again more female students comprised the group of low achievers in science at grade eight. Patterns indicate a (new) tendency towards an increase in male students in this group in 2015. In seven out of eleven countries, the proportion of low achievers among the male students was bigger than that of female students in grade eight, and the change from grade four to grade eight showed an increase in the relative share of male students. The trend is yet insignificant, but should be closely monitored in the future.

From widening gaps throughout the course of schooling towards more gender equity

Adding a different perspective, we categorized countries into groups with similar patterns of gender gaps, and their changes over four years of schooling. This allows simplified illustrations of changes between the two considered cohorts. We determined the following groups: (1) countries with no gender gaps in both grades, (2) countries where existing gender gaps in grade four have closed over the next four years of schooling, and 3) countries where gender gaps at grade four remained at grade eight, have opened, or have widened (see Figure 1). The focus here is on the overall trend, not on the actual size of the gaps.

We can observe two developments: First, at both tails of the achievement distribution in science, the number of countries with gender gaps persisting, opening, or widening decreased from the late 1990s. Compared to then, the two most recent cycles of TIMSS saw more countries showing either no gender gaps at all or where gender gaps that existed in grade four have been closed at grade eight.

Figure 1: Changes in gender gaps in science achievement between grade four and eight for two cohorts of students in 11 countries



Second, there are still several countries showing gender gaps among the high achieving students—though less than in the 1990s. Further, in almost all countries we looked at, there has been no gender gap among the low achieving students in 2011 at grade four and these countries were able to maintain this equity at grade eight in 2015.

In summary, these results suggest that for the high achieving students in science, female students are catching up with their male peers. Even more promising are the results for students with low achievement in science. In the late 1990s, the proportion of female students with low achievement was higher compared to their male peers. However, they have now caught up. This suggests that countries were able to achieve equity at the lower tail of the ability distribution.

DISCUSSION

We identified encouraging evidence that gender equality in science education is increasing.

However, several educational systems show a persisting trend of more male students in the group of high achievers in science. STEM subjects have a long history of being favored by male students, a situation that fosters gender differences in academic competencies and an underrepresentation of women in scientific careers. Male and female students may benefit from different teaching approaches and methods to motivate engagement (James 2007). The findings indicate that some policy initiatives could have shown success, and we hypothesize that those initiatives addressing this problem could be among the successful ones.

At the lower end of the ability distributions, we found male and female students almost equally represented in 2015, while more female students were among the low achievers especially at grade eight in the 1990s. The trends identified in this brief include promising changes in several countries that were able to diminish gender differences in science achievement that existed in the past. Furthermore, findings suggest that female students in general are catching up. A closer look at the specific contexts and policy changes might reveal successful measures to counteract gender differences.

Our research revealed trends in these gaps over 20 years of TIMSS, but it does not explain the mechanisms causing these gaps or any of the underlying factors. Further research is needed to understand these mechanisms better and refine implications and recommendations for policy. IEA contextual data is a valuable research resource to uncover such relations. Although this brief focused only on specific countries and cohorts, it may serve as a template for similar analyses of data from other countries and cohorts that have participated in TIMSS or similar large-scale assessments in education.

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ABOUT IEA

The International Association for the Evaluation of Educational Achievement, known as IEA, is an independent, international consortium of national research institutions and governmental agencies, with headquarters in Amsterdam. Its primary purpose is to conduct large-scale comparative studies of educational achievement with the the aim of gaining more in-depth understanding of the effects of policies and practices within and across systems of education.

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